Cognitive and Behavioral Approaches to Language Acquisition: Conceptual and Empirical Intersections

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The past 20 years have seen research on language acquisition in the cognitive sciences grow immensely. The current paper offers a fairly extensive review of this literature, arguing that new cognitive theories and empirical data are perfectly consistent with core predictions a behavior analytic approach makes about language development. The review focuses on important examples of productive linguistic behavior: word learning and early grammatical behavior. Language experience, through social and other contingencies, influences language development directly. Through these contingencies, the structure of language behavior exhibits a gradual emergence.
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The modern mainstream study of language acquisition has a surprising quality. Despite decades of intense effort collecting observational and experimental facts, debate still rages as to the nature of the language learning child, and perhaps even the nature of language itself. This is somehow made more surprising when we consider the billions of in-home "laboratories" around the world permitting ever-present observation of a child's development. Indeed, language researchers themselves doubtless diligently observe the growth of language in their own children (e.g., Tomasello, 1992). Nevertheless, these observations provide a stark portrait of the debate on language learning: Even given intense observation, individual observers can differ wildly on appropriate theoretical interpretations.

There is, however, one very important consensus among most developmental psycholinguists: There is no substantial explicit negative feedback about grammar in language directed to children. An example of such feedback is presented below, and has two important properties that should be borne in mind. First, the mother must stop the flow of conversation to address the child's error, and secondly, the mother is providing information about language structure in particular – the conversation has ceased to be about the topic of discussion, but instead about the grammaticality of the child's utterance.

Child: Mummy I have toy!
Mother: No, say, "I have *a* toy."

Brown and Hanlon (1970) famously demonstrated in the Adam, Eve, and Sarah mother-child interaction corpora that parents do not offer such information. In tracing the development of complex sentence types in language production by children, Brown and Hanlon sought the basis on which children establish correct usage of these sentences. They discovered that information based on explicit approval and disapproval is extremely rare. The feedback they did isolate was directed towards semantic and phonological problems, with morphological and syntactic errors almost never eliciting it. Driven by early results such as these, many were eager to identify child-directed speech as altogether chaotic: "A record of natural speech will show numerous false starts, deviations from rules, changes of plan in mid-course, and so on." (Chomsky, 1965, p. 4) This famous quote exemplifies an ideological momentum at that time to characterize the child's task as rife with difficulty and void of a certain "linguistic pedagogy" that behaviorist theories supposedly required. To this day, linguistics textbooks are persistent in presenting this tendency (e.g., Fromkin & Rodman, 1997; see Schlinger, 1995, p. 179 for relevant discussion). Even if it were present, some argued, a number of famous anecdotal examples supposedly demonstrate that children might not use it to change their language anyway:

Child: Nobody don't like me.
Mother: No, say, "Nobody likes me."

Child: Nobody don't like me.
Mother: No, say, "Nobody likes me."
Child: Nobody don't like me.
Mother: No, say, "Nobody likes me."
…
Mother: Now listen carefully, say, "Nobody likes me."
Child: Oh! Nobody don't likes me. (McNeill, 1966)

Child: Want other one spoon, Daddy.
Father: You mean, you want *the other spoon*.
Child: Yes, I want other one spoon, please, Daddy.
Father: Can you say "the other spoon"?
Child: Other ... one ... spoon .
Father: Say ... "other."
Child: Other.
Father: "Spoon."
Child: Spoon
Father: "Other ... Spoon ."
Child: Other ... spoon. Now give me other one spoon? (Braine, 1971)

Through Brown and Hanlon's analysis and anecdotes of this kind, the theoretical influence of this consensus was quick and severe. For example, it rapidly became assumed by many that *any* kind of negative evidence is absent in language input (Valian, 1999; Moerk, 2000). Also, formal theorists utilized the absence of negative evidence to support nativist theories of language acquisition (e.g., Wexler & Culicover, 1980), partly on the basis that simple inductive learners would not be able to accomplish the task without negative evidence (a classic example is Gold, 1967). One of the more influential and still-present intellectual tools generated by this debate is "poverty of the stimulus" arguments, a modern version of a kind of reasoning that finds a famous and early expression in Plato's *Meno*: Precocity, without appropriate input, entails rich epistemological innateness (Chomsky, 1986). This logic continues to exert an influence in current research:

> Nonetheless, we show that 18-month-old infants do have command of the syntax of *one*. Because this syntactic knowledge could not have been gleaned exclusively from the input, infants' mastery of this aspect of syntax constitutes evidence for the contribution of innate structure within the learner in acquiring a grammar. (Lidz, Waxman, & Freedman, 2003, p. B65)

The authors refer to this argumentation specifically as poverty of the stimulus "logic." A casual glance at the cognitive science literature reveals its persistent frequency (e.g., Collins, 2003; Crain & Pietroski, 2001; and even outside language in other realms of cognitive development, Spelke, 1994).

Such theoretical consequences took root before further thorough analyses of language-learning corpora, records of parent-child interaction, were conducted. They were quickly taken as foundational in many theories of language acquisition (Moerk, 2000). Some felt that this axiom was adopted far too hastily given the small size of the dataset and the nascence of our quantitative instruments (Bates & Carnevale, 1993; Moerk, personal communication). To those who opposed this momentum, it is not that surprising that mothers should have goals in mind for their children's development that lie outside finicky pedantry about language structure. Language learning is embedded in social contingencies, where everything from phonology to syntax, comprehension and production, are all part of complex dynamics among caregivers, the wider social environment, and the language-learning child. Nevertheless, many linguists since Chomsky have assumed that learning to understand sentences proceeds by "setting a

grammar" through exposure to "sentence examples." Many find this idealization egregious, neglecting the requisite richness of the learning context in which children find themselves (e.g., Halliday, 1975).

An apocryphal yet common interpretation of Skinner's *Verbal Behavior* is that language acquisition hinges mostly on explicit negative feedback of this kind (e.g., Sokolov & Snow, 1994). In early language behavior, the "specifications upon which reinforcement is contingent are at first greatly relaxed" (Skinner, 1957, p. 29), and gradually establishing contingencies "arranged between a verbal response and a *generalized conditional reinforcer*," influencing responses that have "dynamic properties similar to those which it would have acquired if it had been severally followed by all the specific reinforcers at issue." (p. 53) Skinner's framework makes ample room for subtle control. Any bout of language behavior is indeed richly controlled by environmental contexts. Skinner clearly acknowledged this by devoting an entire chapter to it. From the contingencies dictated by simpler reinforcers, early "ends" of conversational "means," such as food and warmth, contingencies based on generalized patterns of behavior can develop and mutually constrain the further development of language. Skinner thus motivates the expectation that parents do not have to stop their children with every grammatical anomaly. In a recent review of these issues, Schlinger (1995) articulates the modern behavior analytic approach to development and language acquisition, and addresses common misconceptions about reinforcement. For example, mainstream textbooks on language learning often invoke "criticisms of reinforcement as a viable language learning process [that] are based on misunderstanding of the concept itself." (p. 181) The author argues that an appropriate conceptualization of learning in a behavior analytic framework does accommodate facts about language learning. The conclusion in the budding cognitive sciences that behavior analysis has little to contribute to understanding language was premature, if not false (see also Bijou & Ribes, 1996).

The current paper reviews recent research in developmental psycholinguistics relevant to behavioral approaches that aim to elucidate the complexity of human learning and behavior. The recent spate of debate concerning higher-order operant approaches would benefit from the examination of current evidence to further refine theory – and support it. In hope of contributing to this effort, I argue below that extensive empirical cognitive work on language acquisition is quite supportive of a behavioral account. Whether one adopts naming (Horne & Lowe, 1996), Sidman's (Sidman & Tailby, 1982; Sidman, 2000), or relational frame theory (Hayes, Barnes-Holmes & Roche, 2001), these data should guide the evolution of theories based on equivalence and other potential derived behavior (e.g., "syntax" as sequential classes, Lazar, 1977; Wulfert & Hayes, 1988; relations, Hayes et al., 2001; relations of relations, Stewart, Barnes-Holmes, & Roche, 1999).

I will begin by laying out some predictions of the behavioral perspective. These predictions will be very broad, expressed in general patterns of verbal behavior that would be expected from a behavior analytic perspective. Next, I offer a selective review of two crucial stages of language development, word learning and particularly early grammatical behavior. These two stages are often attributed to the emergence of truly creative and productive behavior.

Predictions

I will not venture from the common and perhaps "trendy" dichotomy (Michael & Malott, 2002) between the function and structure of the child's language behavior. From a Chomskyan perspective, accounting for language acquisition requires no sense of function whatsoever – such issues are thought to be peripheral to language acquisition (Chomsky, 1986) and not needed for understanding the learning of language structure (Wexler & Cullicover, 1980). Some psycholinguists sometimes make strong statements that "…to a surprising degree, language is the product of the young human brain, such that virtually any exposure conditions short of total isolation and vicious mistreatment will suffice to bring it forth in every child" (Newport & Gleitman, 2002, p. 685). The child is setup for language, and need not necessarily use it extensively to acquire it. Rather from a behavioral perspective, "input" is crucial.

Skinner's (1957) own definition requires control by contingencies in the surrounding verbal community. From here, controlling variables of acquisition can become richly multidimensional (Skinner, 1957, chap. 9), perhaps taking on many forms, from such primary reinforcers as food (e.g., Issacs, Thomas & Goldiamond, 1960) to generalized conversational reinforcers such as "yes" and "uh huh" (Greenspoon, 1955; see Risley, 1977, for an excellent early review). More recently, collateral reinforcement in a game task (Liebermann et al., 1998a, 1998b; Dale & Christiansen, 2004), and even contrastive usage between children and caregivers (e.g., Saxton, 1997), are demonstrated influences on verbal behavior. Social contingencies along with extent of exposure are therefore predicted to be foundational to the language learner.

As for the structure of language, from a Chomskyan perspective, it is seen as abstract and acquired instantaneously. Though this idealized theoretical perspective obviously does not fit with the facts, devotees of the general framework see language learning as underlain by extensive abstract linguistic knowledge (e.g., recently, Lidz et al., 2003; Lidz & Gleitman, 2003; Lust, 1999). The behavioral perspective, instead, sees the topography of language behavior as proceeding through a piecemeal process. It takes considerable time, years in fact, for the child's repertoire to develop into a system of stimulus and response classes, syntactic or semantic. We should thus observe syntactic and semantic relations emerging gradually, initially being relatively strongly controlled by context of usage, and only with considerable exposure extending into adult-like flexible grammatical behavior.

These predictions, though general, are very much in opposition to those made by nativist researchers even today. This paper aims to review mainstream cognitive research on language acquisition to support these behavioral predictions – and thus directly support a behavior analytic perspective itself. This is indeed a far cry from the fine-grained analyses diligently worked out by cognitive researchers, but I hope that readers investigating verbal behavior will find some value in seeing the extensive and consonant findings that have surfaced in the past several years. Catania (1996), Hayes et al. (2001), Salzinger (1991), and Schlinger (1995) offer some guidance on this issue, but they do not thoroughly review the evidence available; it is available in vast quantities. These broad predictions will thus serve as a guide to the subsequent review of cognitive research. Though the review is fairly extensive, it remains inevitably selective. Other topics and details not touched upon by this initial review are ones that the behavioral perspective should of course also address and I point out some of the important ones in discussion (the interested reader may consult, for example, Clark, 2003; Tomasello, 2003; and Bloom, 2000 for excellent recent reviews).

Single-Word Utterances

As Bloom (2000) notes, word learning might at first appear quite simple. Parents point to things and use words, and children sop up these words from such simple interactions. Indeed, it *has* been shown that simple social interactions influence word learning (Clark, 1999; Bloom, Margulis, Tinker & Fujita, 1996). Not surprisingly, these interactions are often about things in the immediate spatial and temporal environment, the "here and now." To paraphrase one of many of Quine's colorful expressions, children start their ontology at arm's length. A well-known and related thesis in developmental psycholinguistics by Gentner (1982; Gentner & Boroditsky, 2001) sees objects as conceptually more tractable for the language-learning child, with actions and events (e.g., *to run*) and abstract words (e.g., *freedom*) being learned later as conceptual development proceeds. Gilette, Gleitman, Gleitman and Lederer (1999; Snedecker, Gleitman & Brent, 1999) also found that adults perceiving the information available to children through video recordings of parent-child interactions were more capable of picking out nouns than verbs, both of which had to be inferred given the surrounding interaction context (the target words were distorted in the video). The debate concerning noun- and verb-based advantages in different languages is fairly long-standing (see Clark, 2003, for an excellent review). However, it appears rather well established that there exists a noun-advantage in many languages, with verb-based advantages being

less robustly supported by the evidence. Parental input and the emergence of sophisticated control seem to account easily for this. The story may therefore appear simple: Children learn from pairings of sound and referent, and source of control by objects emerges more quickly than conceptual control. Despite these patterns, which certainly seem to have a very intuitive explanation, the situation is more complex.

Bloom remarks that "words can be learned without a *strict* spatial and temporal cooccurrence between the word and the meaning," and "serious mistakes – such as a child thinking that *milk* means 'fork' – virtually never occur" (2000, pp. 6-7, emphasis added). Bloom, and earlier Macnamara (1982), argue that word learning is in fact much richer than what a typical matching-to-sample experiment suggests: A variety of parameters are involved in word learning, from temporal and spatial proximity (or relative non-proximity), perceptual and functional cues, and social contingencies, to name a few. Yet children come to know thousands upon thousands of words. The goal of explaining word learning is thus to elucidate these sources of constraint, and how they contribute to word learning.

One important issue in word learning is the extent to which children are constrained by the context in which learning takes place. As noted above, a broad prediction of a behavioral perspective would be context-tied usage at early stages of learning, with more flexible usage emerging with experience. Barrett (1995) discusses some evidence of these context constraints, but found that they were fairly minimal, with only a few words being strongly affected by context of usage. However, it should be noted that the context of word learning does not necessitate contextual control merely in terms of elementary environmental context, e.g., the word *wash* only occurring in the presence of baths. Variables controlling word learning and production can be more varied in nature, such as the presence of water, soap, a rubber duck, or any combination of them, may govern *wash* in early stages of learning.

This may indeed be the case for overextension, in which children use a word such as *dog* for cats, cows, and other four-legged creatures. In such errors, production seems to be governed by a class of objects larger than the true referent, but related in some formal way. For example, Clark's classic study (1973) found that, in Serbian, English and French-learning children, almost all overextension errors could be accounted for in terms of some formal property of the true and competing referent. Recently, Gelman, Croft, Fu, Clausner and Gottfried (1998) found further results concerning how shape and taxonomic class of novel referents govern overextension errors. They demonstrated that, even though *production* errors in younger children are more prominent, *comprehension* of the novel lexical item also exhibits overextension errors. This indicates that the errors are not simply a virtue of a word-selection strategy, but may also be an important part of the word-learning process, being present in both responding to and producing novel words. Even more recently, McDonough (2002) showed that in a task involving only comprehension of competing items (*bus* vs. *train*) extensive overextension errors occurred in young children.

Another related long-standing thesis is Nelson's "functional core" of word learning (Nelson, 1974). The relative perceptual versus functional nature of early word learning has recently generated debate (see Kemler Nelson, Herron & Holt, 2003, for a review). This "functional" approach aims to account for a broad range of early lexical production by arguing that children actually use words as classes of artifact functions – things that can be done with referents. For example, *chair* can refer to a very specific set of perceptual features, but children may instead come to use *chair* in the context of any object that satisfies the function "Can sit on __." In recent research on this topic, Kemler Nelson et al. (2003) showed that children concocted labels for novel objects based on what is done with them, and only resorted to perceptual cues when no artifact function was given. Even though researchers seem invested in one source of information or the other (Kemler Nelson et al., 2003; Smith, Jones & Landau, 1996), evidence suggests that both sources of constraint are involved in language acquisition.

Another constraint, recently of great interest, is that of joint attention, a process described as understanding and sharing attentional goals towards relevant objects and events in the environment. Gaze and attention have long been of interest to language researchers (e.g., Collis; 1977; Bruner, 1983). Recently, Tomasello and his colleagues have targeted this skill as foundational, and not merely facilitative, for word learning (Tomasello, 2003; see also 1999). In an early study, Tomasello and Todd (1983) found that the size of a child's vocabulary at the end of a 6-month observational period is correlated with the extent to which they engaged in joint attention with a caregiver. In a later study in the same direction, Carpenter, Nagell and Tomasello (1998) longitudinally recorded the vocabulary and joint attention between caregiver and child, finding that child vocabulary correlated with time spent in joint attention and how the caregiver's language followed the child's attentional focus (see also Collis, 1977; however, see Slaughter & McConnell, 2003; see also Baldwin & Dare, 2001 for theoretical issues concerning such social processes). Although the development of this skill itself is rarely pursued, largely being attributed to innate faculties of our species, some have sought to understand perspective taking and deixis from a behavioral perspective. McHugh, Barnes-Holmes and Barnes-Holmes (2004; Barnes-Holmes, McHugh, & Barnes-Holmes, 2004) have pursued this line.

Smith (2000) offers a general learning ("associative") perspective on word learning that sees it as founded upon basic processes. Tomasello (2003) criticizes this approach by observing that mere salience of surrounding events cannot predict word learning. This can be tested by presenting salient but irrelevant events to children, while simultaneously offering events that are in accord with functional and goal-based tasks, though less captivating. This has indeed been done, and children successfully learn through the relevant cues (e.g., Moore, Angelopoulos & Bennett, 1999). There is no reason to suppose, however, that a general learning perspective cannot contribute to understanding *how* this control by parental gaze and shared gaze can emerge and become crucial (e.g., McHugh et al., 2004). In addition, imitation, another important process proposed by Tomasello (2003; 1999), has been explored from a behavior analytic perspective (see for example, Kymissis & Poulson, 1990 for a review; see Baer & Sherman, 1964; Sherman, 1965 for early behavior analytic work specific to verbal imitation). Whether this historical account of these crucial social contingencies can help account for patterns of word learning is open to empirical and theoretical consideration.

In summary, the patterns above support the broad predictions outlined in the introduction. Word learning starts simple, and gradually becomes very fast and complexly controlled. Children learn to learn words, with social contingencies and experience actively guiding the process. Initial phases of word learning exhibit preponderant control by readily available contingencies (e.g., objects, or simple social exchanges), social contingencies such as joint attention (which may be learned), and are guided importantly by what and whom the child engages. Moreover, though not touched upon here, research has also examined the quantitative properties of vocabulary input on learning (varied input, de Villiers, 1985; dense input, Huttenlocher, Haight, Bryk, Seltzer & Lyons, 1991; structured presentation, Valian & Casey, 2003). Finally, word learning may be crucially supported by the properties of objects children use to contact other contingencies, such as eating, reaching, making noise, etc. Word learning generally supports a behavior analytic perspective.

Multi-Word Utterances

Though Bloom (2000) forcefully conveys the complexity and fascinating properties of word learning, the development of syntactic abilities has long engendered the most concern and controversy. Lashley's (1951) eloquently described dismay with Markovian or associative chain models of sequential behavior has become a classic expression of the importance of understanding the complex structure of sequential behavior. Today, linguists dub such properties "structure dependence" (Chomsky, 1986), and poverty of the stimulus arguments have often drawn their premises from examples of hierarchically structured sequential behavior. This section reviews recent cognitive research on the beginnings of this behavior.

Many directions of this work support the predictions described above. First, I consider observational and experimental work on the role of input on syntactic development. Next, I describe some recent work investigating forms of negative evidence that may have been overlooked during the history described in the introduction. Finally, some prominent research by Tomasello and colleagues is summarized, supporting the piecemeal development of grammatical behavior.

Input Studies

In response to Chomsky's remarks concerning child-directed speech, and the resulting theoretical impetus towards nativist explanations of language acquisition, several researchers sought evidence that language input to children is highly structured and possibly quite informative for the learner (e.g., Remick, 1971; Snow, 1972; Broen, 1973; Phillips, 1973). As Snow (1994) noted, research on "Baby Talk" existed in linguistic anthropology in the 1960's, but it wasn't until Brown and Bellugi's (1964) work and the previously described ideological momentum that mother-child communication was rigorously collected and quantified. In one of the most well-known examples of this research, Snow (1972), found that English-speaking middle-class children "hear, in fact, a relatively consistent, organized, simplified, and redundant set of utterances which in many ways seems quite well designed as a set of 'language lessons.'" (p. 561) She compared two groups of mothers, one with children at about 10 years of age, and the other at 2 years of age. By quantifying general properties of child-directed speech – for example, quantity of speech, sentence complexity, and partial repetitions – Snow compared language input available to both age groups. Analysis revealed highly significant differences between speech to 10-year olds and 2-year olds.

This unique register available to children became known as "motherese" (Newport, Gleitman, & Gleitman, 1977), and enjoyed rapid attention from researchers of both a learning-based and nativist persuasion. It was not long, however, before considerable problems emerged. First, Newport et al. (1977) noted that it is not clear whether or not motherese is a cause or an effect of learning language. Secondly, when Newport et al. (1977) performed their own detailed analyses on child-directed speech, they found few correlations between caregiver speech and language development. Gleitman, Newport, and Gleitman (1984) offered a further analysis of the data from Newport et al. by breaking their subjects down into age groups in order to avoid having to partial out age. By using what Newport et al. (1977) called a "split-half" analysis to test the reliability of these correlations, they separated the data in two, and compared these component correlations with those of the whole corpus. Under these constraints, almost none of the original correlations came out reliable.

This kind of back-and-forth debate (see also Furrow, Nelson, & Benedict, 1977), troublesome emergence and disappearance of correlations, and difficulty with theoretical interpretations are what characterize these initial attempts at establishing the positive effects of enriched input. Valian (1999), in a fairly pessimistic review, argues that the correlations that have been established are so few that they can be attributed to mere chance (see Scarborough and Wyckoff, 1986, for a similar assessment of Furrow et al., 1979). A negative assessment based on these data, however, would be premature. If the current regression results are indeed attributed to chance, then nothing should be concluded at all, given standards of hypothesis-testing logic of these inferential techniques. This is made more likely when we consider the vast quantity and complexity of language input and interaction, and the limitations on their measurement to date.

Pine (1994) provides a much more even-minded review, considering the ways in which input should be studied. Pine argues that Farrar (1990) and Richards (1990) demonstrate good directions to pursue the effects of input (see also Tomasello & Stahl, 2004). Many studies, some described above, use rather broad categories of input (e.g., sentence complexity or number of inverted yes-no questions), but Farrar and Richards use a more detailed morphological analysis of the input. According to Pine, the goal

of such research is of benefit because it might illuminate how children *do use* the input, rather than seeking a vague kind of facilitative effect. For example, Farrar (1990) codes seven varieties of *specific* grammatical categories, among them plurals, progressives, and the common verb *is*. Several kinds of maternal replies were also coded, including recasts (using the child's specific syntactic pattern) and expansions (using the syntactic pattern in a novel way). Mothers' recasts of plural and progressive errors tended to correlate with children's development of that morpheme. Farrar (1992) uses a similar coding strategy, and finds maternal corrective recasts are related to imitation of those recasts by children (Sokolov, 1993, also offers an impressive analysis of data at this level).

Early input studies were wrought with difficulties. Valian (1999) is quite right in describing the scattered and sporadic results as disappointing. Valian is however among many reviewers (Pine, 1994; Richards, 1994) who note that future directions should pursue input as a valuable topic for research, despite her pessimism. One reason for this is the possibility that crucial input to children may occur in spurts. For example, as mentioned parenthetically in the previous section, the role of input has been well attested in vocabulary acquisition. From the behavior analytic camp itself, Hart and Risley (1995) offer a large database revealing that differing amounts and quality of input can directly influence the rate of vocabulary acquisition. An interesting result by Huttenlocher et al. (1991) is that raw frequency of vocabulary input is not the best predictor of word acquisition, but the density of a word's usage at any one time. Also, the diversity of maternal verb use is more predictive of acquiring new verbs than simply the raw frequency of verb usage (de Villiers, 1985). Indeed, both syntactic and lexical development would exhibit these patterns of acquisition given Nelson's *rare event* theory of input (1987), proposing that highly concentrated but shorter-timescale events are more likely to determine aspects of child language development. Given these patterns, it is not surprising that, for one thing, our current means of measuring input have led to few strong correlations (see Tomasello & Stahl, 2004). And, even more crucially, the extent to which the input has been plumbed is inevitably limited. In many of the earlier studies mentioned above, usually less than an hour's worth of utterances by the mother was included for each child (from any one session), and sometimes even less by the child. It is therefore not surprising at all that the findings are inconsistent and troublesome. It would be like trying to predict the role of coach-input on hockey team winnings in an 80-game season by measuring performance over the span of a few minutes. For this reason more than any, echoing Moerk's still relevant concerns (1980, 1981) – there are still hardly enough data to make normative judgments about the appearance of correlations, significant or otherwise, and the conclusion that rich structural input is merely facilitative, but not necessary.

One way to substantiate observational and analytical studies is through experimental work, in which we can observe the direct effect of language input at work. Well-known early work on this question came from Keith Nelson and his colleagues (Nelson, 1977; Nelson, Carskaddon & Bonvillion, 1973). For example, Nelson (1977) provided two groups of children (28-29 months of age) with different intense periods of input for 5 hours in a two-month study: One group received extensive experience with tag and wh- questions, such as "you are big, aren't you" and "yes, where is the toy?" that *recasted* an utterance by the child; a second group heard recastings of complex verbs, such as the future "will" and the conditional "could" or "would." The results were quite drastic, with all children in the first condition using at least a tag or wh- question after the intervention, and almost all the second group using some of the complex verbs (and, of course, the converse usage was not found – the first group did not use complex verbs extensively, for example).

There have been some failed attempts at such experimental approaches. For example, unpublished experiments by Cazden (1965) failed to show effects of intervention. However, despite her use of them to urge pessimism, Valian (1999) observes that Cazden disputes her own results due to lack of appropriate controls. Another problem of inconsistency may be adduced by the failure of Shatz, Hoff-Ginsberg, and MacIver (1989) to induce usage of conditional *could* in two-year old children. Of course, these authors intensely modeled *could* to these children, whereas Nelson *recasted* the child's utterances.

As mentioned above, it is not always reasonable to suspect that *mere* input is needed for acquiring a form – bare frequency of an item cannot be taken as fully predictive of its acquisition. As Bates, Thal, and MacWhinney (1991) and Fey, Long, and Finestack (2003) note, the child's level of *functional readiness* for a structure must be taken into account when we observe the child's response to intervention (and, as Fey et al. note, this point is crucial for intervention programs with children with language deficits).

This point is underscored by Roth (1984). The author induced relative clauses in children with *relatively little input*. Valian complains that "in some cases massive exposure to a form has been ineffective…in other cases effective…in yet other cases minimal exposure has been effective." (p. 523) However, these points are quite reasonable when we consider the ages at which these children are under experimental study. In Roth (1984), children are between 3.5 and 4.5 years old. Much recent work, described below, on the development of complex language would suggest that, at that age, children are quite prepared to learn more complicated properties of language structure (Tomasello, 2003, 2000). It is equally important to observe that Shatz et al.'s modeling of *could* was not done with recasts (Nelson, 1977) and to young children who may not have had sufficient linguistic experience to support such usage (they were 2 years old).

Valian and Casey (2003) have recently provided evidence that modeled input, when structured appropriately, can contribute to facilitated acquisition. In this experiment, the authors modeled once again the auxiliary verbs because of their syntactic and structural complexity. Children interacted with a puppet toy and engaged in a simple game of question and answer. In an intervention condition, children were provided with two opportunities to hear a modeled auxiliary verb, such as "Where *can* you see the woman?" then "Where *can* you?" The basis for this intervention, as outlined by the authors, is that if children are given an opportunity to parse the input again, they will be permitted to get deeper into the sentence structure, and possibly learn more about the auxiliaries. A control group (without repetition) was able to use a *targeted* auxiliary (used in training) as much as experimental children after intervention; however, with *untrained* auxiliary usage (auxiliaries that were not modeled to the child) and inversion questions of the target auxiliary, children in the experimental group significantly improved far above the control condition (in fact, the control condition did not improve in these measures).

In another surprising study, Akhtar (1999) demonstrates the powerful effect of experience when learning a novel verb (a nonsense or nonce verb). Children in three age groups were exposed to a new transitive verb in an unusual word order (subject-object-verb), for example, "Look! Big Bird the car gopping!" and were presented with an enacted scene illustrating the action. Young children are as likely to use the unusual word order as they are to use the word order that they have heard for a full two years of their lives (i.e., English word order, subject-verb-object). Though the author's own conclusion from this is that generalized, abstract knowledge of the language system is not achieved until after 3 years of age (children in this experiment at that age were able to generalize to English word order), it may also be taken as a demonstration of the powerful effect of experience when learning the syntactic properties of novel words. If input is largely a matter of setting an internal grammar, 2 years is indeed plenty of time for this to be achieved. However, before the age of 3, children are willing to take the form of the verb in which it is modeled and use it themselves, despite its contrast with previous experience and potentially set parameters.

In summary, observational analyses of child input have yielded some promising results when coding schemes are appropriately designed to target specific structures of concern (Pine, 1994; Richards, 1994; Tomasello & Stahl, 2004; see also Rowland, Pine, Lieven & Theakston, 2003, for another good example) and to satisfy the functional readiness of the children at various ages (Bates et al., 1991; Fey et al., 2003). This is further substantiated by experimental studies, demonstrating that the nature of input is an important determiner of learning grammatical structures. Structured input catering to the child's functional readiness seems to be needed for access to a certain structure, and also effective is

intensification of these structures as the child is using them herself. Though these do not *fully* satisfy Pinker's criteria for establishing the necessity and sufficiency of structured input (see Pinker 1989, for a description), they do provide strong evidence for its necessity, and hint at its sufficiency. Nevertheless, the crucial interactive aspect of acquisition can be lost in the technicalities of measurement and theoretical interpretation – but when all these pieces of the puzzle are assembled it seems unlikely that language acquisition "needs" interactive input, in the sense that it "can't happen without it" – language is an inherently interactive process.

Negative Evidence Renewed

As discussed, a rapid consensus emerged in language development research that there exists no explicit negative evidence for children (even among learning-based theorists; Braine, 1971). This is particularly marked for syntactic and morphological errors children make. Parents just seem to disregard these errors in favor of pointing out semantic issues with children's language production. Despite this, this section will consider the outpouring of research, even in the face of frequent criticism (Morgan, Bonamo & Travis, 1995; Marcus, 1993), of isolating implicit negative evidence.

One of the first papers introducing this possibility was Hirsch-Pasek, Treiman, and Schneiderman (1984). The authors recorded play sessions between 40 mother-child pairs. They replicated Brown and Hanlon's (1970) original results by showing that explicit approval or disapproval is not contingent on syntactic errors. However, they did demonstrate that parents were more likely to repeat an ill-formed sentence than a well-formed sentence, but only at a young age (2-years of age, during which language development is likely to importantly grow; Tomasello, 2000). If parents tend to repeat ill-formed structures more frequently than well-formed ones, children may be able to extract information concerning the error of an ill-formed one. Hirsch-Pasek et al. are careful to note that this merely demonstrates a sensitivity to the correctness of the child's sentences (see also Demetras, Post & Snow, 1986; Bohannon & Stanowicz, 1988).

This perspective immediately generated dispute in the literature. Morgan and Travis (1989) reanalyzed Brown's Adam, Eve and Sarah corpus seeking overgeneralization errors with inflected forms ("She goed") and errors with wh-questions ("Where you can go?" or "Where he's been?"). They did in fact find substantial differential responding by mothers in Adam and Eve, but failed to do so with Sarah (though it should be noted that Sarah's data present far fewer both well-formed and ill-formed utterances for analysis). Morgan and Travis accept the presence of potential benefit of this information, but doubt that it is a general and consistent property benefiting children acquiring language. Similarly, Morgan et al. (1995) pursued the influence of negative evidence across language development by using time series analysis and found that it did not provide significant information or change in child language in wh-questions and overgeneralization. Some have argued that the data from Brown (which they used) violates a number of important assumptions required for that kind of analysis (Saxton, Kulcsar, Marshall & Rupra, 1998). In addition, Moerk (2000, personal communication) casts an interesting interpretation on their time-series data that might indicate an interactive dynamic between mother and child. A pattern emerges across all three children: Patterns of error accompany patterns of parental usage, where patterns of correctness accompany reduced usage (see Morgan et al., 1995, Fig. 5). Finally, Marcus (1993) offered an extensive analysis of the possibility of this implicit negative evidence, concluding that it is not useful. Saxton (1993; 1997) makes this same point. These arguments are largely conceptual: It seems implausible that children should be able to track the proportion of response patterns from their caregivers as information to guide language learning.

Bohannon, MacWhinney and Snow (1990) dispute this interpretation (see Gordon, 1990, for further debate). Sensitivity to these contingencies can lead to what Bohannon et al. might call a "probabilistic learner." Even though Valian (1999) argues against this idea, it is important to mention, in

addition, that parameter theories (Chomsky, 1986) of language acquisition require exactly the same mechanism. Parameters, if set probabilistically, need to be weighed incrementally according to positive instances – why should not the child be similarly probabilistically sensitive to "mummy kept moving along in conversation" versus "mummy repeated what I just said – why?" Albeit weak, this constraint may nevertheless exert some influence over the verbal behavior of children subjected to it.

In more recent research, Saxton (2000) offers a corpus analysis of Eve as evidence for the influence of direct adult contrasts to ungrammatical utterances. *Negative evidence* was thus defined as a contrast between the child's and caretaker's language in the target phenomena, independent of specific lexical items. For example, if the child neglects to use a determiner in a noun phrase the parent might expand it. This could potentially be a contrastive source of negative *evidence* rather than explicit negative *feedback*, as described in the introduction. Saxton found that children used the correct form significantly more frequently after negative evidence than after adult move-ons (this counters Morgan et al., 1995). However, correct usage after parental negative feedback *did not* differ significantly from after adult move-ons. Saxton further limited his analysis to all utterances occurring after the child reached 50% accuracy in each error (analyzing each kind of grammatical error individually). The justification for this is that the child is especially attuned to the relevant grammatical structure when she is beginning to use it with 50% accuracy. This further analysis obtained even stronger results, and both negative evidence and negative feedback differed significantly from adult move-ons in inducing correct usage by the child.

Chouinard and Clark (2003) provide a theoretical position much like Saxton's, and Clark (1987) provided an early precedent to this contrast theory of input. The authors conducted an analysis of both English and French child-language corpora. They investigated three-sentence exchanges between the child and parent: child conventionality or unconventionality, parent reformulation/reply, and child response. Unconventionality was simply defined as straying from the expected conventions of any level of organization, including phonological (e.g., "girl dere"), morphological (e.g., "three bird"), lexical (e.g., "suit" instead of "coat"), and syntactic (e.g., "sun gone"). Next, Chouinard and Clark provided *reformulation* as a broad category of adult response that identifies the *locus* of a violation. This simply means that the adult need not repeat verbatim the structures used by the child, but only reformulate target structures in an appropriate way. The second kind of adult response coded was utterance *replays*, defined as repetition of the child's grammatical utterances. Finally, the child's next response was coded for taking up the reformulation, persisting in the error, or ignoring it and continuing conversation. Results of the analysis are rather impressive. Parents *within all children* provided considerably more reformulations of unconventional utterances than they did replays of conventional ones. This also occurred across error types (phonological, etc.). Finally, it appeared that children took up the correction more frequently than they neglected it. More commonly, however, children simply continued the interaction with the parent.

There appears to be impressive evidence that there exist sources of negative evidence for children. Contingent responding discovered by Hirsch-Pasek et al. (1984) *is a plausible source of constraint*, despite the negative assessment by others. Negative evidence can also be derived by contrastive forms used by the caregiver, as argued by Clark (1987) and Saxton (2000). It is interesting that once the constraint of contrastive adult forms emerges, indeed akin to generalized patterns of imitation, it may become an effective contingency for influencing the development of grammatical behavior.

Item-Based Learning

One of the earliest prominent characterizations of child language production was Braine's (1963; 1971) notion of a pivot grammar. This description of child's early language considered it to be largely composed of pivot words and open words which could occur as arguments of pivot words. For example, Braine's famous *allgone* is a pivot word that could be used with many open words: *allgone sticky*, *allgone*

milk, etc. Though many two-word utterances may take a form of this kind (Tomasello, 2003) and are potentially productive (Tomasello, Akhtar, Dodson & Rekau 1997), the pivot grammar framework fails to adequately capture a considerable amount of early production (Bloom, 1971). It also becomes difficult to understand how more complex grammatical behavior might emerge out of pivot grammars (Tomasello, 2003).

The idea that grammar begins in piecemeal fashion, with some words enjoying growing flexibility of usage through incorporating other classes of words as arguments, did not die with pivot grammars. Tomasello's (2003) recent book on language acquisition presents a very similar picture:

> *…usage-based approaches expect children's learning to be more gradual, piecemeal, and lexically dependent – with the acquisition of particular linguistic structures depending heavily on the specific language to which a particular child is exposed, and with generalizations coming only after a fair amount of concrete linguistic material has been learned. (p. 98)*

Tomasello's early book, an extensive analysis of his daughter's language acquisition, provided considerable momentum for this theoretical approach (Tomasello, 1992; 2003). He found that his child's early language was organized strongly around verbs. Each individual verb, according to his analysis, was an "island unto itself," being used in specific kinds of syntactic contexts. For example, the verb *cut* might be used in restricted simple contexts such as *cut book*, *cut paper*, etc. However, a similar verb, such as *draw*, may be more flexibly used after extended exposure. Such productive usage of one verb, in early language, *did not* immediately transfer to other verbs of a similar kind.

In a related study, Lieven, Pine and Baldwin (1997; see also Pine & Lieven, 1993) found that, in analysis of 11 children between the ages of 1 and 3 years, the first 25 fixed patterns of grammatical behavior could account for 60% of all the children's utterances in the sample. When these fixed patterns were included with non-patterned but possibly frozen utterances, over 90% of all utterances could be accounted for. Lieven, Pine and colleagues have more recently pursued the development of more detailed grammatical structures. Theakston, Lieven, Pine and Rowland (2002) found that the various senses of the verb *go* in analysis of these 11 children did not exhibit sophisticated categorical distinctions, but instead depended on the structure in which the verb is used, and the extent to which that sense of *go* is used by the caregiver in the input. Also, Theakston, Lieven, Pine and Rowland (2001) found that a good account of verb development was not so much syntactic complexity as the extent to which children were mastering differing lexical frames for different types of verbs.

Tomasello and colleagues have also thoroughly investigated the development of transitive verb constructions through experimental and observational means. In recent experimental studies, Childers and Tomasello (2001) and Abbot-Smith, Lieven and Tomasello (2004) found that 2.5 year-olds greatly improve their acquisition of transitive verbs through training. Over multiple sessions, children were exposed to differing training, depending on the extent to which familiar or unfamiliar verbs were used in a variety of contexts. Those children who heard the verb in multiple contexts were better able to employ the transitive structure in later testing. Brooks, Tomasello, Dodson and Lewis (1999), in an earlier study, demonstrated that children learning novel transitive verbs are unlikely to use this verb constructively, instead having it fixed in a certain grammatical pattern. Finally, Akhtar and Tomasello (1997) also demonstrated that in an act-out task, comprehension of novel verbs also seems to be constrained by the context in which they are initially learned.

Summary

Multi-word utterances are guided by social and experiential contingencies. Children are highly attuned to the language of their caregivers and are likely much influenced by it in their grammatical development

(Saxton et al., 1998; Saxton, 1997; Saxton, 2000; Chouinard & Clark, 2003, etc.). It seems plausible that both weak (Hirsch-Pasek et al., 1984) and fairly strong (Saxton, 1997; Chouinard & Clark, 2003) sources of *negative* evidence are playing a role in this development.

The growth of multi-word production appears to be constrained specifically by the input presented to children. Skill with syntax proceeds with verbs as concrete lexical "tools," occupying their own syntactic space. Only with extensive experience does this behavior become more abstract, akin to adult grammatical behavior (Tomasello, 2003). Fans of Wittgenstein may detect an echo of *Philosophical Investigations*, as Tomasello conveniently quotes:

> Our language can be seen as an ancient city: a maze of little streets and squares, of old and new houses, and of houses with additions from various periods; and this surrounded by a multitude of new boroughs with straight regular streets and uniform houses. (18).

Conclusion

Many theoretical approaches to language acquisition in the cognitive sciences have been drawn in the very direction that these broad predictions of behavior analysis recommend. Tomasello (2003), and numerous colleagues (e.g., Pine & Lieven, 1993), have contributed reams of research towards a usage-based account of language. Language is seen as crucially social, dependent upon basic learning processes and governed foundationally by social contingencies such as joint attending and "intentional" cues. Snow's (1999) multi-factor social-pragmatic approach takes as foundational the multiple variables influencing language acquisition, and Clark (2003) emphasizes the importance of pragmatics and broader social functions in acquiring language. Elman, at the level of brain-behavior interactions, sees language as guided by multiple interactions in a "conspiracy theory" of language development (Elman, 1999; Elman, Bates, Johnson, Karmiloff-Smith, Parisi & Plunkett, 1996), in which learning is a crucial property of explaining the growth language structure. Bates and MacWhinney (1987; Bates & Carnevale, 1993; MacWhinney, 1996) have reached the same conclusion, seeing language acquisition as driven by multiple sources of constraint in learning, and proceeding by being organized around lexical items. Smith (2000), as mentioned above, would also espouse the two broad predictions.

Recent behavioral theories of untrained responding by human subjects bear some resemblance to these theories on the basic theoretical level discussed here. In fact, the behavior analytic perspective as a whole embraces social contingencies as crucial to language learning. Skinner's early conception of verbal behavior used these contingencies as definitional of verbal behavior itself (Schlinger, 1995). In particular, relational frame theory (Hayes et al., 2001), for example, sees the relationships among responses (such as words in a sentence) as emerging through multiple-exemplar training. This theory's perspective of gradually emerging generalized relational responding is directly comparable to recent usage-based views of syntax acquisition (Tomasello, 2003). In addition, applied behavior analytic contexts have worked towards controlling these various contingencies and input variables to introduce or improve verbal behavior. Although developmental psycholinguists are less often guided by applied contexts, the data described above may offer bridges between the basic and applied contexts in behavior analysis.

Generically, at the very least, the data and conceptual directions of the reviewed cognitive research on language acquisition are perfectly consistent with behavior analysis. The details, however, may of course lead to disagreement – the extent to which mental constructs are invoked, how much rich foundational processes of language change are innate, to what extent functional analyses can explain the minutiae of word and syntax learning, among others. However, disagreement is something that often arises amongst various schools in the cognitive sciences. For example, an entire special issue in a prominent developmental journal has recently been devoted to reconciling dynamical and connectionist accounts of development (Spencer & Thelen, 2003; Thelen & Bates, 2003). On the basis of theoretical

and empirical disagreement, therefore, one cannot discount the potential contribution of any research on language acquisition that recommends such successful predictions as have accounted for the broad patterns of language behavior reviewed here. In fact, Thelen and Bates offer a list of properties that different developmental theories may or may not adopt, such as dynamical patterns of development, representational constructs, a role of social or environmental experience, to name a few. I added a behavioral entry to their table, and subjected these perspectives to multi-dimensional scaling, thereby reducing their 10 dimensions into 2, providing a picture of the proximity among these different perspectives (see Fig. 1). The behavior analytic perspective is not far off from some prominent cognitive theories on development. Chomsky's generative framework, in fact, seems one of the farthest.

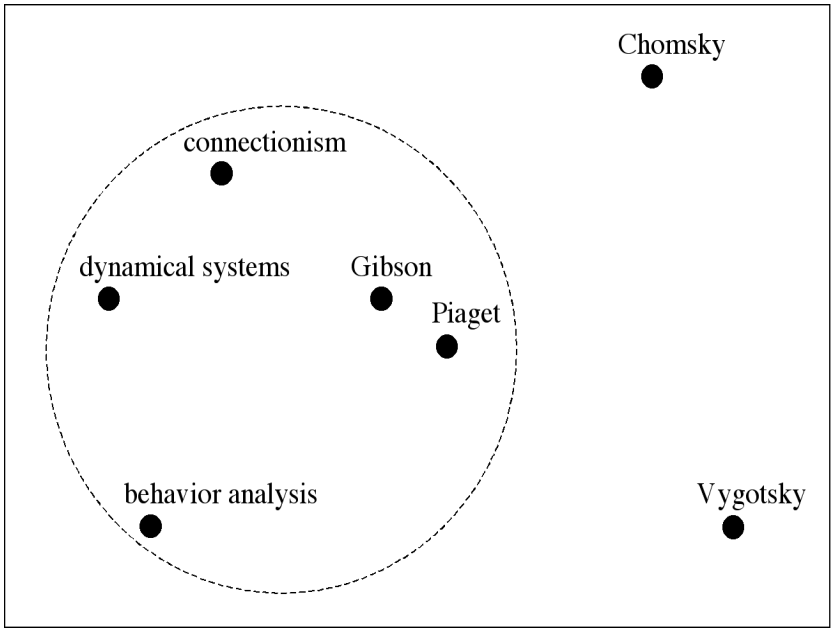

Figure 1: From many descriptive dimensions, multi-dimensional scaling can provide an approximate two-dimensional proximity solution for different perspectives on development (see also Edelman, 1998; Thelen & Bates, 2003).

At a smaller scale, within the behavior analytic approach, higher-order operant perspectives have recently also involved considerable disagreement. Naming (Horne & Lowe, 1996), Sidman's (Sidman, 1994; 2000), and relational frame theory (Hayes et al., 2001) have recently engendered considerable conceptual debate and discussion. Ironically, the latter framework, whose devotees are the most diligent at pursuing basic research on verbal behavior, is the one that has incurred the most acrimonious criticism. If I have contributed anything in this review, I at least hope to have laid out problems of theoretical and empirical detail in language acquisition that lie above these conceptual and empirical issues, thereby showing the inspiring support current cognitive research gives to behavior analysis, and perhaps establish some direction for integrating more complex patterns of language development into behavior analysis.

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