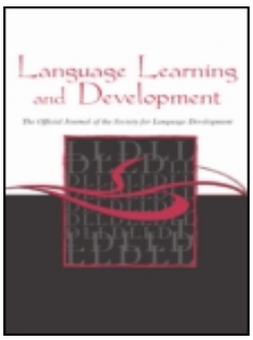

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Regularizing Unpredictable Variation: The Roles of Adult and Child Learners in Language Formation and Change

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In this article we investigate what learners acquire when their input contains inconsistent grammatical morphemes such as those present in pidgins and incipient creoles. In particular, we ask if learners acquire variability veridically or if they change it, making the language more regular as they learn it. In Experiment 1 we taught adult participants an artificial language containing unpredictable variation in 1 grammatical feature. We manipulated the amount of inconsistency and the meaning of the inconsistent item. Postexposure testing showed that participants learned the language, including the variable item, despite the presence of inconsistency. However, their use of variable items reflected their input. Participants exposed to consistent patterns produced consistent patterns, and participants exposed to inconsistency reproduced that inconsistency; they did not make the language more consistent. The meaning of the inconsistent item had no effect. In Experiment 2 we taught adults and 5- to 7-year-old children a similar artificial language. As in Experiment 1, the adults did not regularize the language. However, many children did regularize the language, imposing patterns that were not the same as their input. These results suggest that children and adults do not learn from variable input in the same way. Moreover, they suggest that children may play a unique and important role in creole formation by regularizing grammatical patterns.

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Languages are typically passed down from one generation to the next with a high degree of fidelity—the language spoken by the child is very much the same as that used by the people who provided her input. However, sometimes the learning is not so veridical; the language gets changed as it is learned. Such situations provide a unique perspective on the mechanisms involved in acquisition. They inform us about the limits of these mechanisms, providing information about the kinds of language patterns that humans can and cannot readily learn and about the relation between input and outcome. One commonly discussed example of such a process is the formation of creole languages, where it has been argued that, at some point in the history of the language, learners have altered their input and produced a different type of language as their output.

In this light we have been studying the processes that might be involved in the emergence and development of creole languages and in other situations of language formation and change. This article describes two experiments from a series of studies investigating one particular type of change—*regularization*. We ask how it is that languages with unpredictable variation in their grammars might lose this unpredictability and become regular. Our experiments examine the nature of the input variability and the type of learner acquiring the language to understand the factors that contribute to the regularization of an inconsistent form. In the first experiment we ask whether the consistency of usage and the meaning of a simple grammatical item affects its learning. In the second experiment we compare adult and child learners exposed to inconsistency, asking whether adults and children differ in their tendencies to regularize inconsistency in language.

CREOLE LANGUAGE FORMATION

Creoles are contact languages that emerge when speakers of mutually unintelligible languages come together and need to communicate with each other (Mühlhäusler, 1986; Sebba, 1997; Thomason & Kaufman, 1988).[1] In these situations, adults typically learn some words from the superstrate language (the language spoken by those with the most power) but do not fully acquire the grammar associated with that lexicon. Instead, they create a new language (Mühlhäusler, 1986; Sebba, 1997; Thomason & Kaufman, 1988), often referred to at this stage as a *jargon* or *pidgin*. Pidgins have small vocabularies, few grammatical devices such as tense or number marking, and make little use of complex sentence structures such as embedding (Bakker, 1995; Mühlhäusler, 1986; Romaine, 1988; Sebba, 1997; Thomason, 1997). When the communication is more extensive and the lan-

[1]When only two languages are involved in the contact, bilingualism is the typical result; creoles more commonly develop in situations with multiple languages in contact.

guage more widely used, however, a *creole* emerges. In contrast to pidgins, creoles have larger vocabularies and exhibit more grammatical devices, and most have native speakers (Mühlhäusler, 1986; Romaine, 1988; Sebba, 1997; Thomason, 1997). Although it is often suggested that creoles emerge from pidgins, recent research suggests that the relation between pidgins and creoles is not always of this form. Creoles can emerge from pidgins, but they need not; pidgins can remain small, and creoles can emerge without the prior establishment of a stable pidgin (Mühlhäusler, 1986; Thomason, 2003; Thomason & Kaufman, 1988).

One important feature of creole languages is that their grammars are not precisely the same as any of the native languages of the speakers involved in creating them. This raises the question of how creole languages come to have the grammars that they do. An important early hypothesis is that children contribute grammatical structure to creole languages, when they learn them as their native languages (e.g., Bickerton, 1981, 1984; Hall, 1966). However, many creolists argue that in most instances of creole formation it is adults who initially contribute specific grammatical forms to the language. The precise source of the structures is currently a matter of debate, with native language transfer, (reinterpretations of) superstrate structures, and universals of language reduction and creation all suggested as possibilities (DeGraff, 1999b; Mufwene, 1996).[2] Most current work on creole language emergence is aimed at understanding how exactly these various factors influence the grammars of newly emerging contact languages.[3]

Our work addresses a related but potentially separate issue, asking how forms that are used variably in a language or across a community of speakers might become regular and consistent parts of the grammar. Creole languages have the unusual characteristic that, at their earliest stages, most speakers are non-native speakers of the language. Almost all work examining adult language learners demonstrates that their language contains variability that is not typical of natively acquired languages (Birdsong, 1999; Johnson, Shenkman, Newport, & Medin, 1996; Newport, 1990). For instance, numerous researchers (e.g., Meisel, Clahsen, & Pienemann, 1981; Perdue, 1993; Schumann, 1978; Wolfram, 1985) have noted adult learners are inconsistent in their use of past tense marking in contexts that clearly require it. This is

[2]See DeGraff (1999a, and the papers in DeGraff, 1999c) for an excellent overview of the various views on creolization.

[3]These claims do not entail that children cannot or do not invent grammatical structure. There is clear evidence that children do introduce grammatical structure in certain circumstances, such as when they lack linguistic input (Coppola & Newport, 2004; Goldin-Meadow, 2003; Goldin-Meadow & Mylander, 1984) or when the input they receive has little or no structure (Kegl & Iwata, 1989; Senghas, 1995; Senghas & Coppola, 2001; Senghas, Coppola, Newport, & Supalla, 1997). Evidence on spoken language creoles suggests, however, that in most instances newly forming creole languages do not present these circumstances to child learners, and so there may be no need for children to invent grammatical structures, although Hawaiian Creole may be an important exception to this generalization (Roberts, 1998).

typical even of speakers who have had years of experience with the language, who use it on a regular basis, and whose grammars have stabilized (Adamson, 1988; Newport, 1984, 1990; Sorace, 1999, 2000; Wolfram, 1985). Importantly, the variation present in second language (L2) productions is largely unpredictable (Johnson et al. 1996; Wolfram, 1985; but see Andersen, 1989), unlike the variation present in native speech (Chambers, Trudgill, & Schilling-Estes, 2003; Labov, 1969).[4]

Logically, then, in the earliest stages creoles and other non-native contact varieties should also exhibit this kind of variability since all of the speakers are non-native speakers. Moreover, variability within individuals, as well as differences among individual speakers, translates into variability across the language. The sparse data that exist regarding the early states of contact languages support this supposition (Becker & Veenstra, 2003; Bickerton & Givón, 1976; DeGraff, 1999b; Hudson & Eigsti, 2003; Sankoff, 1994; Senghas, 2000; Senghas, Coppola, Newport, & Supalla, 1997). Bickerton and Givón describe the variation in word order that existed in Hawaiian Creole English (also referred to as Pidgin) in its early stages. Although the predominant word order used by most speakers was subject (S)–verb (V)–object (O), speakers used other orders as well. Which order a speaker used in any sentence was not predicated on the meaning of the sentence, so the variation was unpredictable. However, the particular non-SVO order used by individual speakers depended on their native language. Japanese speakers used SOV as well as SVO, and Filipino speakers used VOS as well as SVO. The native language background of a speaker could predict which alternative order they used but not when they would use one order versus the other. In this instance, then, the language as a whole contained even greater variability than the language of any individual speaker.[5] One should not take from this example that creoles are ad hoc creations of each speaker. There are norms that exist in the languages, but in the early stages these norms are probabilistic rather than deterministic, and individual speakers will be more or less likely to produce speech in accordance with the norms.

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[4]While much of the literature on natural languages describes grammatical rules as deterministic, there is a literature on sociolinguistic variation that describes rules as distributed in continua over communities and as used in a variable fashion by individuals (see, e.g., Labov, 1969, 1994, and the papers in Chambers et al., 2003). However, there are several important ways in which the variable rules of natively acquired natural languages are different from those of second languages, pidgins, or young creoles. Most important for present purposes, because the variable forms of L2 learners are errors, they do not have conditioning linguistic contexts. This is what we refer to as *inconsistent* or *unpredictable* variation.

[5]This point is true of L2 grammars more generally. They demonstrate greater consistency when examined internally than when compared to the target language (Andersen, 1989; Ellis, 1989). However, even when examined at the level of the idiolect, there is inconsistent variation (Andersen, 1989; Johnson et al., 1996). Our larger point thus remains true; because each L2 speaker will differ from the others, a language community that consists of primarily non-native speakers will always contain a high degree of unpredictable variation, both because of individual inconsistency within each L2 speaker and because different L2 speakers differ from each other.

HOW DOES REGULARIZATION HAPPEN?

Typically, languages that are spoken primarily by native speakers do not contain this kind of unpredictable variability, and creoles at later stages are no exception to this rule. The question addressed in our work is how learners take input that contains unpredictable variation and end up with a language that is regular. In particular, we ask whether regularization is a tendency of all language learners, given certain types of linguistic input, or whether it occurs only under more restricted circumstances. One possibility is that learners might acquire *any* probabilistic input in a deterministic fashion, turning probabilistic usage into more regular rules. Alternatively, learners might acquire probabilistic input in this fashion only at certain probability levels or under certain semantic conditions. For example, a form that occurs 75% of the time in a particular context might be acquired as a regular form, whereas one that occurs 45% of the time might not be (see Kroch, 1989, for the suggestion that language change takes place when a form is used above certain probability levels); or a probabilistic form that signals a semantic contrast might be regularized, whereas an arbitrary form might not. Yet another possibility is that learners of different ages might regularize differently. For example, regularization might occur most readily in children, either due to an innate tendency to acquire deterministic linguistic rules (cf. Becker & Veenstra, 2003; Bickerton, 1981; DeGraff, 1999b; Lumsden, 1999) or due simply to their more limited ability to learn from inconsistent data (cf. Newport, 1990). Alternatively, adults might be primarily responsible for regularization, a hypothesis suggested in the literature on creolization (Aitchison, 1996). It is not clear from the existing literature what the answer to these questions might be. However, a few relevant studies do exist.

Perhaps the best known hypothesis about how unstable pidgins change into more regular creoles is the Language Bioprogram Hypothesis (Bickerton 1981, 1984). Bickerton suggests that, when children are exposed to reduced communication systems that do not include all the properties of natural languages, they introduce those properties by drawing on their innate knowledge of natural language structure. Unfortunately there is little direct evidence about whether children are capable of the type of innovation of grammatical structure, ignoring their input, that Bickerton hypothesizes to explain abrupt creolization (though see Coppola & Newport, 2004; Goldin-Meadow, 2003; Goldin-Meadow & Mylander, 1984, for the emergence of grammatical structure in home sign languages without linguistic input). However, there is evidence that, when children are exposed to inconsistent use of grammatical forms, they tend to regularize those forms as they learn them.

Newport and her collaborators have examined the language development of a child who was exposed only to inconsistent (i.e., unpredictably variable) input (Newport, 1999; Ross & Newport, 1996; Singleton, 1989; Singleton & Newport, 2004). The child, called Simon, was deaf and was learning American Sign Lan-

guage (ASL) as his first language. Importantly, his only source of input to ASL was his parents, who had both learned the language in their late teens. Simon's parents' signing contained a number of inconsistencies characteristic of late learners, including the inconsistent use of required grammatical morphemes. Despite this inconsistent input, however, Simon's own signing did not contain this same variability. Rather, Simon acquired consistent, regular use of the morphemes his parents used inconsistently, imposing regularity on the inconsistent system to which he was exposed. In fact, in most respects Simon's signing was indistinguishable from that of children learning the language from native input (the normal acquisition situation in most language communities).[6] Research on deaf children of hearing parents, whose ASL input is even more inconsistent, shows the same outcome (Ross, 2001; Ross & Newport, 2005). The children's language is much more consistent and regular than their input.

Further evidence comes from research on the emergence of Nicaraguan Sign Language. Kegl and Senghas and Coppola (Kegl & Iwata, 1989; Senghas, 1995; Senghas & Coppola, 2001; Senghas, Coppola, Newport & Supalla, 1997) have been studying the creolization of Nicaraguan Sign Language, a community sign language emerging in the unusual circumstances where the users, due to their deafness, have no effective contact with surrounding superstrate or substrate languages. Although detailed data on the input and outcome of individual learners is not available in this situation, Senghas and Coppola have shown that the expansion of spatial grammatical devices in the language is occurring among the young children of the community, who are exposed to inconsistent use of these devices by older signers.

It is not clear whether adults also regularize inconsistency in languages, but there is some indication that they might. Adult learners have difficulty with paradigmatic variation, such as verb conjugation classes and noun classes, and the result of their learning is often a reduction in the number of classes. For instance, Klein and Perdue (1993) described an adult learner of German (which has three noun gender classes, each taking different adjective and article forms) who always uses the same definite and indefinite articles, regardless of the class of the noun.[7] (Despite this levelling of the German paradigm, his language still contains the typical L2 inconsistency; he often produces nouns without determiners.) Although this example involves regularization of *consistent* variation, it suggests that adults may also regularize complex inconsistent variability.

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[6]There was one class of morphemes in this work that Simon did not fully regularize: the classifiers. These morphemes form a highly complex system in ASL, one that is learned quite late even by children with normal input. Singleton and Newport (2004; see also Ross & Newport, 1996) suggested that this likely made it more difficult for Simon to extract even the probabilistic regularities of his input. Nonetheless, even here Simon produced these morphemes more consistently than his parents did.

[7]Of interest is the fact that this learner's native language, Italian, also has articles that differ according to the gender class of the noun, a fact that does not seem to help him in learning German.

There is also evidence from learning in nonlinguistic domains. A relevant line of research comes from studies of probability learning, conducted in the 1950s to 1970s. The aim of this work was to investigate the learning of probabilistic information. For example, participants are asked to watch two lights that flash one at a time. The participant's job is to predict which of the two lights will flash before each trial. Which light actually flashes is probabilistically determined by a counter designed to keep the overall probability within a predetermined range. For instance, in a 70/30 experiment, Light A flashes 70% of the time, and Light B flashes 30% of the time. Using this basic paradigm, participants are exposed to different ratios, as well as to variations in the intervals over which the ratios apply.

The results from most experiments in this literature show that, after very little exposure time, adults' predictions begin to match the exposure probabilities. That is, in the 70/30 example, participants predict that Light A will flash 70% of the time and that Light B will flash 30% of the time (Estes, 1964, 1976). This kind of response pattern is called *probability-matching*. However, some kinds of probabilistic exposure produce more regular behaviors in adult participants. If the system is complex enough, learners may not learn the system veridically but instead will behave as if the system is more regular than it really is (e.g., Gardner, 1957; Weir, 1964). For instance, Gardner found that adults *overmatched* when presented with three as opposed to two lights. That is, following the previous example, if Light A flashes 70% of the time, and Lights B and C each flash 15% of the time, participants guess Light A more than 70% of the time. In a similar experiment, Weir found that half of the adults he tested *maximized*, selecting the more frequent alternative at least 90% of the time.

Similar studies with young children suggest that they may be more likely than adults to regularize probabilistic input (Bever, 1982; Craig & Myers, 1963; Goldowsky, 1995; Stevenson & Weir, 1959; Stevenson & Zigler, 1958; Weir, 1964). Sometimes this regularization involves overmatching or maximizing (Bever, 1982; Stevenson & Weir, 1959; Weir, 1964). In other cases, children seem to impose their own invented patterns on the input (Craig & Myers, 1963; Goldowsky, 1995). Exactly what leads children to maximize versus impose their own patterns is not well understood. The important point, however, is that children do not always learn probabilistic patterns veridically. Instead, their predictions in probability learning tasks sometimes suggest more highly structured representations of probabilistic input.

The studies of language learning suggest that both adults and children may regularize inconsistency present in the input. The probability-learning studies, however, suggest that the tendency to do this might be greater in children than in adults and that different kinds or amounts of inconsistency might lead to different learning outcomes. On the basis of what is currently known, then, it is not clear how regularization might happen in creole languages.

THE PRESENT STUDIES

In a series of miniature language experiments, we attempt to address some of these questions by examining how adult and child learners acquire various types of inconsistent linguistic input in an artificial language. We are particularly interested in participants' treatment of the inconsistencies in the languages: Do they learn the variable items veridically, or do they change the language as they learn it, making it more consistent? In Experiment 1 we begin with adult learners, examining the effects of different amounts of variability, as well as manipulating the meaning of the inconsistent item. In Experiment 2 we present a simplified version of the same manipulations, comparing adult learners to child learners, to ask whether children provide a special contribution to regularization.

Obviously there are many differences between a naturally occurring pidgin–creole genesis situation and an experiment conducted in the lab. Although miniature language experiments of course do not include all of the many properties of natural language acquisition, they do allow us to control the amount and type of variability in input quite precisely and thus to evaluate the contributions of these variables to the process of regularization. In the discussion we return to consider how the outcomes of experiments like ours relate to natural situations of language formation and change, and what they can contribute to our understanding of the processes involved in language acquisition more generally.

EXPERIMENT 1

Earlier we reviewed evidence that adults may, under certain circumstances, regularize inconsistency. There is also reason to believe that, in many situations where creoles have emerged, most learners of the language in the early stages were adults (cf. Arends, 1993; Lefebvre & Lumsden, 1989; Singler, 1995). Adult learners thus have the potential to be responsible for regularization in many cases of creole formation. In this first experiment we ask whether adult learners will regularize the kind of inconsistency present in incipient creole languages.

The answer of course might not be simple: It might depend on the nature of both the language and the variability, as well as on the amount of variation presented. With this in mind, we manipulated both the amount of variability present in the input and the meaning of the variable item. These variables were manipulated independently. We exposed participants to a miniature language in which all the elements displayed regular properties, except the determiners. We manipulated the consistency of the determiners by having them occur with nouns only sometimes; otherwise the nouns appeared with no determiner. We manipulated the proportion of occurrences in which the nouns appeared with determiners (amount of inconsistency) as well as the way in which determiners were assigned to nouns (meaning of

inconsistent item). After exposure, we tested participants to see what they had learned, using production and judgment tasks focused on eliciting knowledge of the variable items (the determiners) to assess whether learners had regularized the inconsistencies present in the input.

Method

Participants

Forty-three native English speakers participated in the experiment. All were students at the University of Rochester. Data are reported for 40 of these participants. Two participants did not complete the experiment, and the data from one participant was unscorable because he made up his own novel words when tested. Of the 40 participants, 22 were women and 18 were men. Their mean age was 22.7 years. All participants, then, were well beyond the critical period for language acquisition (Johnson & Newport, 1989; Lenneberg, 1967). Participants were run and tested individually. They were paid daily for their participation and received a bonus on completion of the experiment. Participants were randomly assigned to one of eight experimental conditions, with five in each condition.

Description of the Language

The language contains 51 words: 36 nouns, 7 intransitive verbs, 5 transitive verbs, 1 negative (neg), and 2 determiners (det), 1 for each of 2 noun classes. The language was created in conjunction with a small world of objects and actions, whose permissible combinations restricted the number of possible sentences. Even with these semantic restrictions there are over 13,200 possible sentences in the language. The grammatical structure of the language is shown in Figure 1. The basic word order is (neg)V–S–O. When they occur, the determiners follow the nouns within the noun phrases (NPs). This basic structure permits four possible sentence types: intransitive, transitive, negative intransitive, and negative transitive.

All aspects of the language were consistent and regular, except the appearance of determiners within the NPs. Determiners occurred probabilistically; the percentage of NPs with determiners varied across input conditions (45%, 60%, 75%, and 100%, described later).

The nature of the experimental manipulation influenced our decision to use a V–S–O language. Because the crucial manipulation occurs in the NP, we wanted a

$$S \longrightarrow (\text{NEG})\ V + NP_{Subj} + (NP_{Obj})$$
$$NP \xrightarrow[NC1/mass]{} N + DET_1$$
$$NP \xrightarrow[NC2/count]{} N + DET_2$$

FIGURE 1 Grammatical structure of the language.

simple testing task that would reliably elicit NPs from participants. A V–S–O word order could be used easily with a sentence completion task, in which the participant is given a verb and is asked to complete the sentence. The postnominal location of determiners within the NP was chosen according to what is typical for V–S–O languages (Greenberg, 1963).

The nouns were divided into two classes. To evaluate the effect of meaning on the learning of the inconsistency, the basis for noun class membership differed between experimental conditions. In the *gender* condition, nouns were assigned to classes on an arbitrary basis, with 20 nouns in Class 1 and the remaining 16 nouns in Class 2. In the *count/mass* condition, count nouns were in one class and mass nouns were in the other. Nine nouns were mass nouns and the remaining 27 were count nouns. The only grammatical consequence of noun class membership in the language (for both gender and count/mass conditions) is determiner selection: Each class of nouns takes a different determiner. Although in both conditions the two determiners thus function primarily as nominal agreement markers, in the count/mass condition they contain more concrete semantic reference than in the gender condition (in which they carry no meaning features). A word list and gloss for each word is presented in Appendix A. The exact nature of the linguistic input received by a participant varied according to consistency condition assignment, which is described in detail in the Experimental Manipulation section later.

Presentation

Participants were told that they would be exposed to a language without instruction and that their task was to try to learn the language from the example sentences they would hear. They were asked to pretend that they had been shipwrecked on an island and needed to learn the local language in order to survive. They were informed that they would have to make up their own sentences at the end of the experiment.

Participants were exposed to the language by videotape for six sessions, each lasting 25 to 29 min. All presentation of the language was auditory. Participants were seated in front of a video monitor on which they watched a scene or event. They then heard a sentence in the miniature language that described the scene. Sentences were spoken at a normal rate with English prosody and phonology; as a result, they sounded very natural and fluent. There was no explicit instruction in grammar or vocabulary: Participants were required to learn the language solely from the auditory exposure to the sentences. For example, a participant in the count/mass condition would see a plastic bowling ball hitting a bowling pin and would hear the following:

(1) /flɪm rʊŋmawt po blɛrgənfal po/
hit bowling-ball det2 bowling-pin det2
‘The bowling ball hits the bowling pin.’

The exposure set contained 230 sentences and their corresponding visual scenes. Half the exposure set sentences were intransitive, half were transitive. Due to the particular meanings of the intransitive verbs in the language, the number of possible (i.e., semantically plausible) intransitive sentences is smaller than the number of possible transitive sentences. Each intransitive verb occurred 15 to 18 times in the115 intransitive sentences. Each transitive verb occurred 14 to 27 times in the 115 transitive sentences. Each verb was presented either in both negative and positive sentences, or in only positive sentences; no verb was presented in only negative sentences. The negative sentences were included to help the participants learn the meaning of the verbs, especially the intransitives, as well as to expand the number of possible sentences in the language.

Each noun in the language occurred three to four times in the 115 intransitive sentences and three to four times in each syntactic position (subject and object) in the 115 transitive sentences. Each noun could appear in both positive and negative sentences or only in positive sentences; no noun appeared in only negative sentences. Overall, there were relatively few negative sentences in the presentation set—7 transitives and 43 intransitives.[8]

The sentences in the exposure set were clustered into groups of 2 to 10 scenes based on a similar theme (e.g., color or size). Sets were constructed to minimally vary features of meaning from one scene to the next. This was intended to aid participants in extracting the meanings of individual words.[9] Each exposure session contained a different set of approximately 115 sentences drawn from the exposure set. The intransitive and transitive sentences were divided into approximate halves. Each exposure session consisted of two of these "halves," not necessarily of the same transitivity. Each half, and thus each sentence (and scene), was presented three times over the course of the six exposure sessions. The first session consisted of both intransitive halves. The second session consisted of both transitive halves. The remaining sessions consisted of a mixture of transitive and intransitive sentences. Participants were asked to repeat each sentence after hearing it; they were told that this was pronunciation practice that would be helpful because they would have to produce their own sentences at the end of the experiment. The entire experiment took seven sessions to complete (the six exposure sessions and one test session). The sessions were scheduled over 7 to 10 days, depending on the participant's availability.

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[8]As noted, the negative sentences were included to expand the number of possible sentences, especially for verbs that had few semantically possible positive sentences. There was a much larger number of possible positive transitive sentences, so this means of expanding the presentation set was used primarily for the intransitives.

[9]Most sets presented scenes ordered so that only one feature of the meaning changed from one scene to the next—for example, a blue object, followed by a nonblue object, followed by a blue object, followed by another nonblue object. In this example, the noun changes from one sentence to the next, but the verb does not. Other clusters were more complex; both the noun and the verb could differ between contiguous sentences, for example, the car is small, the bowling pin is big, the wooden block is small, the hammer is big, the rocking horse is small, the boat is big.

Experimental Manipulation

All participants were exposed to the same basic sentences. Input sentences differed across conditions only in the use of the determiners. One contrast across conditions was in the meaning of the determiners. As described previously, half the participants were exposed to a language in which the nouns were divided into two classes, each of which took a different determiner, on the basis of meaning (count/mass nouns). The other half were exposed to a language in which the nouns were divided into two classes in an arbitrary fashion (gender condition).

Within each meaning condition, participants were further divided into four conditions based on the frequency or consistency of use of determiners within the input sentences. Sentences varied in the occurrence versus nonoccurrence of the determiners; participants were exposed to a particular mixture of sentences with and without determiners.[10] Although there are other ways in which one might instantiate grammatical variability (see Hudson Kam & Newport, 2005, for experiments investigating other such manipulations), this type of variation is characteristic of late learners' speech when the target language is not morphologically complex, such as English, French, or Portuguese, the lexifiers of most spoken creole languages. Thus this type of variation is likely to have been present in the early stages of many creoles (cf. Becker & Veenstra, 2003, for evidence that there was inconsistent use and omission of inflectional morphemes in the early stages of French-lexified creoles, which later changed to encode meaningful distinctions). Participants in the *low* input group heard nouns with determiners 45% of the time; 55% of the nouns in their input occurred with no determiner. Participants in the *mid* input group were exposed to determiners 60% of the time. Participants in the *high* input group heard determiners 75% of the time. Participants in the *perfect* input group served as controls and were exposed to perfectly consistent and invariant use of determiners. All other parts of the grammar were the same, and completely consistent, in all four input groups.

In order to observe the learning of truly variable usage, it was important to assure that there were no conditioning contexts associated with the appearance or omission of determiners. The occurrence percentages for each condition (45%, 60%, 75%, and 100%) were therefore imposed not only for determiner usage across noun phrases overall but also were maintained for determiner usage in each session, in each sentence type, and in each of the three syntactic positions. For example, in the presentation set of the low input group, 45% of intransitive subjects,

[10]In these experiments, where determiners were either present or absent, variation in the consistency of use of determiners was identical with variation in the frequency of appearance of the determiners. In forthcoming work (Hudson Kam & Newport, 2005), we manipulated consistency of grammatical context for determiners, independently of their frequency of use, and showed that it is consistency, not merely frequency, to which learners are sensitive. For this reason we use the term *consistency* in this article, even though the manipulation also involved frequency.

transitive subjects, and transitive objects occurred with determiners, and this was true for each exposure session. However, these occurrence percentages were not precisely the same for each noun; individual nouns occurred with determiners within a range centered around the condition percentage. For example, for the low input group, the percentage of determiner occurrence for any particular noun ranged from 33% to 55% (averaging to 45%). (The percentages of determiner occurrence for each noun at the three inconsistent input levels are given in Appendix B. The fourth input group received completely consistent input so there was no variation across individual nouns.) The particular sentences with missing determiners were selected randomly.[11] Importantly, each presentation of a particular sentence had the potential to be different from the other two, so that there was no pattern of determiner omission available to be learned from the input data.[12]

The four input consistency levels combine with the two meaning conditions to produce a 2 × 4 experimental design, resulting in eight different conditions, with 5 participants in each condition.

Although we are actually varying frequency of occurrence, we are calling this variation in *consistency.* Our thinking is that a form which is used 75% of the time is more predictable than one which is used 45% of the time and thus is more consistent. There are other ways of operationalizing consistency (and in future experiments we have used other kinds of consistency), but this is the kind of variation that is most typical of late-learned speech when the target language is not morphologically complex, as is the case with languages like English, French, or Portuguese, the lexifiers of most spoken creole languages. Thus, this kind of variation is the most likely to have been present in the early stages of many actual creoles.

Tests

Participants were given four different tests to evaluate their performance. One test examined participants' knowledge of the vocabulary of the language and served as a criterion for their ability to take certain other tests. One test examined participants' knowledge of the general structure of the language, focusing on the consistent aspects of the language. Two tests examined their knowledge of the inconsistent parts of the language (the determiners). Tests were given in the order in which they are described later.

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[11]This was not random for each group individually. The 75% input condition was created first, by randomly removing determiners, then additional determiners were randomly removed to create the 60% input group, and finally, more determiners were randomly removed to create the 45% input set. Thus any sentences missing determiners in the 75% input set were also missing determiners in the 60% and 45% conditions. Each input set is a strict subset of the next larger set.

[12]Thus a particular transitive sentence could appear with two determiners, with a determiner in the subject NP, the object NP, or no determiner.

Vocabulary. A vocabulary test was given twice. The first vocabulary test was administered after participants watched the videotape in the fourth session. In this task, participants were tested on their knowledge of 12 vocabulary items. Participants were told that this test was designed to give them some idea of how they were doing up to this point—that it was for their own benefit. Participants were asked to provide a name for each object as it appeared on a video monitor and were given as much time as they wanted to respond. All responses were videotaped, but (in accord with the instructions) the results were not analyzed.

A second vocabulary test was used to evaluate whether participants had learned enough vocabulary to be tested on more complex aspects of the language and was administered with the other tests in the final session. Participants were tested on the same 12 items as in the first vocabulary test, but the order in which the items appeared was different.[13] Presentation and recording were the same as in the first vocabulary test.

Sentence completion task. The second test was a sentence completion task. Participants were given this task only if they achieved a score of at least 5/12 on the second vocabulary test. This task was designed to evaluate participants' own production of determiners, as compared with the inconsistent appearance of determiners in their input. Participants saw a scene and heard the first word of the corresponding sentence. They were then asked to produce the complete sentence and were given as much time as they needed to provide an answer. For example, a participant sees a piece of cotton fall and hears the word /gɛrn/'fall'. She should then say /gɛrn kowɑlt kɑ /'fall cotton det'. Because the language is V–S–O, participants were always given the verb and were to produce the whole sentence, including the NPs (the part of the language containing the inconsistency). There were 24 test sentences (12 transitive and 12 intransitive), resulting in 36 possible NPs and therefore 36 possible determiners. Participants were first tested on the transitive sentences and then on the intransitives. The set of test sentences was designed so that 12 nouns each appeared once in each possible syntactic position (intransitive subject, transitive subject, and transitive object). The first use of the individual noun varied between subject and object position in the transitive sentences; some nouns were first used as subjects and others as objects. The test sentences included all seven intransitive verbs and four of the five transitive verbs.[14] Participants were

[13]We used the same nouns twice for one main reason: These are the nouns required to complete the sentences in the production task, and we wanted to direct attention to them in an implicit way. When participants were later asked if they realized that they had been tested on the same nouns twice, only a few said yes. Several participants commented during the second test that they would have performed better on the first if it had contained the nouns in the second test, suggesting that indeed they did not notice the repetition.

[14]The transitive verb /smɪt/'be beside' was not included in the test sentences due to its meaning. Either noun can legitimately function as the subject of /smɪt/, because if the boat is beside the box, the box is also beside the boat. This property of /smɪt/ made it undesirable as a test verb given that we wanted to control the identity of the subject and object nouns in each test sentence.

instructed to indicate where a word they could not recall should go in the sentence, for instance, by stating "another word goes here." This allowed us to include the data from incomplete responses. Responses were videotaped and later transcribed for analysis. All sentences used in this and other tests were novel to the participants and were not part of the exposure set.

Grammaticality judgment task. The third test was a grammaticality judgment task that also examined participants' knowledge of determiner usage, but through judgment rather than production. Unlike the sentence completion task, all participants performed this task, regardless of their score on the second vocabulary test. Participants were asked to listen to 36 sentences one by one and judge each of them on a 4-point scale according to how much they "liked" or "disliked" the sentence. Participants were instructed to respond that they really liked a sentence when it sounded like a sentence from the language that they had been learning and to respond that they really disliked a sentence when it sounded completely unlike a sentence from the language. They were also told that if they thought a sentence was mostly, but not completely, like or unlike sentences from the language, they should use the middle of the scale.[15]

The 36 test sentences consisted of three variations of 12 base sentences. One form of each sentence was correct, one had the determiner in the wrong location (preceding the noun), and one had no determiner at all. The sentences were randomly ordered, with the constraint that two versions of the same base sentence could not follow each other. The three variations of one base sentence can be seen in Example 2:

(2) a. /gɛrn fɛrluka po/ (correct: det follows noun)
'fall girl det'
b. /gɛrn po fɛrluka/ (incorrect: det precedes noun)
'fall det girl'
c. /gɛrn fɛrluka/ (incorrect: no det)
'fall girl'

Four of the 12 base sentences varied the determiner occurring with a transitive subject, 4 varied the determiner occurring with a transitive object, and 4 were intransitive. Sentences were presented by audio tape recorder, and responses were recorded by the experimenter. Participants had 3 sec in which to respond to each test item. Again, all sentences were novel.

Forced choice grammar test. The fourth test, also a grammaticality judgment task, examined what participants had learned about the rest of the language. All participants completed this test regardless of their score on the second vocabu-

[15]Participants actually responded by pointing to one of four different "happy" or "sad" faces. This allowed us to use the same general method with children in subsequent studies.

lary test. In this task, participants listened to 16 pairs of sentences and were asked to select the sentence from each pair that sounded most like a sentence from the language that they had been learning. The two sentences in each pair were versions of the same sentence, one grammatical, the other ungrammatical. Participants listened to the sentences on audiotape and circled 1 or 2 on an answer sheet, depending on whether they preferred the first or second sentence in the pair. Half of the sentence pairs tested participants' knowledge of verb subcategorization, that is, whether they knew that transitive verbs required two nouns and intransitives only one. The remaining sentence pairs tested whether participants knew that a verb was required in every sentence. These rules of the grammar were tested for both transitive and intransitive sentences. For transitive sentences with missing arguments, either the subject or the object could be the missing argument. Which sentence (first or second) in the pair was grammatical was randomized, as was the ordering of sentence pairs in the test, with the constraint that no more than two sentences could occur in a row that tested the same rule and were of the same valence. There was a 1-sec pause between the two sentences that formed a pair and a 5-sec pause between pairs. Pairs were not identified as such, except by the occurrence of the longer pause. All sentences were novel; none appeared in the exposure set.

Results

Vocabulary

In accord with the instructions given to participants, the results of the first vocabulary test were not tabulated. The results from the second vocabulary test were examined and, as described, were used as a criterion for deciding whether or not a participant would be given all (or only some) of the remaining tests. Thirty-seven participants produced at least 5 correct vocabulary items (out of a possible 12) and so were given all other tests. Due to their low vocabulary scores, the other 3 participants were not given the sentence completion task (because results on this test would not be interpretable if participants could not produce the relevant nouns) but were given the two grammaticality judgment tasks. Two of the participants who did not achieve this criterion were in the count/mass meaning condition; one was in the high consistency condition, the other the mid consistency condition. The third participant who did not achieve criterion was in the gender condition, mid consistency.

Forced-Choice Grammar Test

This test examined participants' knowledge of parts of the grammar other than determiners. We conducted this test to ensure that learners in all conditions successfully acquired those parts of the grammar represented consistently in the input. This test examined participants' knowledge of sentence construction (i.e., did they know that a verb is required in every sentence) and verb subcategorization (did

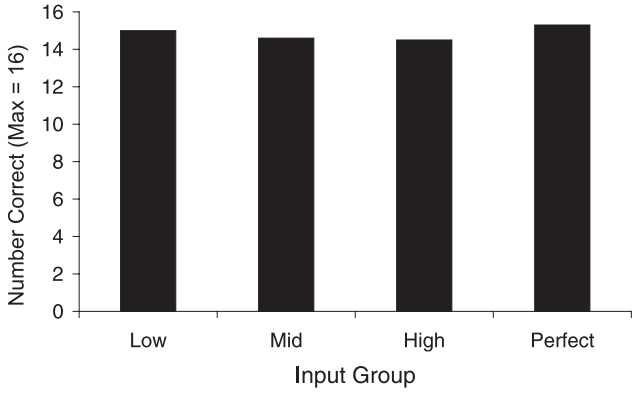

FIGURE 2 Mean scores for general grammar test by input level.

they know that one set of verbs is transitive, requiring two nouns, and another intransitive, requiring only one noun). Figure 2 shows the mean scores on this test for participants in each of the four input conditions. The mean overall score was 14.85 correct out of a possible 16 (SD = 1.49). This was significantly and substantially higher than chance, $t(39) = 28.99$, $p < .001$. There was no significant effect of meaning condition or input consistency. Participants' knowledge of these facets of the language was thus unaffected by the quality and consistency of their determiner input.

Sentence Completion Task

The results of this test were of primary interest. It permitted us to observe the effect of consistency of linguistic input on the production of determiners. Our main question was whether participants reproduced the inconsistency of determiners present in their input or regularized the inconsistency to which they were exposed. For each participant we computed the percentage of determiner production (the number of correct determiners used by the participant, divided by the number of possible determiner usages, multiplied by 100). The number of possible determiner usages was simply the number of correct nouns produced by the participant in this task. Figure 3 shows the mean percentage of correct determiner production for the four input groups, across the two meaning conditions (solid lines). For comparison, the dashed line shows the percentage of determiners present in the input.

Figure 3 shows that, as the consistency of determiners in the input increased, participants' production of determiners also increased—the more determiners they heard, the more they produced. This effect of input level was significant, $F(3, 29) = 19.06$, $p < .0001$. In fact, the mean percentage of determiners produced by participants was very close to the level present in their input. This did not differ with the meaning of the inconsistent item: There was no significant difference in the num-

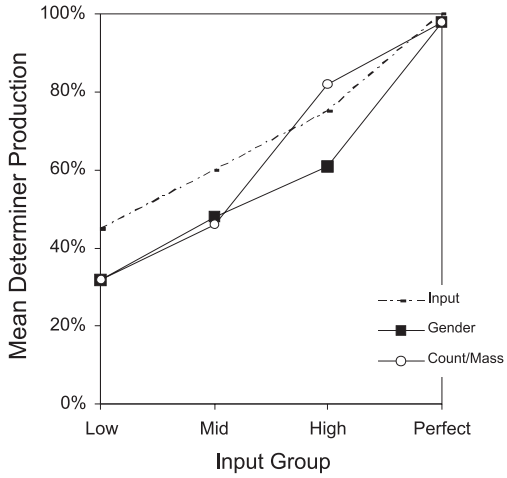

FIGURE 3 Mean percentage of nouns produced with determiners by input level and meaning condition.

ber of determiners produced by participants in the count/mass condition versus the gender condition. The interaction between the two factors, meaning and level of consistency, was also not significant. Because there was no effect of meaning and no significant interaction henceforth the data will be reported for the two meaning groups combined.

However, this pattern of performance does not necessarily indicate probability matching rather than rule formation or regularization. The group means could perhaps be an average across individuals who each formed regular rules. We thus examined the consistency of production among individual participants.

One type of rule participants could have imposed would be to produce determiners categorically, either all or none of the time. (The significant effect of input level in our data would in this case result from a changing proportion of participants using all versus none.) To examine this, we categorized participants as exhibiting a categorical rule when they showed determiner use at or below 10% (categorical no-determiner rule) or determiner use at or above 90% (categorical use of determiners). We found 6 participants (out of 37) who appeared to have created one of these rules. Four participants adopted a no-det rule. These 4 used determiners 10%, 3%, 0%, and 9% of the time. They were distributed among the consistency conditions: one in the high consistency condition, two in the mid consistency condition, and one in the low consistency condition. Two participants used determiners categorically, at 93% and 100%. These 2 participants were both in the high consistency condition. However, most participants (31 out of 37) did not qualify as exhibiting either categorical rule.

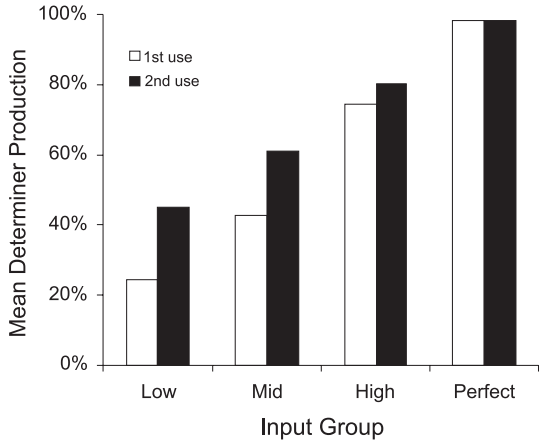

FIGURE 4 Mean determiner use for first and second mentions of nouns by input level.

There are other types of rules that participants could have formed. The test was designed so that all 12 nouns appeared once in each syntactic context, for a total of three appearances each. This enabled us to see whether participants had imposed more complex rules on the determiners, for example, using them to encode a definite–indefinite distinction, as in English. We examined participants' determiner productions in the first versus second mentions of a particular noun over the test, which loosely corresponds to the English usage of indefinite and definite determiners, respectively. Because half the nouns were first used as subjects and half were first used as objects, we could examine the production of determiners for first and second mention independent of syntactic position of the noun. Figure 4 shows the mean determiner use for first and second mentions for the four input groups. We found that participants used determiners significantly more often the second time they used a particular noun than the first, $F(1, 29) = 11.08$, $p < .002$.[16] There was no significant difference between the productions of the participants in the two meaning groups and no significant interaction between meaning and mention. As is evident in Figure 4, the magnitude of the difference in determiner production for first and second mentions increased as consistency of input decreased, $F_{\text{linear}}(1, 29) = 6.21$, $p < .019$. That is, participants exposed to fewer determiners were more likely to produce more determiners the second time they produced a noun (compared to the first time) than participants exposed to more consistent input. Partici-

[16]Due to the way the test was administered, the transitive and intransitive sentences were in separate sets. This makes it difficult to compare first usage (which was always in a transitive sentence) to all subsequent uses (in both transitive and intransitive sentences). If all first uses were in the same syntactic position this would be problematic. However, as mentioned in the description of the tests, the first use of a noun varied between being a subject and an object.

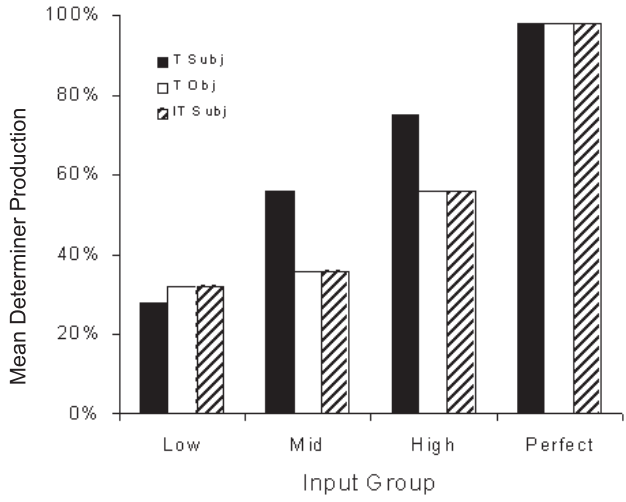

FIGURE 5 Mean determiner production by syntactic position and input level.

pants in the high input condition showed little difference in determiner usage by noun mention (only 5.6%), whereas participants in the low input condition used 20.7% more determiners with second mentions than first mentions. Interestingly, however, production percentages for second mentions, although higher than those for first mentions, are not categorical but instead are quite close to the percentages of determiners present overall in participants' input. The mean percentage of determiners produced with second mention nouns for the four input groups were, from low to perfect: 45%, 61%, 80%, and 98%.

We also asked whether there was evidence of a case-like system in the participants' productions, that is, whether they used the determiners selectively with subject or object NPs. As shown in Figure 5, participants did not use determiners significantly differently with subjects than with objects. However, there was a marginally significant tendency to use determiners more frequently with transitive subjects than with NPs in other syntactic positions, $F(1, 29) = 4.06$, $p < .053$. This pattern was not evident in the low or perfect conditions, only in the mid and high input conditions. Even in transitive subject NPs, however, determiners were not used categorically but were used with about the same percentages as in the input overall. This is very much like the trend found in the first- versus second-mention data discussed previously.

These analyses depend on all participants having formed the same kinds of rules over the data. However, it is possible that each participant formed her own rule and produced determiners in a systematic way but different from the other learners such that the patterns were hidden in the overall analyses. To investigate

TABLE 1
Percentage of Participants in Each Production Systematicity Category by Input Group

	Production Type		
Input Group	*Systematic User*	*Systematic Non-User*	*Variable User*
100	100.0	0.0	0.0
75	11.1	11.1	77.8
60	0.0	25.0	75.0
45	0.0	0.0	100.0

this, we examined each participant's productions for evidence of patterns in her speech and then classified the participant according to the presence or absence of a pattern. There were two subtypes of patterned or systematic use of determiners. *Systematic user* includes participants who used determiners with all NPs. *Systematic non-user* includes participants who used no determiners at all.[17] Participants who used determiners variably, without a systematic pattern but like the inconsistent input we provided, were classified as *Variable users*. Table 1 shows the percentage of participants in each of the four input percentage groups who fell into these three categories. The data in this table confirm the overall analyses: Only those exposed to perfect consistency produce it; those exposed to variable input almost always produce variability.

In summary, participants generally used determiners in their productions about as often as they heard them in the input, although a few participants did show evidence of having imposed more categorical rules on their determiner systems. Although the input had no categorical or probabilistic patterns involving any kind of subregularities, participants used determiners less often the first time they used a noun and more often the second time. There was also a slight tendency for participants to use determiners more often with transitive subjects than with other NPs.

Grammaticality Judgment Task

This task was designed to assess participants' knowledge of the determiner system of the language through grammaticality judgments. The use of grammaticality judgments was intended to remove constraints imposed by the production system and permit a different view of the participants' grammars. It is possible that the variability seen in the production task was due to something other than variable grammatical knowledge. If participants had internalized a categorical rule, they

[17]Participants were allowed one exception to their pattern. For instance, several participants used the determiner only with the noun /fʌmpogʌ/'bird', suggesting that they may have been treating it as part of the noun form itself. These participants were nevertheless categorized as non-users on the basis of the rest of their productions.

should make categorical judgments. In contrast, if participants' internalized rules are variable and dependent on the degree of consistency present in their input, then their judgments should also vary according to their input. Like the production task, the judgment task was designed to allow for the possibility that participants might have internalized a case-based det rule. This would show up as different judgments for nouns in different syntactic positions.

Responses were divided according to the particular form of the determiner manipulation (no determiner, determiner preceding the noun, determiner in correct location), as well as by the syntactic position of the NP in which the determiner manipulation occurred (subject of transitive, object of transitive, intransitive). Figure 6 shows the mean ratings given by participants in each input group for each type of determiner manipulation, on a scale of 1 (*disliked*) to 4 (*liked*). The main effects of input consistency level and meaning condition were not significant, and neither was the interaction between these two. A significant main effect of determiner manipulation, $F(2, 64) = 246.89$, $p < .0001$, is qualified by a significant interaction between input consistency and determiner manipulation, $F(6, 64) = 9.38$, $p < .0001$. These results reflect the fact that participants in all four input groups liked correct sentences and disliked sentences with misplaced determiners but differed in their ratings of sentences with missing determiners. In accord with the production results, they rated these sentences more highly as the proportion of sentences lacking determiners in the input increased, $F_{\text{linear}}(1, 38) = 17.41$, $p < .0001$. Moreover, planned contrasts reveal that participants whose input contained a higher proportion of sentences with than without determiners rated sentences with determiners higher than those without determiners: perfect input group, $F(1, 9) =$

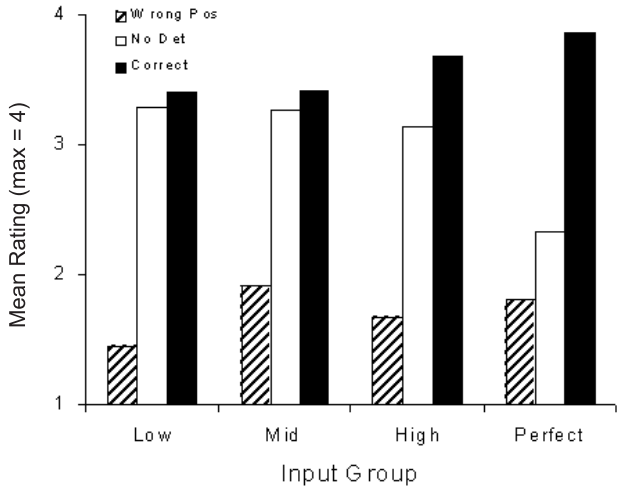

FIGURE 6 Mean sentence ratings by determiner manipulation and input level.

104.18, $p < .0001$; high input group, $F(1, 9) = 14.71$, $p < .004$. In contrast, when the input contained similar ratios of sentences with and without determiners (as in the mid and low input conditions), participants did not reliably distinguish the two types of sentences.

The design of the test also allowed us to see whether participants had imposed a case-like rule on their determiner systems. Similar to the production data, we found that participants had a tendency to rate determiner manipulations in intransitive subjects and transitive objects higher than manipulations involving transitive subjects: intransitive subject $M = 2.8$, $SD = .46$; transitive object $M = 2.83$, $SD = .42$; transitive subject $M = 2.67$, $SD = .40$; post-hoc contrast of mean of intransitive subject and transitive object versus transitive subject mean, $F(1, 32) = 279.67$, $p < .0001$. However, there was a significant three-way interaction between input level, syntactic position, and determiner manipulation, $F(12, 128) = 1.91$, $p < .038$, reflecting the fact that there was no consistent pattern in participants' judgments for subjects and objects overall.

Overall, then, participants preferred the sentence types that they had heard most often in their input. This preference was not categorical, however. Participants readily accepted sentences which lacked a determiner if they had heard such sentences in their input. Ratings of sentences with missing determiners increased as the proportion of such sentences in the input increased. In addition, there were effects of the syntactic position of the noun, although these did not show a consistent pattern.

Discussion

The results of this experiment indicate that adults are able to learn the unpredictable variation characteristic of a pidgin or a creole in its earliest stages. That is, they can learn and reproduce the amount and type of variation that is present in their input, but they do not regularize the language as they learn it. This result appears in the data from both the production and the judgment tasks. This in turn indicates that adults may not be responsible for regularizing creole languages, at least not if the variability they contain in their early stages is like the variation we presented to participants in this experiment. This of course raises the question of how pidgin languages do become regularized. One possibility is that children, not adults, are responsible for regularizing creole languages. This is the focus of Experiment 2.

EXPERIMENT 2

We know from the studies conducted by Newport and her colleagues that children exposed to inconsistent input end up with a grammar that is much more consistent than their input (Newport, 1999; Ross, 2001; Singleton & Newport, 2004), something not done by the adults in Experiment 1. Studies of probability

learning also indicate that children are more likely than adults to sharpen their response patterns and are less likely than adults to produce probabilistic output in response to probabilistic input (e.g., Goldowsky, 1995; Weir, 1964). Experiment 2 directly explores whether children regularize more than adults when learning inconsistent languages. To test this, we compared children and adults in a simplified version of Experiment 1. In particular, we exposed child and adult learners to a miniature artificial language that contained inconsistency and then tested them to see what they had learned about the consistent and inconsistent parts of the language.

Method

Participants

Nineteen children and eight adults participated in the study. Four of the children failed to learn enough words to produce any sentences and so did not complete the study. No adults failed to learn enough to complete the study. The mean age of the children who completed the study was 6;4.10. Mean age of the adult participants was 20;1.15.

Child participants were recruited through local daycares and preschools. Most received a small toy at the end of each session.[18] Adult participants were students at either the University of Rochester or University of California, Berkeley, at the time of the study. They were paid daily for their participation and received a bonus on completion of the experiment.

Description of the Language

The language contains 17 words: 4 verbs, 12 nouns, and 1 determiner.[19] Unlike the language in Experiment 1, there is only one noun class and therefore only one determiner. As in Experiment 1, all aspects of the language were consistent and regular, except for the appearance of the determiner within the NPs. The percentage of NPs with determiners varied across input conditions (100% and 60%, as described later). The vocabulary with glosses is listed in Appendix A (the words in bold). Although this is a larger vocabulary than is often used with children in artificial language experiments (see, e.g., Moeser & Olson, 1974, but see also Braine et al., 1990), it was learnable to some extent by almost all of the children. The lexicon was used in conjunction with a set of objects and actions that resulted in 99 semantically possible sentences. As in Experiment 1, the exposure set consisted of a subset of these, with some sentences reserved for testing.

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[18]This was against the policy of one of the centers.

[19]Pilot work suggested that the language used in Experiment 1 was too large for children to acquire in a reasonable time.

Presentation

Participants were typically run in groups of two or three. This allowed us to run numerous children at the same site within as short a time as possible.[20] However, as described later, all testing was done with participants individually.

The exposure set consisted of 12 intransitive sentences and 12 transitive sentences. Each of the 12 nouns appeared once in each syntactic position (intransitive subject, transitive subject, transitive object) in the exposure set. The intransitive sentences were split equally between the two intransitive verbs: six sentences were "fall" events, six were "move" events. The transitive sentences consisted of three "inside-of" events and nine "hit" events. This reflects the fact that there are more possible "hit" events than there are "inside of" events.

Pilot work suggested that the videotaped exposure used in Experiment 1 was ineffective for use with children, so in this experiment we used live exposure. Children also found it difficult to learn the vocabulary from the sentences, so we directly taught participants the vocabulary items. However, there was no explicit teaching of the grammatical aspects of the language.[21] Importantly, the same methods were used with the adult participants in this experiment as were used with the child participants.

There were six exposure sessions and a final test session, each of which lasted approximately 10 to 20 min. The seven sessions were completed over 9 days by all participants.

Exposure proceeded as follows: The experimenter began by explaining to the participants that she was going to teach them a new language called Sillyspeak; they would learn some new words for things and some new ways to say things. For the adults, exposure began at this point. For the children, the experimenter proceeded to chat for a few moments, explaining what it means to speak another language. To prevent them from asking her questions about the language, she told them that she herself did not know the language, that she was learning it with them. At this point, exposure began.

On the first day participants were taught the vocabulary, excluding the determiner. The vocabulary list was run through four times. Each run began with the four verbs. The experimenter said "if you want to say 'hit' in Sillyspeak you say /flɪm/," then the same thing for /prɑg/'inside of', /mɛrt/'move', and /gɛrn/'fall'. Participants were asked to repeat the Sillyspeak word after they heard it. Each of the verbs was accompanied by a gesture, and participants (especially the chil-

[20]The adults were always run with the same partner, and there were always only two people in the session. In contrast, the children were run in groups of two or three, and the composition of the groups sometimes changed from day to day. Occasionally a child was run by him or herself when another child at that site was absent.

[21]The children did frequently ask questions about the language. When this happened, the experimenter reminded the children that she did not speak the language and so could not answer their questions.

dren) often repeated the gestures also, although they were not explicitly asked to do so. After running through the four verbs, they were taught the nouns. On the first run through the nouns, participants were shown a toy and asked to name it and were corrected if required. This was done to ensure that they were encoding the intended meaning. The experimenter then told participants how to say the word in Sillyspeak. The nouns were presented without determiners during vocabulary learning.

Sentences were first introduced in the second session. This session began with a pass through the vocabulary. The experimenter then demonstrated how to "put words together" to "say bigger things" and presented the 12 intransitive sentences. She showed the participants a scene and then said the corresponding sentence out loud (read from a piece of paper on her lap). As with the vocabulary, participants were asked to repeat the sentence after hearing it. The session continued with a second run through the vocabulary, and then the 12 transitive sentences. The 3rd and 4th days proceeded in exactly the same way. Session 5 consisted of one pass through the vocabulary, one pass through the intransitives, one pass though the transitives, and a second pass through the intransitives. Session 6 consisted of one pass through the transitives, one through the intransitives, and a second through the transitives. This design allowed 12 passes through the vocabulary and 6 through each kind of sentence.

Occasionally participants had difficulty repeating the sentence. When this happened, the experimenter went through the sentence a second time. This was most common with the children, and was quite frequent the first few times they heard, and had to say, the sentences.[22] To keep them engaged, the children were allowed to help enact the some of the sentences.

Experimental Manipulation

All participants were exposed to the same basic sentences. Input sentences differed across conditions only in the use of determiners. There were two determiner conditions in this experiment: completely consistent (100%) and inconsistent (60%). As in Experiment 1, the inconsistent percentage was true for nouns overall; individual nouns occurred with the determiner within a range that averaged to 60%. The actual percentages for each noun are shown in Appendix B. Note that these percentages are true only of the nouns occurring within sentences; nouns were presented without determiners during vocabulary training.

[22]A second reading was also sometimes required due to inattention. The children were often run in rooms where there were other children and sometimes got distracted.

Tests

In the final session participants were given three tests to evaluate their performance. Two tests examined participants' knowledge of determiners. One test examined their knowledge of consistent aspects of the grammar of the language. Tests were given in the order in which they appear later. Testing always occurred individually.

Sentence completion task. This task was designed to elicit the production of noun phrases, the part of the sentence containing the inconsistency. As in Experiment 1, we used a sentence completion task to accomplish this. First, the participant was shown a series of toys and asked to name them. This continued until she had named five to seven objects or it became clear that she did not know any more, whichever came first. Objects that had been named became part of the participant's test set. Objects were selected (for showing) in two principled ways. First, the participant was always shown at least two of the three container objects (cup, barrel, and truck), because only these objects can be used with the verb /prɑg/'inside of'. Second, toys that had been remembered by previous participants were shown early. Often the participant would begin to spontaneously produce words she knew, and when they did this they were asked what the word meant. If the participant produced the correct English word or retrieved the correct object, the object was included in the test set.

Once a set of objects had been selected, the sentence completion task began. Using the objects the participant had named, she was shown an event or scene, and then told what the sentence should mean in English and what the first word of the corresponding Sillyspeak sentence was. For example, if the participant had correctly produced /blægʌ/'bear', the experimenter would wind the bear up (which made it move), put it down in front of the participant, and say "OK, I want you to tell me how to say 'the bear moves' in Sillyspeak. The first word would be /mɛrt/, right?" If the participant had difficulty, they were reminded that they had learned how to say things like "the bear falls" and "the rhinoceros moves" in Sillyspeak, but they were not reminded how to say these familiar sentences in Sillyspeak. The first few sentences were always intransitives. This allowed the children to gain confidence with the task before attempting the longer transitive sentences. Transitive and intransitive sentences were interspersed. The experimenter wrote down each response before moving on to the next sentence. A subset of participants was videotaped and their productions later coded for reliability by a research assistant who was blind to exposure condition. As in all tests, the test sentences were novel; they had not occurred in the exposure set.

Determiner judgment test. Participants listened to 18 sentences one-by-one and judged each of them on a 4-point scale, according to how much they liked or disliked the sentence, by pointing to one of four different faces ranging from

happy to sad. Participants were instructed to respond that they really liked a sentence (picking the happy face) when it sounded just like a Sillyspeak sentence and to respond that they really disliked a sentence (picking the sad face) when it sounded completely different from Sillyspeak. They were also told that if they thought a sentence was mostly, but not completely, like or unlike sentences from the language, they should use the middle of the scale (slightly happy and slightly sad faces). The task was begun only after the participant had given evidence that they understood it, either by telling the experimenter what the different faces meant in their own words or, when necessary, by rating some practice English sentences.

The 18 test sentences consisted of three variations on six base sentences. One version of the sentence was correct, one had the determiner in an incorrect location (preceding the noun), and one had no determiner at all. Two of the six base sentences varied the determiner occurring with a transitive subject, two varied the determiner occurring with a transitive object, and two were intransitive (therefore varying the determiner occurring with the subject). Sentences were presented by audio tape recorder, and the experimenter recorded responses on a response sheet. Participants had 4 sec in which to respond to each test item (occasionally participants were allowed a little extra time by pausing the tape player). The experimenter's eyes were shielded from view to prevent her from cuing the participant with her eye gaze. Again, the test sentences were novel; they had not occurred in the exposure set.

General grammar test. The third test examined what participants had learned about aspects of the language that were always represented consistently in the input. Specifically, it examined whether participants thought that sentences required verbs (sentence structure) and if they knew that some verbs (the transitives) require two nouns and others (the intransitives) allow only one noun (verb subcategorization). In this task, participants listened to 16 sentences and were asked to judge each using the same set of faces used in the previous task. The 16 sentences were actually two versions of each of 8 sentences, one grammatical and the other ungrammatical. The ungrammatical versions of the sentences testing sentence structure had no verb. The ungrammatical versions of the sentences testing verb subcategorization had an extra noun (intransitive verbs) or were missing a noun (transitives). All nouns occurred with determiners. Test sentences were randomized with the constraint that the two versions of the same base sentence could not follow each other. Sentences were played on an audio tape recorder, and the experimenter recorded the responses on a response sheet. As in the determiner manipulation judgment task, participants were given 4 sec in which to provide a rating, although sometimes the tape was paused to allow them to respond. Participants were reminded how to use the faces to respond before the test began. Again, all test sentences were novel; none appeared in the exposure set or the other judgment task.

Results

As in Experiment 1, results from the general grammar test are presented first, followed by the results from the determiner tests.

General Grammar Test

Table 2 shows the mean ratings given by child and adult participants to test strings in the various categories. The data were subjected to a repeated measures analysis of variance (ANOVA) with age group (adult vs. child) and determiner input type (consistent vs. inconsistent) as between-subjects factors and string correctness (right vs. wrong), rule type (verb required vs. number of arguments), and transitivity (intransitive vs. transitive) as within-subject factors. Correctness was significant, $F(1, 18) = 24.78$, $p < .001$, reflecting participants' tendency to give higher ratings to correct than to incorrect strings. Rule type was also significant, $F(1, 18) = 7.37$, $p = .014$, with participants giving higher ratings to sentences testing verb transitivity (argument number) than to those testing whether or not a verb was required in a sentence. However, there was a significant interaction between these two variables, $F(1, 18) = 8.22$, $p = .01$; although participants rated strings in

TABLE 2
Mean Ratings (Max = 4) for Grammatical (Right) and Ungrammatical (Wrong) Strings by Rule Type and Transitivity for Adult and Child Participants by Input Group

	Rule							
	Verb Required				*Number of Arguments*			
	Right		*Wrong*		*Right*		*Wrong*	
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Children								
100%								
Transitive	3.94	.06	3.19	.34	3.63	.31	2.75	.39
Intransitive	3.63	.25	3.44	.33	3.56	.18	2.88	.41
60%								
Transitive	3.17	.42	2.83	.49	3.00	.50	2.17	.40
Intransitive	3.33	.33	3.25	.36	3.25	.31	2.75	.42
Adults								
100%								
Transitive	3.88	.13	3.25	.25	4.00	.00	3.25	.14
Intransitive	3.75	.14	3.63	.38	4.00	.00	3.00	.00
60%								
Transitive	3.63	.38	3.25	.48	4.00	.00	2.25	.43
Intransitive	3.50	.29	3.63	.24	3.63	.13	2.25	.52

which the verb had the correct number of arguments higher than strings where the verb had the incorrect number of arguments, they did not do so reliably. The main effects of age group, input type, and transitivity were not significant, nor were any interactions with these variables. Thus all participants were able to learn the consistent parts of the language, regardless of age and determiner input type.

Production Task

Reliability. Agreement between the live transcriptions and those produced by a second coder (a research assistant blind to experimental condition) from the videotapes was 100%.

Production. Figure 7 shows the mean percentage production of determiners for all nouns for child and adult participants in the consistent (100%) and inconsistent (60%) input groups. As the figure shows, for both adult and child participants, those exposed to consistent input produced more determiners than those exposed to inconsistent input. In an ANOVA with age group and input consistency as between-subjects variables, the only significant result was for input consistency, $F(1, 19) = 11.39$, $p = .003$. Neither age nor the interaction between age and input group were significant.[23]

This analysis, however, potentially hides a difference between the adult and child participants; it is possible that individual participants are using determiners in consistent ways not evident in the overall percentage determiner use. To investigate this we examined each participant's productions for evidence of patterns in her speech and then classified the participants according to the presence or absence of a pattern, as in Experiment 1.

Table 3 shows the percentage of participants in each age and input group falling into each category of our pattern analysis. As in Experiment 1, there were multiple subtypes of patterned or systematic determiner use: *Systematic user*, *Systematic non-user*, and one additional category not found in Experiment 1, *Systematic other*. Systematic other includes participants who used determiners in another systematic way, for instance, using determiners with all object NPs but not subject NPs.[24] Participants who used determiners variably were classified as *Variable users*.

The main result is that there is a large difference between adults and children in their overall tendency to use determiners systematically, particularly in the 60% condition. Figure 8 shows the percentage of adult and child participants receiving consistent input (100% condition) or inconsistent input (60%) who show a system-

[23]Mean determiner production in the 60% condition is somewhat lower here than in Experiment 1. However, as described, in this experiment the nouns were presented without determiners during vocabulary training, so the overall percentage of nouns with determiners in the 60% condition is actually only 35% if all noun presentations are included in the computation.

[24]As in Experiment 1, participants were allowed one exception to their pattern.

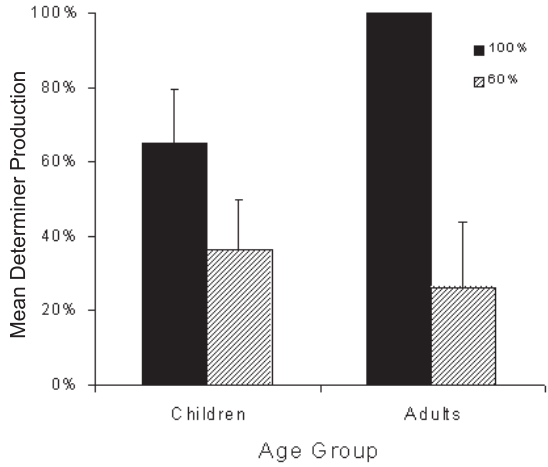

FIGURE 7 Mean percentage of nouns produced with determiners by input level and age group.

atic, rule-like pattern of determiner use in their productions. The data from the same conditions of Experiment 1 are included in the figure for comparison. Figure 8 clearly shows a very different picture than Figure 7. Children are very likely to produce consistent patterns, even when receiving inconsistent input; adults, however, are not. Adults are systematic when their input is consistent and variable when their input contains variation. In Experiment 2 it appears that a slightly higher proportion of adults were systematic than was seen in Experiment 1. However, this was actually an increase of only one adult participant. Due to the small size of the adult sample, the difference between children and adults from Experi-

TABLE 3
Percentage of Participants in Each Production Systematicity Category by Input Group

	Production Type				
Input Group	*Systematic User*	*Systematic Nonuser*	*Systematic Other*	*Systematic Total*	*Variable User*
Children					
100%	50.0	25.0	12.5	87.5	12.5
60%	14.3	57.0	0.0	71.3	28.6
Adults					
100%	100.0	0.0	0.0	100.0	0.0
60%	0.0	50.0	0.0	50.0	50.0

Note. Variable user data stands in contrast to the systematic data.

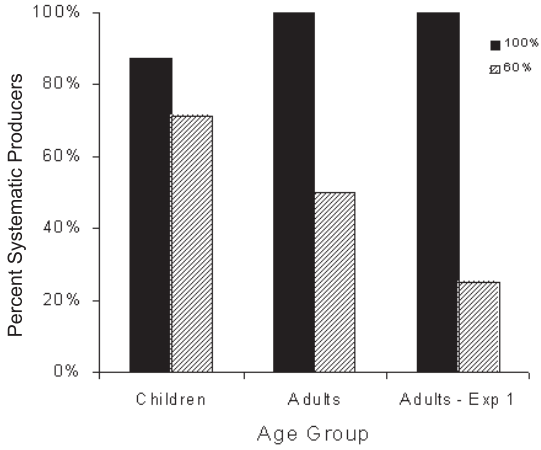

FIGURE 8 Percentage of child and adult participants exposed to 100% and 60% determiner usage who are systematic, Experiments 1 and 2.

ment 2 (tested using a Cochran's chi-square with input consistency as the experimental factor, systematicity as the response factor, and age group as the layered factor) is not significant.[25] If we compare the participants in the 100% and 60% conditions of Experiment 1 (the data presented in Table 1) to the children, the comparison shows highly significant differences between adults and children, Cochran's χ^2 (1) = 9.76, $p < .002$. Children show a strong tendency to use determiners systematically, regardless of their input consistency. In contrast, adults use determiners systematically when their input does so; when the input presents determiners inconsistently, most adults do the same.

One other interesting point emerges from a careful examination of Tables 1 and 3, which is the occurrence of other systematic patterns in the speech of the children but not the adults. One child used determiners in transitive, but not in intransitive, sentences. This pattern is particularly interesting because it appears to be based on linguistic categories that were not differentiated by determiner usage in the input. No adults imposed any similar kind of idiosyncratic pattern.

Determiner Judgment Test

This test also evaluated participants' knowledge of determiners but by having them judge sentences in which we manipulated the determiners. Participants judged 18 strings: 6 had the determiner present and in the correct location, 6 were missing a

[25]Because adults were run in Experiment 2 only to verify the results already obtained in Experiment 1, there were only 4 adults in each condition of Experiment 2. Even here, however, Pearson's chi-squares computed for each age group show that the adult data is much less likely to be drawn from a distribution where input consistency does not affect systematicity ($p = .1$) than the children's data ($p = .44$).

determiner, and 6 had the determiner in an incorrect location (before rather than after the noun). Across the 6 items of each type, we varied whether the NP in which this manipulation occurred was an intransitive subject, a transitive subject, or a transitive object. Each string was judged on a 4-point scale of happy to sad faces, which we score here as ranging from 1 (*lowest rating*) to 4 (*highest rating*).

Mean ratings for each category of sentence (determiner correct, determiner missing, and determiner in the wrong location) for adults and children are shown in Table 4. Data were subjected to a repeated measures ANOVA with age group and input consistency as between-subjects factors and test string type a within-subject factor. The main effects of age group and input consistency were not significant. The main effect of string type was significant, $F(2, 36) = 297.59$, $p < .0001$. Wholly correct strings were judged highest by participants, and strings with missing determiners were judged higher than those with the determiner in the wrong location (before the noun).

Planned comparisons on the ratings of correct sentences and sentences missing determiners showed significant differences for adults and children in both input groups (two-tailed paired samples *t* tests): adults consistent input, $t(3) = 12.21$, $p = .001$; adults inconsistent input group, $t(3) = 4.24$, $p = .024$; children consistent input, $t(7) = 3.1$, $p = .017$; children inconsistent input, $t(7) = 6.41$, $p = .001$. We also examined whether participants differentiated between sentences with missing determiners (which some had heard) and those with the determiner in the wrong location. This difference was only significant for the adults who had been exposed to inconsistent input, $t(3) = 4.54$, $p = .02$. Children and adults exposed to consistent input judged both kinds of sentences equally unacceptable. Importantly, children in the 60% condition did not prefer sentences with missing determiners to a sentence type that they had never heard. Taken together, these results suggest that adults exposed to inconsistent input have internalized a grammar that differentiates

TABLE 4
Mean Ratings (Max = 4) for Each String Type by Syntactic Type for Children and Adults by Input Group

	String Type					
	Correct Det		*No Det*		*Det in Wrong Place*	
	M	*SE*	*M*	*SE*	*M*	*SE*
Children						
100%	3.69	.14	2.50	.33	2.28	.31
60%	3.54	.22	2.52	.28	2.50	.37
Adults						
100%	3.96	.04	2.69	.07	2.48	.23
60%	3.81	.12	3.06	.12	1.50	.29

between more and less common structures, with both kinds of experienced structures differentiated from structures that were never experienced. In contrast, the children seem to have extracted knowledge that leads to a preference for the frequently experienced sentence structure type but that does not distinguish between the less frequently experienced sentence structures and those not previously encountered.

Discussion

The results of Experiment 2 demonstrate that it is possible to compare children and adults in the type of learning experiments we conducted with only adults in Experiment 1. Young children can learn small artificial languages well enough to produce novel utterances in a short period of time. Indeed, there were no differences between adults' and children's performance on the general grammar task. Although we are by no means the first to use this methodology with children, the language in our study was much larger, and the children in our study much younger, than in most previous studies (e.g., Braine et al., 1990; Brooks, Braine, Catalano, Brody, & Sudhalter, 1993; Ingram & Pye, 1993; Johnston, Blatchley, & Olness, 1990). We feel that our success in expanding this method has implications for future research in language acquisition by adding another technique to the toolbox of acquisition researchers.

Most important, the results suggest that children learn unpredictable variation differently than adults. They have a stronger tendency to impose systematicity on inconsistent input and sometimes impose patterns on this input that are not produced by adult learners. These differences in the production task are also in accord with the results from the judgment task, where children exposed to inconsistent input preferred sentences with determiners in their most frequent location but did not distinguish between sentences missing determiners and those with the determiner in the wrong location. In this task they performed like children exposed to consistent input, rather than like the adults exposed to inconsistent input. Children, it seems, prefer regularity in language and sometimes perceive or produce such regularity even when it is not present in their input.

GENERAL DISCUSSION

The results of Experiment 1 demonstrate that adult learners can learn inconsistent linguistic input, but they are not likely to impose consistency on such input as they learn it. The adult learners reproduced approximately the same level of inconsistency that was present in their input. Their tendency to maintain inconsistency, and not to regularize this variability, was unaffected by the level of consistency they received or the meaning of the inconsistent items. Their grammaticality judgments were perfectly in accord with their productions: The more they had heard deter-

miners, the more they favored their presence over their omission; the differences between their ratings of present versus absent determiners changed continuously with the proportions of determiners present during exposure.

In Experiment 2 we found that children were much more likely than adults to produce (or not produce) determiners systematically. Some of the children systematically used determiners everywhere or systematically omitted them everywhere, overregularizing the patterns that were inconsistently present in their input. Occasional children systematically imposed language-like patterns that were not present in their input. Altogether, 80% of the children followed some systematic pattern regarding determiner production, independent of the level of determiner use in their input. Children also judged determiner use more categorically than adults.

What do these results mean for thinking about creole formation? They suggest that children may play an important role in creole formation, as well as other types of language emergence and change, after all. Research on "home sign" systems has shown that children can introduce grammatical structure even when they lack conventional linguistic input (Coppola & Newport, 2004; Goldin-Meadow, 2003; Goldin-Meadow & Mylander, 1984). Studies of children exposed only to inconsistent input (Newport, 1999; Ross, 2001; Singleton & Newport, 2004), as well as research on the formation of Nicaraguan Sign Language (Kegl & Iwata, 1989; Senghas, 1995; Senghas & Coppola, 2001; Senghas et al., 1997), shows that child learners can surpass and reorganize inconsistent input, forming grammatical rules from input that did not contain such regularities. The present research shows, under closely controlled conditions, that children learn differently than adults and that they may thereby serve to regularize and stabilize the grammar of an emerging language. Thus, like Bickerton (1981, 1984, 1988), Labov (1990), Sankoff and Laberge (1973), Slobin (1977), and Traugott (1973, 1977), we are suggesting that children are important contributors to creole genesis. In contrast to some of these theories, we are not suggesting that children necessarily invent new languages when exposed to a pidgin or early creole. Rather, we suggest that they pick up on probabilistic patterns in their input and regularize them as they learn (Newport, 1999; Romaine, 1989; Slobin, 1977).

Broader Implications

What is the nature of the learning mechanisms involved in the regularization we are studying and of the striking differences between adult and child learners? One possibility, much discussed in the language acquisition literature, is that the learning mechanisms producing such phenomena must arise from a mechanism specific to language (Chomsky, 1965, 1981, 1995). Similarly, many creolists assume that the mechanisms involved in creole formation arise from a language-specific faculty (Bickerton, 1981, 1984, 1988). On this account, differences between adult and child

learners result from differences in the accessibility of Universal Grammar or some other language-specific learning device. Another possibility, however, is that the learning mechanisms tapped in our experiments are, at least in part, not specific to language, although they may help to explain aspects of language structure and change. Recall our earlier discussion of findings from the probability learning literature: Adult learners sometimes probability-match and sometimes overmatch probabilistic information, with probability matching being the more common outcome; however, children are more likely than adults to maximize or impose their own patterns. We believe that regularization in our studies is somewhat like overmatching or maximizing in probability learning experiments. The adults who participated in our studies performed much like adults in probability learning: They were very unlikely to regularize. In contrast, children did not probability match and instead were very likely to regularize. The variation in patterns imposed by the children is also consistent with the probability learning literature. Studies of probability learning in children have found that children are prone to display nonrandom patterns in their responses, for instance using a Left, Middle, Right strategy in a three light task (Bogartz, 1965; Craig & Meyers, 1963; Stevenson & Weir, 1959; Weir, 1964). Goldowsky (1995) demonstrated that this phenomenon is not limited to simple light-flash studies. In a study using complex visual patterns modeled after the ASL morphology acquired by Simon (and therefore organized somewhat like our miniature languages), he also found that children imposed consistency on probabilistic stimuli. The correspondences between our findings and those of probability-learning studies would suggest that regularization is not specific to learning inconsistent language input but rather is a more widespread learning phenomenon.

Recent research on word segmentation, syntax, and other topics in language acquisition (Mintz, Newport, & Bever, 2002; Newport & Aslin, 2004; Saffran, Aslin, & Newport, 1996; Saffran, Newport, & Aslin, 1996; Thompson & Newport, 2004) suggests that certain aspects of language acquisition may be accomplished by *statistical learning*, that is, by mechanisms that compute various complex statistics of the occurrence and distribution of linguistic forms. One might imagine that statistical learning would always produce veridical outcomes, reproducing in output the statistics provided in the input. However, learning (including statistical learning) is not always veridical (cf. Newport & Aslin, 2000, 2004). We believe the present examples of regularization may be important instances of probabilistic or statistical learning in which learners change their input as they learn.

We are not claiming on the basis of these studies that all language learning is accomplished by general mechanisms. Indeed, even in these data, certain aspects of regularization employ notions that may be particular to language (e.g., the child who used determiners in transitive but not intransitive sentences was forming a linguistic generalization, not likely to emerge in studies of light flashes). However, we are suggesting that some aspects of regularization may result from general learning mechanisms, interacting with complex input that is difficult to learn. Exactly how and why regularization occurs the way it does is the focus of ongoing research.

Of particular interest is the question of how general learning mechanisms could produce the striking differences we see between adult and child learners faced with the same inconsistent input. One possibility is that adult and child learners may represent different points along a continuum of some ability important to language acquisition, such as working or short-term memory, and this difference may produce differing abilities to learn from inconsistent input (Newport, 1990, 1999). Children may regularize because they fail at learning all of the complex variability. Adults are better able to deal with the complex learning task that inconsistency presents, and therefore are more likely to learn it veridically. If this is correct, younger children might regularize even more than the children in our study, and adults in more complex learning circumstances might behave like children. We are currently investigating these possibilities. At this time our data cannot distinguish between the two possible explanations (language specific learning mechanisms versus general learning mechanisms). However, the results of our ongoing studies will speak to this distinction.

Another question raised by our results is why different learners regularize in different ways. Based on the results of Simon and other deaf children learning ASL from imperfect input (Ross, 2001; Ross & Newport, 1996, 2005; Singleton & Newport, 2004), we had anticipated that the children in our study would regularize their language simply by using more systematically the determiners that were inconsistently used in their input (what Singleton & Newport, 2004, called "frequency boosting"). Although this was the case with some children, it was not true for all. Some learners systematized by using determiners all the time, others by never using them, and one by using determiners with nouns in transitive sentences but not intransitive sentences. These differences in learning outcome are not due to variations in the input these individuals received, as this was the same for all participants. They are also not due to differences in the precise age or gender of the child or in how well the language was learned overall. Instead it appears that the variation is simply due to individual differences in learning. The same kinds of individual differences were seen in the adult participants in Experiments 1 and 2, although with a different likelihood of systematicity overall for adults than children. (Of the 27 participants in Experiment 1 who were exposed to inconsistent input, the majority were variable users, one was a systematic user, and three were systematic non-users.) This is a question that deserves further research.

One further point deserves mention. We believe that this research demonstrates the usefulness of artificial language experiments in understanding and testing ideas about the mechanisms involved in language acquisition and how these mechanisms can effect language change. Several current theories of creolization, such as those of Lefebvre (1996, 1998) and McWhorter (1997), rely to some degree on adults' ability to learn an incipient language from other adult learners. These investigators suggest that grammatical features in the creoles they study were developed at an early stage in the language. On this view, later arriving adults did not develop the grammar of the language; they learned it (from input that was likely variable).

The participants in our experiments accomplished this, demonstrating that adults can learn from input comparable to that provided by other adult learners. The converging evidence from our study of learning and the claims of certain theories of creolization thus supports the validity of our method and demonstrates the potential relevance of our results to studies of creolization. On the other hand, artificial language learning studies may also show that learners do not behave in complete accord with theory. If artificial language studies such as our own are a valid method for studying processes involved in creolization, findings which diverge from theoretical predictions may also help to refine our understanding of how creoles are formed. The adults in our experiments did not regularize, suggesting that this might be the role that children play in creole formation, also consonant with our results.

Of course, not every aspect of pidgin and creole circumstances are modeled in our experiments; in order to control variables and observe their effects individually, many of the realistic circumstances of creolization have been removed. It is therefore possible that adults as well as children are responsible for regularizing pidgin–creole languages, but the kind of variation or the circumstances of learning in our experiments are not conducive to regularization by adults. In a separate series of studies (Hudson & Newport, 2005) we have investigated whether other kinds of input variation might produce adult regularization. In all such studies, however, it is important to compare adults and children, because children may always differ from adults in their likelihood to regularize.

Summary

These experiments have shown that, given a particular kind of unpredictable variation in input very likely to have been present in many language contact situations, adult learners do not typically regularize it. Instead, they learn and reproduce this variability. In contrast, children do not learn such variability veridically; they impose systematicity on the language as they learn it. These findings suggest that adults may not form creoles alone but that children may be important contributors to the process of creole genesis: Children may serve to smooth out the erratic bumps left in pidgins by the adults who create them. These results are consonant with the views of Bickerton (1981, 1984, 1988), DeGraff (1999b), Sankoff and Laberge (1973), Slobin (1977), and others who have suggested an important role for children in the formation of creole languages. They are also in accord with the views of Kiparsky (1971), Slobin (1977), Traugott (1973, 1977), and others who have suggested a special role for children in other processes of language formation and change.

However, our findings go beyond the phenomenon of creolization. The mechanisms available to learners exposed to atypical input must also be available to learners exposed to typical input. Our findings therefore also speak to the pro-

cesses involved in language acquisition more generally. Two types of hypotheses are compatible with these results: First, it may be the case that children bring to the task of language learning some special expectations and rule-learning processes, utilized specifically in the case of language acquisition (Bickerton, 1981, 1984; Chomsky, 1965, 1981, 1995; DeGraff, 1999b). Alternatively, the regularization seen in creolization may result from constraints on more general probability learning mechanisms interacting with a particular kind of complex input in such a way as to lead to very different learning outcomes in young and mature learners. Similarities between our results and those in the much older probability learning literature (Bever, 1982; Weir, 1964) lead us to be particularly interested in the latter hypothesis; indeed we suggest that statistical learning, a new approach to language learning that has begun to be of widespread interest in our field (Newport & Aslin, 2000, 2004; Saffran, Aslin, & Newport, 1996), involves constraints and complexities of learning that may ultimately account for a number of interesting, nonveridical aspects of language acquisition. However, more definitive evidence on this question will require further research. In the meantime, we believe these findings provide an important contribution to these questions.

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APPENDIX A
Vocabulary

Determiners	*Negator*
kɑ—noun gender one/mass noun determiner **po**—noun gender two/count noun determiner	sɪg—not

Nouns by Substance Type (Count/Mass) and Noun Gender Class (1/2)

Count

Noun Class 1	*Noun Class 2*
flɛrbɪt—glass	gɛntʌ—plastic doughnut
mæŋ—plastic block	klamən—nail
flɑmbʌt—tree	mɪktʌ—hammer
mɛlnɑg—car	**blɪfən**—truck
blɛrgnfɑl—bowling pin	mog—airplane
dʊgolʌ—drum	mɪsnʌ—snake
dɪlbʌ—barrel	**fɛrlukʌ**—girl
flʊgɛrdo—ladybug	**rʊŋmɑt**—ball
bæmpogən—wooden block	rinolɑ—log
blægʌ—bear	slɛrgən—alligator
lombʌ—rocking horse	**fʊmpogʌ**—bird
mæuznɛr—boat	**nɑgrʌ**—rhino
nɛrk—frog	
lædnʌ—turtle	
mɛrnɑt—boy	

Mass

Noun Class 1	*Noun Class 2*
gɛrko—sand	blɛrfi—playdough
sʊlto—glitter	kiɛro—water
zæmpər —cold cream	mɛlanʌ—bubble paper
pɛrnɪsəl—cloth	fɑgəl—koolaid
kowɑltʌ—cotton batton	

Verbs

Intransitive	*Transitive*
slʊb—be blue	lʊks—on (S is on O)
fɪlk—be red	blɪt—under (S is under O)
lɛmz—be yellow	smɪt—beside (S is beside O)
spɑd—be big	**flɪm**—hit
mʊnd—be small	**prɑg**—inside (S is inside O)
mɛrt—move	
gɛrn—fall	

Note. All words listed here were used in Experiment 1. Those in bold were also used in Experiment 2.

APPENDIX B
Percentage of Nouns Occurring With Determiners by Condition

Noun	*Gloss*	*Low (45%)*	*Mid (60%)*	*High (75%)*	*Experiment 2*
flɛrbɪt	cup/glass	43	53	73	78
mæŋ	plastɪc block	43	57	77	—
flɑmbt	tree	52	70	78	—
mɛlnɑg	car	33	53	63	50
mæuznər	boat	48	61	76	—
nɛrk	frog	53	70	80	56
lædnʌ	turtle	44	52	74	44
mɛrnɑt	boy	37	70	78	50
blɛrgənfɑl	bowlɪng pɪn	47	50	53	—
dʊgolʌ	drum	44	44	61	—
dɪlbʌ	barrel	40	57	70	72
flʊgɛrdo	ladybug	37	74	78	—
bæmpogən	wooden block	48	41	74	—
blægʌ	bear	47	57	70	58
lomb	rockɪng horse	47	67	83	—
gɛrko	sand	47	57	73	—
sʊlto	glɪtter	39	52	70	—
zæmpər	cold cream	41	41	63	—
pɛrnɪsəl	cloth	44	63	78	—
kowɑltʌ	cotton batton	44	67	74	—
gɛntʌ	plastɪc rɪng	48	67	70	—
klamən	naɪl	41	59	74	—
mɪktʌ	hammer	44	70	78	—
blɪfən	truck	52	59	74	44
mog	aɪrplane	41	52	63	—
mɪsnʌ	snake	48	52	70	—
fɛrlukʌ	gɪrl	52	74	85	56
rʊŋmɑt	ball	41	67	74	67
rɪnolɑ	log	48	63	81	—
slɛrgən	allɪgator	43	60	73	—
fʊmpogʌ	bɪrd	41	63	78	67
nɑgrʌ	rhɪno	52	56	93	56
blɛrfɪ	playdough	50	57	77	—
kɪɛrno	water	54	67	83	—
mɛlɑnʌ	bubble paper	56	74	85	—
fɑgəl	koolaid	39	67	85	—