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8 Regression in the Service of Development

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Discontinuities in development highlight underlying developmental processes that are gradual. In this chapter I focus on such apparent discontinuities in the emergence of language and related skills. I demonstrate that a commonly proposed model of mental development is consistent with specific regressions in the child's manifest mastery of certain linguistic behaviors. I outline the application of this model to two primary language-specific capacities—the mastery of phonetics and the mastery of sentence processing. In each case there is an early emergence of a basic unit, followed by a behavioral differentiation of the component parts of that unit. In phonology this is reflected in the initial development of "syllables" and a subsequent differentiation of "phones" during the first year of life. In syntax it is the initial develoment of a "canonical clause" and subsequent differentiation of it into phrases and words between 2 and 8 years of age. In each case, the analytic phase of differentiation is accompanied by a temporary decrease, a "regression" in manifest language behaviors and capacities. Maturationally concomitant developments in nonlinguistic behaviors show that, in the normal course, linguistic development parallels other cognitive skills. The import of this is that language acquisition can be seen to be similar to the acquisition of all behavioral systems, rather than presenting a unique, modality-specific developmental pattern.

A General Property of Behavioral Development

Consider first a common taxonomic description of mental growth. In this model, the child starts at any given point with certain fundamental canonical capacities. These capacities are subsequently refined, in the course of which they become broken down into constituent capacities—ultimately the constituents are reintegrated into a deeper reconstitution of the original behavioral capacity.

Three kinds of superficially different models share this dialectical property; the *organic* Werner (1957), the *interactionist* Piaget (1950), and the *empiricist* Bruner (1977). Werner (1954) outlines a standard developmental sequence that pervades all aspects of mental development:

syncretic—analytic—synthetic

In the syncretic stage, a given skill (ranging from movement to thinking) is behaviorally expressed holistically—the child uses set global schemata for behavior and organization of his or her experiences. During the analytic phase the child focuses on the isolation of component processes of a skill, ultimately reaching a stage of resynthesis of them into an integrated capacity.

Piaget (1950) outlines a similar course for the emergence of each relatively stable mental system. He generally is concerned with the child's mastery of *a priori* conceptual categories, such as the notion of existence, number, space, and time. In each case the child starts with control over some canonical aspect of behavior, then differentiates separate components of that behavior via self-examination, and finally regulates the operation of the separate components by means of a conceptual schema that equilibrates the operation of the separate components.

The empiricist grants the child initial behavioral schemata (e.g., a global arm movement); these are supplemented with refined schemata based on experience (e.g., controlled finger–thumb opposition), which are ultimately arranged (albeit by wordly contingencies) into integrated behaviors.

The mechanism of conceptual and behavioral discovery differs in each of these cases from the relatively central to the peripheral; it is not important for the present discussion which of these views is correct, especially because they borrow from each other in critical ways. Rather, it serves the purpose of this chapter to note that each kind of developmental theory includes a typical tripartite description of development: The child initially utilizes a canonical behavioral form, analyzes it into constituents, and reintegrates them into a broader basis for the same class of behaviors.

Canonical Forms of Language

Spoken language systematically relates pairs of sounds and meanings. Accordingly, we organize our investigation of language development around the mastery of *syllables* and *sentences,* the canonical forms for the expression of sounds and meanings. In the following, I present case studies of apparent regressions in the acquisition of these forms, a brief survey of the infant's vocal development, and a detailed examination of the emergence of sentence comprehension. In each case, I argue that the "regression" in a manifest behavior is itself a function of maturationally progressive analytic processes.

The Emergence of the Phone in Infant Vocalization. The syllable is the ordinary minimal unit of speech sound that can be spoken in isolation. It has a straightforward acoustic definition—a sustainable speech sound that is bounded by nonsustained sounds. Under this description, possible "syllables" range from a single sustained continuant consonant (e.g., "s"), to a long diphthong surrounded by consonant clusters (e.g., "tfstroisplts"). Inasmuch as all vowels are continuant and have much more sustained speech power than other continuants, the typical center of a syllable is a vowel; the typical syllable boundary is a consonant. Accordingly, the canonical syllable has the form CV(C).

Each language has its own canonical syllabic structure, which the child ultimately masters. We can study the early stages of this process by examining the vocal output of the infant during the first year of life. A classic study of the phonetic development of the child's repetoire is that of Irwin and his colleagues (1946). Although their methods depended on phonetic transcription, they are adequate for the purpose of exploring such features as the development of syllables and consonants.

The data reveal two periods of expansion in the infant's phonetic repetoire, from 1 to 3 months and from 4 to 9 months. (An exhaustive analysis of Irwin's data is presented in Bever, 1961.) During the first period the typical vocalization is a vowel surrounded by two glottal stops or glottal continuants. The main differentiation during this period is in the variety of vowel sounds. During the fourth month, the child's vocal output stops increasing and differentiating. This regression reverses in the next month, when the consonant sounds differentiate—now the child characteristically produces strings with different consonants and the same vowel, as well as consonants in isolation. In light of the tripartite developmental schema outlined above, we can interpret this as a shift from the production and differentiation of complete syllables to the elaboration of component parts of syllables.

Recent work on the perceptual differentiation of speechlike sounds by infants is consistent with this interpretation. For example, Mehler and Bertoncini (1978) report that newborns respond differentially to distinct syllables (e.g., *pat* versus *tap*) better than to nonsyllabic consonant sequences that differ in the same way (e.g., *pst* versus *tsp*). Similarly, a variety of studies have shown that infants discriminate consonant transitions when they are placed in the context of a syllable but do not discriminate the same transitions out of context (see Juczsyk [1980], for a recent review).

Concomitant Behavioral Developments. I have isolated two periods of expansion of the phonetic repetoire, interrupted by a period of relative vocal quiescence around age 3 months. Our interpretation suggests that the first period corresonds to a "syncretic." syllabic stage, whereas the second period corresponds to a more analytic, phone, stage. Other behavioral changes during the same period illuminate the related neurological developments associated with this shift. For example, Lewis (1954) delineated two phases of vocal "imitation" by the infant, with an intervening period with no imitation. At 1 to 3 months, the infant produces approximate imitations of adult vocalizations; at 4 months the infant stops imitating entirely and then starts to produce more refined imitations at 8 to 9 months.

Numerous other behaviors show a similar regression in their development around age 3 months. For example, the grasping response, the tonic neck reflex, the Moro response, and the plantar/dorsal response ratio all decrease sharply at that age, with certain replacement behaviors emerging at age 5 to 9 months, where relevant. (See Bever, 1961; Maratos, this volume; Prechtl, this volume).

All these behavioral regressions can be interpreted as reflecting an increase in the extent to which behavior is organized at the cortical level. In this view the period of "developmental quiescence" at the end of the third month reflects cortical inhibition of the lower brain systems, without developed structures with which to replace those systems. (McGraw, 1946). Accordingly, the shift in vocal development could be interpreted as "caused" by the shift from reflex to cortical organization of behavior. However, the matter is undoubtedly more complex (see Lecours, this volume). One could also argue that analytic phonetic differentiation is the developmental stage that must follow the syncretic syllabic stage, rendering cortical activity relatively more important.

The Perception of Canonical Sentences. A characteristic function of language is to represent propositions. The sentence is the minimal independen linguistic unit that expresses a proposition.

The notion of a "sentence" is similar to that of a syllable, in the sense that it is the proposition-bearing structure that can be uttered in isolation; many phrases exist that unambiguously express a complete set of propositional relations (e.g., deverbal noun phrases in English, "the mooing of the cow" . . .). But these sequences cannot stand alone as separate utterances. Only a specific subset of proposition-bearing sequences can stand alone—the sentences. In fact, we must *define* the sentence as the unit that can be uttered alone and that native speakers perceive as presenting phrases that have basic propositional relations to each other (*actor, action, object, modifier*) (Wundt, 1914).

Each language has its own "canonical" sentence form (Greenberg, 1961). In English it is "actor, action (object)." with an explicitly tensed verb. It would be easy to think that such an order reflects and is caused by the "natural" order of thoughts (Bruner, 1974; McNiell, 1979; Osgood, 1977). Many languages (e.g., Turkish) have different canonical sentence orders, so this cannot be an overriding universal principle. However, the proposal that there is a psychologically natural order of linguistic elements partly defines the problem I focus on in this section. I suggest that the young child acquires a set schema that represents his or her interpretation of the canonical sentence in his or her language. As he or she matures, this schema is analysed interally, and distinct subparts are differentiated, both clauses and phrases within clauses. As these components become differentiated, the natural behavioral order constraints can take effect; accordingly, older children are more sensitive to such natural-order constraints than are younger children.

Early Canonical Sentence Comprehension

Certain evidence indicates that children develop a canonical sentence schema at an early age. The basic technique we have used to investigate this is an "acting-out" sentence comprehension paradigm, developed by Bever, Mehler, and Valian (Bever, 1970a). Children characteristically are presented first with a number of intransitive sentences, such as "the pig is sleeping," "the rabbit is hopping," etc. In each case, the child is to pick the corresponding toy animal and make it "act out" the sentence. After this common training on how to act out intransitive sentences, the experimenter shifts to the more complex sentence forms of interest.

In our first studies we focused on the child's comprehension of reversible and nonreversible active, passive, and cleft sentences. "Reversibility" refers to the semantic possibility of having either the object or the subject of the sentence be the actor (e.g., "the cow kisses the pig"). Irreversible sentences of two types occur, semantically normal ("the policeman eats the candy") and semantically absurd ("the candy eats the policeman"). Table 8.1 presents the percentage of 2-year-olds who correctly acted out each sentence type.[1] Two-year-olds perform randomly on passives and subject-initial cleft sentences, regardless of semantic constraints. However, it is remarkable that children as young as 2.0 perform correctly on active sentences and on object-initial cleft sentences. Two-year-olds, however do not correctly comprehend passive and subject-first cleft sentences. In fact they perform at a chance level, both on the passive and on the subject-first cleft sentence.

It is appropriate to conclude that the 2-year-old child uses a fixed template for sentence processing:

$$NP\text{–}V\text{–}(NP) = actor\text{–}action\text{–}(object)$$

Only sentences with this superficial form can be processed at all. Because the passive and subject-first cleft sentences do not conform to this template, the child performs randomly on them. The hypothesis that the child uses a canonical template is further supported by the fact that performance on object-first cleft sentences is *better* than chance during the second year. This is explained by the fact that the child can treat such sequences as "it's *NP* that *NP–V*," by ignoring everything but the last *NP–V* subsequence: That part of the sentence conforms to one of the two versions of the canonical sentence, allowing the child to comprehend the *actor–action* relation and act on the other animal as the object by a process of elimination.

These results have been replicated in various ways, (e.g., de Villiers & de Villiers, 1978; Maratsos, 1977). It is important to note that differences in methodology can increase or decrease the child's apparent overall linguistic

[1] Characteristically we accepted any approximately correct action as "correct"; For example, young children often interpret the verb "lick" as though it were actually, "bump hard with the nose." Our main focus was to determine which noun was chosen as the actor and which as the object. For further methodological details, see Bever (1970a) or Slobin (1978a).

TABLE 8.1
Proportion of Reversible Sentences Acted Out Correctly
by Children 2.0 to 5.8

(Taken from Bever, 1970, Figures 6 & 7)

	Simple[a]				Cleft[b]			
	N	*Subject First*	*Object First*	Δ	*N*	*Subject First*	*Object First*	Δ
2.0–2.7	25	66	58	8	30	87	73	14
2.8–3.3	34	70	34	36	21	81	65	16
3.4–3.7	32	73	39	34	28	89	69	17
3.8–3.11	34	80	63	16	32	96	55	41
4.0–4.3	35	87	56	31	34	96	76	20
4.4–4.7	25	90	62	28	21	93	82	11
4.8–5.7	43	97	92	5	30	86	86	−1

[a] Sample simple sentences—Subject first: the cow pushes the zebra
Object first: the zebra is pushed by the cow

[b] Sample cleft sentences—Subject first: it's the cow that pushes the gorilla
Object first: it's the zebra that the cow pushes

After 6 warm-up trials with making single, small toy animals act out intransitive sentences, children acted out three subject- and three object-first simple sentences or cleft sentences, presented in a pseudorandom experimental order. The simple-sentence and cleft-sentence experiments involved different children. Only actual responses are taken into account in this table.

capacity. For example, young children perform less well on all sentences if they are forced to choose between two pictures rather than act out the sentence (Turner & Rommetveit, 1967). We were primarily concerned with the child's pattern of the perception of grammatical relations and consequently accepted many approximate actions that other researchers might score as incorrect. Finally, our pretraining technique, in which children learned how to play the "acting-out" game with simple intransitive sentences, filtered out some potential subjects before they even came to the main experiment with transitive verbs. In fact, we were unable to use 12% of the 2-year-old subjects because they did not succeed at the intransitive-verb task. Nevertheless, even these children may have been able to understand the sentences in general, but not in our laboratory: The experimental setting upset some of the children, some should have been taking a nap, were hungry, sick, etc. In brief, the preceding results should be interpreted as bearing on the child's pattern of discriminating the actor from the object of a sentence, *not* an assessment of the child's absolute linguistic capacity.

Our results showed that the 2-year-old child has a remarkable capacity for the actor/object discrimination. I have interpreted the child's early capacity to distinguish the actor from the object as the result of the *NP–V–(NP)* canonical template that reflects the dominant surface word-order pattern of English (Bever, 1971). As I mentioned previously, this cannot be proposed as a structural *linguistic* universal, because some languages may have common forms in which the object precedes the subject. However, the notion that the subject precedes the object because that order corresponds to the way we think about the world has a certain intuitive appeal. In this view, the child builds up a structural *NP–V–NP* expectation, based on the order in which he or she thinks of the corresponding concepts. Several researchers have argued that the *actor ... object* order is behaviorally natural because of the fact that actors are characteristically animate and therefore characteristically have an intention to act *before* they do so. (See, especially, Bruner, 1974) In this view, the speaking child starts out thinking about the actor's intention—this makes it most natural to express the actor as the first noun in the sentence. Although such a description cannot account for *all* sentences (e.g., those depicting unintended acts), the claim is that such sentences are relatively rare. Osgood and Bock (1977) have embedded the natural-order hypothesis within more technical models of speech processing, with much the same theoretical result. They furthermore examined a number of languages and concluded that the natural *actor ... object* order is followed in the majority of cases. This is strong presumptive evidence for the existence of such a behaviorally natural order.

My later analyses depend on the assumption that the child's first stage of canonical sentence comprehension relies on a *structural* template, rather than on such a behaviorally based predisposition. It is necessary to consider the inadequacies of the "natural-order" hypothesis as applied to the child's comprehension of simple sentences. First, this position cannot explain the young child's relative success with the object-first cleft sentences, inasmuch as they specifically violate the natural order. Second, we would expect the child's performance on subject-initial cleft sentences to be as good as on simple actives, rather than at chance level. Third, performance on passives should be systematically reversed, as opposed to being at chance level. Finally, we would expect the young child's performance to be influenced strongly by the relative semantic probabilities: On the naturalness hypothesis, it is the overall semantic organization that is the ultimate cause of the standard word order. Nevertheless, the young children are relatively unaffected by the semantic constraints as we manipulated them.

In sum, the pattern of comprehension in the young child is inconsistent with the natural-order hypothesis. We can also utilize a direct behavioral experiment involving sentence processing to demonstrate the structural basis of the canonical sequence. We presented young children with reversible sentences containing a subject or object relative clause, as shown in Table 8.2 (Townsend, Ottaviano, & Bever, 1979). These sentences have a superficial *NVN* sequence initially (in subject relatives) and finally (in object relatives). One second after each sentence, the child was presented with a probe word (a verb) and asked if it had occurred in the sentence. The results showed that the youngest children responded relatively quickly to verbs located in the surface sequence that conformed to the canonical-sentence structure. Clearly, this result does not depend on the semantic sense of the sentences, but on the extent to which they exhibit *apparent* canonical sequences. (We return later to the performance of older children and adults on this task).

A different way to demonstrate that the canonical sentence is defined structurally rather than in terms of semantics or word order is to use non-English sentences that preserve potential semantic patterns and relative order of the subject and object. This can be achieved by presenting children with *NP–NP–V* and *V–NP–NP* sequences. We did this on the same kind of acting-out task as described previously, and found that children perform randomly throughout ages 2 to 4 (Table 8.3). (The basic pattern is replicated in Slobin & Bever, 1981.)

TABLE 8.2
Reaction Time (Seconds) to Recognize Probed Verbs in Complex Sentences With and Initial and Final *NVN* Sequence
(Taken from Townsend et al., 1979, Table 1; 12 3-year-old Subjects)

	Initial V	*Final V*
V in *NVN* sequence	2.29–*SR*[a]	2.18–*OR*[b]
V not in *NVN* sequence	3.29–*OR*[b]	2.67–*SR*[a]

[a]Subject Relative (*SR*): *The owl scratched the fox* that touched the monkey.

[b]Object Relative (*OR*): The owl that scratched *the fox touched the monkey*.

(The superficial *NVN* sequence is underlined.)

Subjects heard each sentence, followed by a probe word. They responded "yes" or "no" to indicate whether the probe word was, or was not, in the sentence. The critical positive probes were the first-clause or second-clause verb ("scratched" or "touched") above.

TABLE 8.3
Percentage of Initial Nouns Taken as Actor in Acting-Out Task

Age	*N*	*NNV*[a]	*VNN*[b]
2	18	51	46
3	21	43	42
4	12	43	49

[a]NNV–"the cow the horse pushes"
[b]VNN–"pushes the cow the horse"
The procedure was similar to that described in Table 8.1.

Random performance on these nonsentential sequences, even at the oldest age (4), is startling, inasmuch as each sequence does correspond to a possible within-sentence arrangement. *NP–NP–V*, appears in relative clauses ("the horse the cow licks . . .), whereas *V–NP–NP* appears in indirect object constructions ("give your dog a bone") and in questions with "be", and "have" ("has the dog a bone?"). Apparently, even a 4-year-old child cannot generalize from these constructions to interpret the test sequences systematically. In our interpretation this is because the test sequences violate one or another canonical sentence feature. The relative-clause sequence can never appear as an isolated sentence. The imperative indirect-object sequence does not present an uninterrupted *V–NP = Action–Object* sequence; the transitive *"have + NP + NP"* questions are limited to just "have" and "be".

We also can consider sentence comprehension in other languages, which have different kinds of canonical sentences. For example, Sinclair and Bronkhart (1972) found that French children perform randomly on acting-out sentences that did not have articles and inflections on the verb. (e.g., *"garcon pousser fille"*). Because French word order is like that of English, in this case the natural-order hypothesis has the same difficulty in accounting for the result: Even though the word order represents the canonical "actor–action–object" sequence, the sentence fails to have a criterial property of a French sentence—determiners and inflectional endings. Accordingly, young children cannot perform at all systematically on such sequences.

Certain languages allow us to show that the canonical-sentence form acquired by children does not necessarily depend on fixed word order. For example, in Turkish all six orders of *actor, action,* and *object* are linguistically acceptable, so long as the object inflection is attached to the object noun (in definite noun phrases). This is reflected in the fact that 2-year-old

Turkish children respond correctly to all word orders with an object inflection; at the same time, they perform randomly on all sequence orders when the inflections are deleted, despite the fact that there is a favorite grammatical order, *VNN*. (Slobin & Bever, 1981; Slobin, 1980). This result further disproves the natural-order hypothesis for the priority of actors before objects. Remarkably young Turkish children ignore word order and focus on the criterial clue—object inflection. In our interpretation, the Turkish child constructs an unordered canonical sentence scheme:

Ninf = Object
V = Action
N = Actor

It is the general thesis of this chapter that the 3 to 4-year-old differentiates the internal structure of the canonical sentence forms. During this phase we might expect the appearance of such mentally "natural" strategies as "the first noun is the actor." This strategy can appear only *after* the child has analyzed the internal structure of the canonical-sentence form. During the early period of its use, the canonical sentence is a syncretic whole, and does not afford the child any internal structure over which natural generalizations can be applied.

Several experimental results confirm this expectation. By about age 3½, children perform systematically *worse* on the passive and object-first cleft sentences (Table 8.1). The performance decrease in the passives has been replicated by several different investigators. The decrease in passive comprehension can be taken as an example of a "developmental regression." Although a regression, we now interpret it as a function of the*progressive* internal differentiation of the constituent phrases of a canonical sentence. Once the child develops an internal differentiation of the parts of the sentence, then the natural word-order constraint can have its effect. In other words, we can accept the naturalness hypothesis as a true fact about sentence processing, so long as we do not invoke it to account for the child's first sentential schemata. Once the child segregates the initial noun phrase, the naturalness hypothesis can apply, decreasing comprehension on passives and other object-first sentences and increasing it on subject-first sentences.

A developmental increase in the tendency to interpret the first noun as an actor also occurs in other languages. For example, children speaking German (Mills, 1979) and Hebrew (Frankel et al, in press; Frankel & Arbel, in press) show a tendency to take the first noun as the actor, except when there is an explicit object inflection on the initial noun. We found a similar result in Serbo-Croatian (Bever & Slobin, 1981; Slobin, 1981). Serbo-Croatian is particularly interesting because all sequence orders are grammatical. Furthermore, some noun-inflection systems do not differentiate subject and object, and some do. This makes it possible to test the separate effects of work order, subject inflection and object inflection. The basic findings are consistent with our interpretation of the English data. The 2-year-old Serbo-Croatian children respond systematically only to the sequence in the *NVN* form.

As shown in Table 8.4, children 2.0 to 2.7 respond randomly if the inflected noun phrase is initial (regardless of whether it is inflected to be subject or object), and they choose the first noun as the actor if the first noun is uninflected, regardless of whether the final noun is inflected and in which way. The conclusion from this is that the child starts out with a canonical-sentence form:

$$N\ (\text{not infl}) - V - N = \textit{Actor—Action—Object}$$

Sentences departing from that form are acted out in random order. The *NVN* sequence is the dominant order in adult speech, which may explain why it is

TABLE 8.4
Percentage of Initial Nouns Chosen as Actors in Acting-Out Task in Serbo–Croatian
(From Slobin and Bever, 1980)

		Final Inflections		*Initial Inflections*		*No Inflection*
Age	*N*	*NVO*	*NVS*	*SVN*	*OVN*	*NVN*
2/0–2/7	16	72	67	50	47	67
2/8–3/3	16	78	44	82	13	74

NVO Dete HRANI PSA "The CHILD feeds the dog"
NVS PAČEL jubi devojčica "The girl kisses the duckling"
OVN Čoveka grebe Pile "The chicken scratches the man"
SVN Lovac juri jagnje "The hunter chases the lamb"
N = noun without an explicit suffix
S = noun with explicit subject-marking suffix
O = noun with explicit object-marking suffix
Same procedure as described in Table 8.1, with native speakers of Serbo–Croatian in Yugoslavia.

salient for the child. Furthermore, the fact that the child must master many different inflections and also accept sentences with no inflections may explain why there is an early dependence on word order.

It remains to be seen why the Serbo–Croatian child responds systematically to sentences with no initial inflections. One possibility is that the confusing and ambiguous nature of inflectional endings in Serbo–Croatian makes sentence processing impossible if the initial noun phrase presents an ambiguous inflection. A fixed word-order schema would render irrelevant any inflection on the final noun phrase. This restriction demonstrates that the 2.0 to 2.7-year-old is *not* using the natural-order strategy, inasmuch as that would apply to all sentence types (especially those with initial subject-inflected nouns).

This interpretation is supported by the later developments in the child's comprehension patterns (Table 8.4). The natural word-order strategy becomes extremely strong by age 2.8 to 3.3, *except* in the case of inflected object-initial sentences. That is, as in German and Hebrew, the initial-object inflection becomes particularly important and has much more effect in blocking the natural-order strategy than does a final-subject inflection. In Serbo–Croatian, this may be because a final-subject inflection cannot block the left–right application of the natural-order strategy until the very end of the sequence, after the strategy has *already* applied.

Turkish sentences (of the sort we were studying) always present an object inflection. Is there any evidence of the order strategy appearing at the ages corresponding to its appearance in other languages? A weak effect exists, but only for the uninflected (i.e., ungrammatical) *NNV* sequences. This suggests that when the Turkish child differentiates an interal analysis of the canonical-sentence form, the unambiguous clarity of the omnipresent object inflection blocks the natural word-order strategy (see Slobin & Bever, 1980).

In brief, the natural-order strategy can be interpreted as available to the child only after he or she has analyzed the internal structure of the canonical sentence into phrases, and only if the structure of the language allows some ambiguity of propositional relations.

One of the most startling results was the fact that the young children often indicated that they were aware of the oddness of semantically irreversible sentences. For example, one 2-year-old responded to "the candy eats the policeman" by picking up the candy and bouncing it all over the policeman. When asked what happened, she reported, "it ate him," and announced, laughing, "the policeman's inside the candy's tummy. That's silly."

Differentiation of the phrases internal to a sentence makes it possible for the 3-year-old child to respond with sensitivity to the semantic implications of the opposite word order. For example, the child can now consider as separate phrases "policeman," "candy," and "eat," comparing the relative likelihood of either noun phrase as the actor. This differentiation underlies the increased sensitivity to semantic constraints as the child gets older. This too, can be characterised as a regression in the child's ability to process semantically unlikely sentences. (Table 8.5). However, we see that it is a natural consequence of the internal differentiation of the parts of the sentence, making it possible to consider alternate propositions made up of the same phrases. Such an interpretation resolves a puzzle implicit to the anecdote about the young child who noticed that it was funny that the candy would eat the policeman, even as she was correctly acting it out. In an earlier discussion of the young child's insensitivity to semantic constraints, I argued that young children simply do not know enough about the world to apply such constraints and that only by age 3½ have they accumulated sufficient worldly experience (Bever, 1970a). This unlikely hypothesis has been questioned by some (Macnamara, 1972) on the reasonable grounds that even young children know a great deal about the world, especially the part of the world we were testing. It is reasonable to claim that a young child knows that candy usually is eaten, and does not do the eating. Our own subject indicated this by her humor at the reverse situation. The present explanation for the emergence of semantic strategies in comprehension is that the young child cannot make use of his or her knowledge in sentence comprehension because the sentence is treated as an impenetrable object that does not allow the child to consider

TABLE 8.5
Percentage Correct on Probable and Improbable Active Sentences
(From Bever, 1970)

Age	*N*	*Probable*[a]	*Improbable*[b]	*Probable–Improbable*
2	83	80	68	12
3	79	88	49	39
4	77	90	57	33
5	24	100	75	25

[a]Probable–the policeman eats the candy
[b]Improbable–the candy eats the policeman
Same procedure as described in Table 8.1.

any alternative interpretations to the one specified by the canonical structure. The older child has available an analysis of the separate phrases, can consider alternative interpretations, and responds according to the more natural constraints.

The differentiation of Interclause Relations. The previous investigations focused on the isolation of semantic relations within clauses. Given that recursion is an essential feature of language, it is important to investigate the child's comprehension of the relationship between clauses. Here too, we can anticipate the possibility that the child starts out with a canonical-structural schema governing the relationship between clauses. As he or she analyzes the internal structure of the schema, so that the clauses are assigned separate representations, natural-order strategies can come into play.

Temporally related clauses with the conjunctions "before" and "after" offer a distinction similar to that between structural organization and natural order in the interpretation of within-clause grammatical relations. In structural terms, the meanings of the conjunctions specify exactly the order of the events mentioned in the clauses and also specify which clause is main and which subordinate. In behavioral terms, there is a principle of natural temporal order that has been suggested (Clark & Clark, (1968); Townsend & Bever, (1978). On this principle the order of the clauses most naturally corresponds to the order of the events described. Indeed, Clark and Clark (1968) have argued that the basic strategy that children use to interpret temporal sentences is the temporal-order strategy. We can formulate it as the following:

First clause = first event

The temporal-order strategy involving relations between clauses is *prima facie* similar to the word-order strategy within clauses. Accordingly, we would expect that 3 to 5-year-old children would be particularily susceptible to it, whereas younger children would not. We found that the temporal-naturalness strategy does characterize the comprehension of complex sentences at age 3. Children acted out two-clause intransitive sentences like those in Table 8.6. The results are also summarized in Table 8.6. We found that the sentences that conform to the naturalness constraint are consistently responded to better by age 3. (In these experiments we counted only those responses in which both actions were acted out, because we were primarily concerned with order comprehension. As before, we also accepted under-

TABLE 8.6

Percentage Correct Action Orders in Two-Clause Sentences (Only Case Where Both Clauses Were Acted Out)

Age	N	After S_1, S_2[a]	S_2 After S_1[b]	Before S_2, S_1[c]	S_1 Before S_2[d]	E After	E Before	E is in Natural Order		E not in Natural Order	
2	16	53	50	66	65	52	66	14	59	58	1
3	18	68	34	53	71	51	62	11	70	44	26
4	22	95	43	61	95	69	78	9	95	52	43

[a] After S_1, S_2 (Natural order)—after the cow jumped the pig ran

[b] S_2 after S_1—the pig ran after the cow jumped

[c] Before S_2, S_1—before the pig ran the cow jumped

[d] S_1 before S_2 (Natural order)—the cow jumped before the pig ran
Similar to the procedure described in Table 8.1.

standable variants on the actual actions performed by the child. Finally, we acted out the two choices for the child, if he refused to act them out himself—the order of presented choices was randomized).

Two-year-old children, however, show no effect of temporal order—rather they appear to find sentences with "before" easier than those with "after," independent of surface order. We argued that this reflects a canonicial complex-sentence form:

Main clause = Main event
Subordinate clause = subordinate event

which, in the case of temporally ordered events appears as *Event 1–Event 2*. That is, the 2-year-old recognizes that there are separate events in a main and subordinate clause, but does not attend to their relative position in the surface order. Rather, he or she is using an unordered canonical complex-sentence strategy which is appropriated for sentences with "before":

NP V (NP) = main event = first event
CONJ + NP V (NP) = subordinate event = later event

Feagens (1980) found that young children also perform well on sentences with "until," which is temporally similar to "before." As the older child analyzes the internal structure of the complex sentence into two sequential separate clauses, then the natural-order hypothesis can apply, leading him or her to understand the order of events according to the order of mention. This development leads to a *decrease* in the developing child's capacity to act out sentences that do not conform to the temporal-order strategy. However, this regression is appropriately interpreted as the result of a progressive differentiation of the internal structure of complex sentences into separate clauses. Once clauses are segregated as separate parts of a sentence, the effects of order of mention can follow "naturally" and determine the child's performance. (The shift to a temporal strategy in older children is also reported by Feagens.)

We also kept careful track of the number of refusals on each sentence type and the number of instances in which only one of the two actions was acted out. The 2-year-old children acted out both clauses in "before" and "after"-sentences with the same overall frequency (39%). However, the distribution of the incomplete responses further supports the canonical complex-template interpretation. The main clause is acted out alone three times as often as is the subordinate clause.

The temporal-order strategy has an intuitively clear basis in speech behavior—we tend to think of events in the order in which they are presented to us. Furthermore, order of events is one of the most basic ways in which propositions are related in discourses. Another central interpropositional relation is *cause–effect*. (Townsend & Bever, 1978) We have not studied this experimentally ourselves. However, Piaget (1950) reports that children go through a phase of saying sentences like "we're in a tunnel because it's dark in here" or "I'm in the water because I'm wet." In these cases the child maintains a cause–effect order of propositions despite the fact that the conjunction structurally requires the reverse interpretation. That is, the child appears to use a natural causal-order strategy:

First clause = cause

This strategy is reflected in relative comprehension difficulty among adults of sentences that fail to conform to it. (Townsend & Bever (1978). My own observation is that the overriding effect of the clause-order strategy in the speech of children occurs during the third to fourth year. Younger children seem to grasp the correct causal relation of those cause–effect sentences they can deal with at all. This is consistent with the proposal that only by the fourth year do children clearly differentiate and focus on the first clause as part of a complex sentence. Two-year-olds seem, in contrast, to give greater relative weight to the most recent clause. For example, in the temporally ordered two-clause sentences, the second clause was acted out alone three times as often as the first clause (Table 8.7).

The emergence of focus on the first clause at age 4 is also born out by a version of the verb-probe test described in the foregoing. Subjects were presented with verbs following coordinate constructions; the verb was either from the first or second clause. Three-year-olds showed a clear recency effect—the most recent verb was the most quickly identified. Four-year-olds, however, strongly reversed this pattern. This overall developmental shift to relatively fast latency to initial verbs was found with several other two-clause constructions (Table 8.8). (Townsend et al., 1979).

Inter–Intraclause Relations: Pronouns. Whole clauses can be related by subordinating conjunctions such as "before" and "after." There are other kinds of connections between clauses; for example, pronoun relations that link a phrase in one clause to a phrase in another. The examples in Table 8.8 demonstrate pronominal constructions that we presented to children to

TABLE 8.7
Percentage of Types of Response to Temporal Sentences Produced by 2-Year-Old Children

	After S_1, S_2	S_2 *After* S_1	*Before* S_2, S_1	S_1 *Before* S_2
Both clauses	41	37	35	43
Only first clause	5	8	0	4
Only second clause	22	12	21	2
Refused totally	33	43	43	51

From the same experiment as in Table 8.6.

TABLE 8.8
Recognition Latencies (Seconds) to Verbs in Initial and Final Clauses
(From Townsend et al., 1979, Table 1)

		Coordinate[a]		*Comparative*[b]		*Temporal*		*Main–Relative*[d]	
		First V	*Second V*	*First V*	*Second V*	*First V*	*Second V*	*First V*	*Second V*
Age	*N*								
3	12	3.5	2.7	2.2	2.4	2.6	2.6	2.8	2.4
4	12	2.0	2.9	1.3	3.0	1.9	2.0	1.8	2.0
5	12	1.6	1.4	1.6	1.8	1.2	1.2	1.3	1.0

[a]Coordinate–the owl scratched the fox and he touched the monkey
[b]Comparative–the owl scratched the fox faster than he touched the monkey
[c]Temporal–after (before) the owl scratched the fox he touched the monkey
[d]Main-Relative–the owl (that) scratched the fox (that) touched the monkey
From the same experiment as presented in Table 8.2.

act out with toys. The child had two different toy animals in front of him or her at each trial. In each case, the question was, did the child choose one or two animals to perform the actions? For adults there is only one circumstance in which the choice of two animals is required—when the noun in an initial main clause precedes the pronoun in the following subordinate clause. All the other cases allow the pronoun to be interpreted as the same or different

TABLE 8.9
Percentage of Times in Which the Same Actor Was Chosen to ACt Out
Both Clauses of Sentences with Pronouns

Age			2	3	4
	Main Clause	Subordinate Clause			
(a)	Noun	Pronoun	54	66	45
	Pronoun	Noun	36	46	34
	Difference		18	20	11
	1st Clause	2nd Clause			
(b)	Noun	Pronoun	46	80	56
	Pronoun	Noun	44	34	21
	Difference		2	46	35

After (before) the cow jumped, he slept
After (before) he jumped, the cow slept
The cow slept after (before) he jumped
He slept after (before) the cow jumped
Same paradigm as in Table 8.6. Each subject was presented with each of eight possible pronoun–noun combinations with *Before* and *After*. Only sentences in which the clauses were acted out in the correct order are included.

animal. Table 8.9 presents the frequency with which, at each age, the child chose the same noun to carry out both actions.

We restrict our discussion to the cases in which the child acted out the clauses in the correct temporal order, inasmuch as the interaction between acting-out order, structure, and in correct order could be quite complicated.

Two aspects of the main/subordinate clause relation appear to determine the child's choice in those cases where adults would have a choice. At all ages the child shows some relative tendency to match the noun and pronoun when the noun is in the main clause and the pronoun is in the subordinate clause (Table 8.9a). Furthermore, an order strategy emerges, by the third year, of matching the noun and pronoun relatively more often when the noun precedes the pronoun (Table 8.9b). This also reflects the child's shift from relating clauses by sensitivity to a subordinate marker to relating them in terms of their serial order.

The Differentiation of the Sentence Constituent. I have suggested that several apparent regressions in the child's ability to comprehend sentences are in fact due to a progressive development of an internal analysis of the canonical-sentence form. The internal differentiation of *parts* of sentences make the sentences vulnerable to the overriding effect of natural order and semantic constraints, which in turn can lead to decreased performance on those constructions that do not conform to the natural order or likely meaning. If the child is developing an internal differentiation of sentences, we should be able to observe changing patterns in how he or she processes sentences for purposes other than comprehension. In particular, we should find systematic patterns in the way he or she organizes linguistic material in immediate memory.

We tested this prediction in several ways. First, we studied the ability of children from ages 3 to 6 years to repeat simple three-word sequences. We used four kinds of sequences, as shown in Table 8.10, all of which drew on the same set of words, arranged in one of four ways: sentences, backward sentences, word-class paradigms, and "random." The "forward" sentences were of the form "adj-noun-verb." This form was not the simplest canonical-sentence structure. We used it, however, because the normal three-word canonical sentence (e.g., "boys like girls") is also well formed when uttered backward. Our purpose in including the backward sequences was to isolate the effect of syntax, as opposed to an effect of words that are related in a semantic field. The paradigm and the random sequences were included to isolate the effect of word class itself. Finally, we isolated the effect of the semantic field by comparing the performance on those sequences that are unified in such a field (the forward and backward sentences) with those sequences that are not united in such a field (the random and paradigm sequences).

TABLE 8.10
Percentage of Words Recalled for Each Type of Word Sequence

Age	*N*	*Sentence (S)*[a]	*Backward (B)*[b]	*Paradigm (P)*[c]	*Random (R)*[d]	*Effect of "Word Order" S–B*	*Effect of "Word Class" P–R*	*Effect of "Semantics"* $\frac{(S+B)-(P+R)}{2}$
3	23	32	33	18	15	−1	3	11
4	24	40	23	23	22	17	1	11
5	19	38	33	27	28	5	−1	8
6	17	44	38	33	25	6	8	12

[a] Sentence: nice boys laugh small cows eat green leaves grow

[b] Backward: laugh boys nice eat cows small grow leaves green

[c] Paradigm: laugh eat grow boys cows leaves nice small green

[d] Random: laugh boys small green grow cows leaves nice eat

Subjects were presented for immediate recall with nine-word sequences, one from each of the types exemplified, in a random order across subjects.

Each child was presented with three sequences of each type at once, with a pause after each triplet (for a total of nine words in each stimulus). The sequence types and the sequences within each type were presented in varying orders, counterbalanced across age and sex.

The results show that children reached a ceiling of about one sentence correctly recalled by age 4 (Table 8.13). Their performance on the other sequence types developed much more slowly. In fact, performance on backward sentences was *worse* at age 4 than at age 3, and performance on random sequence was worse at age 6 than at age 5. We also examined the separate effect of word order, semantic field, and word class. Semantic-field effect is greatest at age 3, word order at age 4, and word class at age 6. This relative order of structural properties is consistent with our findings in the sentence-comprehension tasks reviewed previously. The absolute age, however, is about a year older than for the effects we found in those experiments. This might be because sentence repetition is a less natural task than sentence comprehension or because the grammatical sentence form we used was not the simplest canonical one.

These results indicate the following: At age 3 the child treats the repetition task primarily as a problem in isolated word recall, making use of the semantic connectedness among the words. At age 4, word order is dominant when it corresponds to a possible sentence. *Ex hypothesi,* this reflects the emerging isolation of the separate words as distinct parts of each sentence, in distinct locations. By age 5, semantic effects do obtain, even when the sequence is not an actual sentence (as in the backward sequences). Finally, at age 6, the child is able to make use of word-class information as an aid to recall: The developing internal analysis of parts of the sentence has progressed to the point where the internal structure of different words is being learned.

The emergence of a focus on the word, as opposed to the complete sentence, can be tested in another way. We adapted a technique of Savin and Bever (1970) to extract information about the relative ease of thinking of the beginning of a sequence in terms of the first word, or in terms of the first word of a particular sentence. The technique is to present subjects with sets of three-word sentences, such as those in Table 8.11a and b. The listener's task is to press a key as soon as he hears a target sentence—he or she is informed of the target either as "the story, 'boys kiss girls'," or as "the story that begins with the word 'boys'." All the sentences are three-word "subject–verb–object" sentences, so the structure of the target sentence is always predictable. Furthermore, the subject is told that the target is the *only* sequence that begins with the word "boys." That is, the two kinds of instruction are logically *identical* in these materials, and the listeners know this. Table 8.11a presents the reaction times for the two instructions presented to college undergraduates. Despite their knowledge that the instructions are functionally

TABLE 8.11a
Latencies (msed) for Responses to Sentences, Given Initial Word or Whole Sentence as Targets (Eight Subjects)

Word Latency[a]	*Sentence Latency*[b]	*Word–Sentence Difference*	*Percentage of Subjects Having Positive Difference*
290	251	39	100

[a]Initial word target: "boys"

[b]Whole sentence target: "boys like girls"

Subjects hear a series of three-word sentences, listening for a particular target sentence. When the target is heard the subject purshed a button. The given targets were either the entire sentence ("setence latency") or only the first word ("word latency").

TABLE 8.11b
Latencies (msec) for Responses to Sentences, Given Initial Word or Whole Sentence Targets, for Subjects of Different Ages

Age	*N*	*Word Latency*	*Sentence Latency*	*Word-Sentence Difference*	*Percentage of Subjects Showing Positive Difference*
4	17	1255	993	+262	71
5	22	795	892	−97	46
6 + 7	26	541	609	−168	39
8 + 9	19	409	441	−32	47
10 + 11	35	329	322	+7	63

Same procedure as described for Table 8.11a.

identical, adults respond faster with sentence instructions than with word instructions. This is particularly striking because their response time characteristically is faster than the time it takes to complete the word "boys." That is, *thinking* about the initial word as the first sounds of the anticipated sentence leads to faster response times than thinking of it as the initial word of *some NVN* sentence, even before the word is over. Another way of putting this is to say that in these experimental conditions (McNiell & Lindig, 1973) the sentence is a more accessible level of linguistic processing than the word.

We adapted this technique for use with children between the ages of 4 and 12. We built an electrically triggered jack-in-the-box, which jumped out when the child hit a button at the right time. This maintained the younger childrens' interest in the reaction-time task. Each younger child was told that the jack-in-the-box liked to hear certain stories and that the subject should hit the button as soon as the right story started, so that the jack-in-the-box could hear it too. The experimenter told the child before each trial what the next target story would be—sometimes presenting it in terms of the initial word, "boys," sometimes presenting the entire sentence. Table 8.11b displays the mean reaction times on these tasks across age. Older children are increasingly fast on both tasks. Like the adults, the 4-year-olds are significantly faster with sentence instructions than with word instructions. Six-to seven-year-old children, however are reliably faster with word instructions. This is consistent with our claim that these children are going through a period of analyzing the internal structure of each sentence and of each word in the sentence—relatively speaking, children at this age tend to process sentences literally as sequences of words. Accordingly, the level of the word is more easily accessed than the level of the sentence.

Regressions in Cognitive Performance

The preceding discussion reviews a variety of developmental phenomena in language comprehension that are best understood as due to the 2- to 5-year-old child's increasing differentiation of the constituent parts of sentences. This phenomenon is not limited to linguistic development; rather it is characteristic of all aspects of cognitive development during this age period. (See also the chapters by Mehler and by Strauss, in this volume.) In each aspect, we find the same stages as in the development of sentence processing—an initial stage of fixed capacity, followed by a stage at which internal differentiation of the structure allows contingent generalizations to dominate behavior, leading to temporary regressions in manifest capacity.

Conservation of Inequalities. The acquisition of the ability to make relative numerosity judgments has been studied a great deal because of its centrality to the emergence of the concept of number itself. In this discussion I do not address the latter question, just as the preceding sections do not explore the child's acquisition of the concept of a structurally well-formed sentence. Consider the child's ability to maintain his or her perception of numerical inequality despite perceptually confusing transformations of stimuli. For example, if a child of 5 is presented with an array like that on the left in the following, he or she will volunteer that the top row has more and will maintain this even if the array is transformed so that it looks like the array on the right.

```
    0 0 0 0 0 0                    000000
   0   0   0   0               0   0   0   0
```

A 3- to 4-year-old child does not respond in this way. After volunteering that the upper row on the left has more, the child characteristically concludes that the lower row on the right has more, even though he or she has just observed its transformation from the row on the left. (Bever, Mehler, & Epstein, 1968; Mehler & Bever, 1967). Furthermore, the 2-year-old child performs like the 5-year-old on this task. Here we have an instance of a clear regression—the 3-year-old "loses" a capacity, and performs systematically worse than before.[2]

Our original interpretation of this phenomenon was that the 2-year-old was using a basic capacity that had specific limits on its domain of application. The 3-year-old was postulated to develop a perceptual generalization, "things that look bigger have more." Further research has suggested that the 2-year-old's capacity for relative numerosity judgments is sensitive to many minor stimulus and methodological variables. In my present interpretation the 2-year-old has available set schemata for assessing quantities; by age 3, the child's concept of quantity includes a differentiation of the internal constituents of quantified material. With such a differentiation, contingently true generalizations can be recognized (e.g., that larger things tend to have more constituents). Again, in our present reinterpretation, the 3-year-old child has differentiated the internal structure of a problem, allowing true generalizations over that structure to take effect. That is, the 2-year-old child is, by hypothesis, just as capable of learning such generalizations, but he or she cannot apply them to those objects and behaviors that are not yet internally differentiated.

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[2]Notice that this task can be interpreted as "conservation of an inequality relation," which might seem to have great implications for Piagetian interpretations of conservation experiments in general. I now think that the entire matter is muddled; in any case, it is not directly germane to the present discussion. The many replications of our original findings yield results that differ in a variety of ways, usually interpretable as due to differences in methodology or scoring technique. In particular, we were not concerned to use the standard test of conservation in which the child is presented with an "equal" array, and must maintain the report of equality under transformation. Our reluctance to use the equality relation is because the terms for expressing it ("the same") tend to be ambiguous; "same" might refer to physical identity or to numerical identity or to identity of constituent material. Use of terms like "same amount" may not resolve the ambiguity for a 2-year-old who does not understand "amount." Furthermore, the child must choose between three alternatives (the arrays are "the same" or "this one has more" or "that one has more"). It is no surprise that a 2-year-old cannot handle this level of complexity, just as he or she cannot comprehend subject-initial cleft sentences.

Second, we include in our studies only children who recognize the original relationship correctly—other researchers report results from *all* children they study, including those who may not have correctly perceived the relative amount in the first array. Obviously, this procedure deflates success at all ages, although it is not motivated by an understanding of conservation. Conservation requires that a child demonstrate that he maintains a relationship under transformation—if the child does not understand the original relationship between two arrays, how can he or she be expected to conserve it?

It is important to note, however, that other research does usually report a decrease in the child's performance from age 2 to 3, even if the 2-year-olds do not perform better than chance on the particular task.

Regressions in Learning Capacity

The research on the onset of nonconservation during the third year of life has a parallel form of argumentation to the research on the onset of perceptual strategies in sentence comprehension. In each case an internal analysis of the stimulus situation makes possible the effect of contingent generalizations, which are false in crucial cases, and which underly temporary regressions in overt capacity. In each case, I have attempted to show the inadequacy of our earlier hypothesis that it is the child's "discovery" of these generalizations that causes the regressions; in each case, I appeal to the internal differentiation of a set capacity as a precursor to the application of independently recognizable contingent generalizations.

We can test the child's proclivity to analyze the internal structure of situations in which there is no relevant contingent generalization. If the 3-year-old child exhibits an analytic predisposition in such situations, that will confirm our claim that this can underly the different behavior patterns of 2- and 3- to 4-year-old children. "Place learning" offers such a situation. The child is presented with two inverted cups on each trial; one cup has a reward under it, the other does not. The child is invited to pick up the cup he or she wishes on each trial.

This experimental version of "which hand has the candy?" can be deployed in a variety of ways. We first extended downward in age a series of experiments by Weir (1964), showing that older children tend less than younger children to "maximize" in a probability learning paradigm. In this paradigm one of the cups (e.g., the one on the left) has the reward more often than the one on the right, on a random schedule. The most rational strategy in this situation is to maximize (i.e., *always* to choose the more frequent cup).

TABLE 8.12
Performance on 5:3 Two-Choice Probability Place Learning

Age	*N*	*Trials to Maximize*	*Percentage of Subjects Who Maximize*	*Percentage of Subjects Who Minimize*	*Percentage Individual Maximizing Choices on Last 10 Trials*	*Percentage of Alternations*
2	16	17	63	18	75	20
3	30	—	47	0	68	43
4	6	—	17	0	57	66

On each of 40 trials subjects chose one of two inverted cups with different toy animals on them (e.g., a lion on the left and a zebra on the right). The maximizing cup covered an M & M candy 5/8 times, the minimizing cup the other 3/8 times, on a random schedule. Criterion for "maximizing" or "minimizing" was six choices in a row of the appropriate cup.

Children, however (as well as rats and many adult humans), often do not do this. Rather, they choose both stimuli to some extent. We used this paradigm with children aged 2 to 4, as a way of probing the child's internal representation of choice sequences. In our first study, we used a reinforcement ratio of 5:3 between the cups. Children were run through 40 trials, after the game had been explained to them. We found that the frequency of choosing the more probable cup was significantly higher in the 2-year-olds. (Table 8.12) Furthermore, significantly more 2-year-old subjects developed a maximizing strategy. (We defined *maximizing* as choosing the more probable cup six times in a row and *minimizing* as choosing the less probable cup six times in a row.)

We replicated this experiment, using a 5:4 ratio, to see how sensitive the young child's performance is to small differences in reward probability. The results are similar to the first experiment, with decreasing numbers of maximizers among the older children (Table 8.13).

The number of "minimizers" also decreases with age in both studies, although it is consistently less than the number of maximizers at age 2. We can reconstruct the child's behavior in the following way: the 2-year-old chooses one cup and sticks with it for a few trials. This reflects the fact that in the first experiment more than 80% of the 2-year-olds were either maximizers or minimizers. If the cup continues to pay off more than the other cup, the child stays with it. This is reflected in the fact that the ratio of maximizers to minimizers is lower for the 5:4 experiment than the 5:3 one—it makes less difference. In sum, the 2-year-old uses two rules:

1. Pick the same cup as the preceding trial.
2. If it is the losing cup more often than not (in the last few trials) shift to the other cup and continue to apply Rule 1.

TABLE 8.13
Performance on 5/4 Two-Choice Probability Place Learning

Age	*N*	*Trials to Maximize*	*Percentage of Subjects Who Maximize*	*Percentage of Subjects Who Minimize*	*Percentage Maximizing Choices on Last 10 Trials*	*Percentage of Altenations*
2	20	27	52	16	40	16
3	25	27	40	12	59	51
4	17		6	0	39	68

Same procedure as described in Table 8.12 with 5/9 trials reinforced on the maximizing cup, and 4/9 on the minimizing cup.

The older child appears to be attempting to turn the same kind of formulations into a more comprehensive rule that will cover *all* the cases. Although the individual algorithms may differ, the overall net effect will be to increase the number of alternations, following both positive and negative reinforcement. This is reflected in the increase with age in the number of alternation trials in both experiments. (The individual formulations used by the older subjects appear to differ greatly, which is why I do not present an analysis here). Both younger and older children can be viewed as applying rules. But only the older child insists that the domain of the rules be each part of the situation—the younger child is content with a more global treatment (and a more rewarding one). Again, we do not have to postulate that the basic mechanisms for solving the problem differ between younger and older children. Rather, the older children develop an internal trial-by-trial representation of the situation, which then presents them with the (impossible) task of attempting to predict each trial specifically.

Probability learning can bring out a subject's desire to impose a complete structure, but the problem does not have any trial-by-trial structure itself and therefore cannot reveal systematic differences in the subject's analytic sensitivity (as opposed to his or her zeal to make complete predictions). Discrimination learning, however, offers such a possibility because we can vary the number of dimensions that a given task offers.

We used a version of the "which cup has the candy?" task in a way that allowed us to vary the number of discriminable dimensions. In the basic paradigm the child was presented with the two cups—each now having the same small toy animal mounted on it (e.g., a lion). The child's task was simply to learn that the reinforcement was always on the left (or right). Children were run through 40 trials after the game was explained to them. The results (Table 8.14) showed that 2-year-olds are capable of mastering this discrimination with a very small number of trials. (Our criterion was six correct choices in a row.) Three-year-olds also do so, but with somewhat

TABLE 8.14
No. of Trials to Criterion (Six Correct in a Row) in a Left–Right Place-Learning Experiment

Age	*N*	*Same Animals*	*N*	*Different Animals*
2	24	1.9	22	1.8
3	26	3.6	23	5.3
4	22	2.9	18	2.9

Subjects chose on each of 40 trials one of two inverted cups. The same cup (right or left) always covered an M & M candy. In the same-animals condition, each cup had the same toy animal mounted on it. In the different-animals condition, each cup had a different toy animal mounted on it.

more difficulty (nonsignificant in our studies). Why should this be so? Why should there be *any* tendency for simple place learning to be more difficult for 3-year-olds than for 2-year-olds? In our general theory, the 3-year-old is more aware of potentially different aspects of the situation. In the case of our studies, the cups could vary slightly in their position, the animals might have had some individual differences, and so on. If the 3-year-old is more aware of the possible features to discriminate, then he or she is more likely to try out false hypotheses.

We achieved control over this possibility by making the cups easier to differentiate—we placed *different* animals on each one (e.g., a lion on the left, an elephant on the right). This roughly *doubles* the discriminative cues available for a subject—the subject could learn either Rule 1 or Rule 2:

1. Pick the one on the left (or right).
2. Pick the lion.

This increase in discriminability is reflected in a slightly improved performance by the 2-year-old children. The 3-year-olds, however, now do significantly worse, both compared with the 2-year-olds in the different-animal condition and compared with 3-year-olds in the same-animal condition. This developmental regression can be interpreted as due to the 3-year-old's increased sensitivity to the potential internal dimensions of a situation, and his or her prediliction for mastering all discriminable dimensions. Thus, by hypothesis, the 3-year-old attempts to learn both Rule 1 *and* Rule 2 separately, which leads to increased learning time for the task. It is not the case that the 3-year-old is simply less effective than the 2-year-old—rather, he or she is aware of more dimensions and unable as yet to integrate them into a single solution.

This interpretation is further supported by the behavior of children when the above situations include uncued reversal of the reinforcement (i.e., the reward is suddenly consistently placed under the previously unrewarded cup.) In this paradigm, subjects were reversed either: (1) 10 trials after they reached criterion on the initial learning; or else (2) after 40 initial learning trials were completed Table 8.15).

Two-year-olds tolerate reversal fairly well, learning the reversed situation in three times as many trials as the original discrimination, both in the same-animal and different-animal condition. Older children also learn it almost as readily as original learning, when the animals are the same. When the animals are different, however, the performance of the older children is considerably worse than on the original learning. This follows from the view that the 3-year-old has learned both rules as separate entities and so has twice as much to unlearn as the 2-year-old.

Ordinarily one would not turn to such behaviorist paradigms for support of a cognitive theory. However, these studies elicit regressions in effective

TABLE 8.15

Age	N	Reversal Learning Same Animals	N	Different Animals
2	24	6.1	22	6.8
3	26	5.4	23	14.2
4	22	2.0	18	2.6

Continuation of the experiment described in Table 8.14. The reinforced cup is reversed (after up to 40 trials initial learning) without any indication to the subject.

performance, independent of any worldly contingent probabilities. Accordingly, they demonstrate our general thesis in domains independent of language and explicit concept development—3-year-olds differentiate the internal structure of situations more deeply than 2-year-olds but are often unable to integrate the dimensions they diffentiate. Hence, they can perform *less* well than 2-year-olds on certain tasks.

A Correlation With the Emergence of Cerebral Asymmetries for Words. There is no obvious neurological change at age 3 that accounts for these developments. However, we have found a relation between the extent of right-earedness for word perception and the extent to which a 3- to 5-year-old child uses the natural-order strategy in sentence comprehension (Bever, 1971). It would be tempting to conclude that the emergence of cerebral asymmetry causes the emergence of the strategy by making possible internal analysis of sentence structure. Such a causative relation, however, is not necessary. In our present interpretation, the left hemisphere is dominant for all analytic activity, at any age. That is, the fact that the 3- to 5-year-old is analyzing the lexical structure of sentences could underly both the emergence of the natural word-order strategy *and* the emergence of cerebral asymmetry for the word level of language behavior (Bever, 1980).

Comprehension Regressions in Second-Language Learning. We have outlined the fact that a large number of different developmental phenomena occur at the time when the child is integrating the internal structure of the canonical sentence. It appears that he or she is developing an internal dimensional analysis in a variety of situations, not just language processing. That is, we can conclude that such strategies as *"NP 1 = the subject"* develop because of a general maturation by the child which results in an increased analysis of the internal structure of *all* activities. Our general hypothesis, however, leaves open the possibility that this strategy can emerge during language learning even at an older age. On our account the strategy emerges as a by-product of the child's attempt to provide an internal analysis of the sentence into component parts. If that occurs at ages other than 3 to 4 in special populations, then we might expect the natural-order strategy to emerge in those populations.

Children learning English as a second language comprise such a population. We found that as their overall ability in English increases, they go through a period of relative dependence on the natural-order strategy. We tested this in 30 Spanish-speaking children ages 6 to 7 (Table 8.16). We first recorded a conversation with each child in English. The child was encouraged to tell his or her favorite story, or to say what happened on the way to school, etc. Six independent judges listened to the interviews with each child and rated the child along a number of dimensions, including overall mastery of English. We also analyzed the utterances for mean length of utterance (MLU). This yielded three ways of ordering the children by age, by MLU, or by assessed mastery of English.

Each child participated in an acting-out task, using both active/passive and subject-first/object-first cleft sentences. (The methodology is presented in Bever & Denton [1980]—it is basically similar to the acting-out procedure outlined previously. However, we gave extra attention to making sure that the children knew the English names of each animal, sometimes discussing it in Spanish with them). There is no pattern as a function of age or by MLU group. However when subjects are ranked by assessed mastery of English, they show a marked decrease in performance on object-first constructions. (Subjective mastery of English was assessed by a panel of native speakers, who listened to recorded sentences of free speech by each child).

We interpret this result in the following way. As the Spanish-speaking child first deals with English, he or she sets up a canonical sentence; then, as his or her mastery of English improves overall, he or she analyzes the internal structure of the canonical sentence, which allows for the application of the natural word-order strategy. This indicates that the appearance of the strategy is not necessarily a function of biological maturation, although it may be in the natural course of first-language acquisition. Its independence of

TABLE 8.16
Percentage Correct in English Sentence Paradigms With 6-7-Year-Old Spanish-Speaking Children

Mean-Rated English English Ability (on 7-pt. scale)	*N*	*Subject First*	*Object First*	
3	8	75	52	23
4	8	92	47	45
5	8	92	42	50
6	6	92	70	22

Children acted out sentences in the same kinds of paradigm described in Table 8.1. They are grouped according to increasing mastery of conversational English.

maturation is further support for our view that the regressions occur as a function of a standard pattern of learning rather than as a function of maturational dynamics alone.

Performance Regressions in Difficult Conservation Tasks

We can also demonstrate that regressions in conservation tasks can occur at different ages. To show this we used a version of weight conservation with children ages 3 to 12. We found that children go through at least two periods of performance regression, apparently due to different analyses of the internal structure of what effects how much something weighs.

Each child was presented with two large transparent plastic boxes. (The boxes about 1 foot long x 8 inches deep x 8 inches high; they also had handles on the top). The child observed the experimenter pour a cup of Puffed Wheat (a lightweight commercial cereal) into each box. The experimenter then closed each box and discussed with the child whether one of the boxes would be harder to pick up (heavier than the other) or whether they would be the same. After the child agreed that they would be the "same" (virtually all children did so agree, even at age 3), the experimenter turned on a fan inside one of the boxes. (The other box contained an identical fan that was left off.) The child again reported on which box would be harder to pick up. Then the fan was turned off, with the child again reporting on relative weight. Then the fan on the other box was turned on, with a weight report from the child. Finally, both fans were turned off and the child reported for the last time on the relative weight of the boxes.

The results are presented in Table 8.17. Like most tests of conservation in the concrete-operational child, reliable conservation does not occur until age 7. However, conservation of the blowing phase was not reached reliably even at age 12. Furthermore, there are *two* performance regressions, points at which older children perform worse than younger children. Such results highlight the extent to which the measure of conservation depends on the emergence of a physical theory that allows the child to rationalize his answer—whereas the child does have such a theory for the weight of objects at rest, he does not have an integrated theory about the weight of objects moving in a closed system. Thus, it is not that these children do not have conservation, they lack the compensating physical knowledge that would make conservation behavior possible in this situation.

The performance regressions are interpretable as the result of internal analysis of the physical structure of the problem. Basically there are three phases of this analysis—younger children seem to assume that the blowing (or most recently blowing) box is the heavier of the two (if they report a difference at all). This would seem to relate to the strategy that "if it looks

TABLE 8.17
Percentage of Answers as to Which of the Two Boxes is Heavier

			Stage $1^a + 3^b$			Stage $2^c + 4^d$	
Age	*N*	*Same*	*Blowing More*	*Static More*	*Same*	*Just Blown More*	*Static More*
3–4	64	44	38	19	59	30	13
5–6	45	35	39	23	44	30	27
7–8	38	66	17	16	89	10	4
9–10	48	45	21	37	85	8	9
11–12	35	58	31	12	91	6	2

Children were presented with two large transparent plastic covered boxes. Each box had a cup's worth of puffed rice (a commercial cereal) in a small pile. The children first agreen that each box would have "the same" difficulty of being lifted, or the same weight. Then the conditions were run in order; in each condition the child was asked, "are they the same weight (difficulty of lifting) or does one have more (is one harder to lift)?"

[a]Stage one—A fan inside the first box is on, creating a "snowstorm in a box."

[b]Stage 2—The fan is off—the cereal is spread out evenly on the bottom.

[c]Stage 3—A fan inside the other box is on.

[d]Stage 4—Both fans again off.

bigger, it must have more." Because the blowing box looks like a box with a cereal "snowstorm" in it, it looks like it has more in it. At a later age the child seems to base his or her decision on a theory of how weight works—namely, the box that has more cereal lying on the bottom weighs more. Accordingly, at this later stage, the box that is blowing is reported as weighing *less* than the other. (By this age, we were able to get many verbal reports confirming this interpretation). Finally, at ages 11 and 12, those children who still do not conserve tend to report that the (recently) blowing box weighs more. At this age, they have many elaborate theories as to why this is true, always bearing on a theory of how weight expresses itself. Some argue that the puffed wheat striking the bottom does so harder than that striking the top, because of gravity; some argue that it is because of a conversion of the fan's energy to mass (!); some argue that the increased motion creates increased inertia (!); etc.

This conservation experiment demonstrates that children's performance on such tasks depends on their internal analysis of the nature of the phenomenon and how to measure it. As the child's theories about these matters change, so does his or her performance. In brief, just as in sentence perception, regressions are not limited to age 4 to 5. They occur also in other domains as a function of the child's attempts to analyze the internal structure of a problem.

Conclusion—the Integration of Knowledge and Behavior

I have demonstrated that many apparent regressions in behavior can be interpreted as the result of an increasing capacity to process the internal structure of a domain of behavior. This increase may be understood as the result of internal neurological developments, as during the first year; it may be viewed as the result of normal maturational processes, perhaps more dependent on environmental stimulation, at later ages. Finally, as in the case of second-language learning or physical conservation, it may occur under the impact of special efforts to acquire a new skill or scientific knowledge.

Such interpretations remove some of the mystery surrounding apparent developmental regressions. Although we do not understand exactly how the child goes about analyzing the internal structure of his or her world we must accept that he or she does so. The demonstration that apparent regressions can be interpreted as the direct result of such analysis removes their status as paradoxical phenomena.

A central problem of developmental psychology is to isolate what is the result of a quantitative change and what is the result of a qualitative change. I have discussed three developmental phases—the canonical, the analytic, and the structurally integrated. I have not explained how the first and third of these are discovered by the child, nor do I think that there are any satisfactory theories available that attempt to explain how such structures are learned. In each case the child arrives at a rich internal structure with very little specific environmental shaping. Accordingly, these structures appear to result from the environmental selection of internally generated structures. In that sense, the emergence of the initial structures, and their final integration, rests on innate qualitative developments.

The internal differentiation process that underlies the apparent regressions during the analytic phase is directly interpretable as due to a *quantitative* increase in general intelligence. If we define intelligence as the ability to maintain different variables in mind at the same time, then we can interpret the changes in the analytic phases of development as the result of cumulative increase in such capacity. In this view developmental regressions are important because they isolate periods of quantitative consolidation in mental growth.

REFERENCES

Bever, T. G., & Denton, N. P. The perception system of speech may be learned separately for each language. *The Bilingual Review*, In press.

Bever, T. G., Mehler, J., & Epstein, J. What children do in spite of what they know. *Science*, 1968, 162, 979–998.

Bever, T. G. The cognitive basis for linguistic structures. In *Cognition and Language Development*, New York: Wiley, 1970.

Bever, T. G. The comprehension and memory of sentences with temporal relations in the child and adult. In *Advances in Psycholinguistics,* Amsterdam: North Holland, 1970.

Bever, T. G. The dominant hemisphere is the locus of perceptual learning in speech behavior. In *Mechanisms of Language Development,* New York: Academic Press, 1971.

Bever, T. G. Broca & Lashley were right: Cerebral dominance is an accident of growth. In *Biology and Language,* Cambridge, Mass.: M.I.T. Press, 1980.

Bever, T. G. *Development from vocal to verbal behavior in children.* Undergrad Dissertative Harvard, 1961.

Bruner, J. From communication to language; a psychological perspective. *Cognition,* 1974, 3, 255–287.

Bullowa, M., Jones, L., & Bever, T. G. The development of vocalization in infants. In *The acquisition of language "SSRC conference on first language learning; 1961,"* Child Development Monographs, 1964.

Clark, H., & Clark, E. Semantic distinctions and memory for complex sentences. *Quarterly Journal of Experimental Psychology,* 1968, 20, 129–138.

deViliers, J., deVilliers, P. A. A cross-sectional study of the acquisition of grammatical morphemes in child speech. *Journal of Psycholinquistic Research,* 1973, 2(3), 267–278.

Ervin-Trip, S. Imitation in childrens language. In *E. M. Lerneberg,* Cambridge. Mass.: M.I.T. Press, 1964.

Ervin-Tripp, S. Discourse agreement; how children answer questions. In *Cognition and Language Development,* New York: Wiley, 1970.

Feagens, L. Childrens understanding of some temporal terms denoting order duration and simultaneity. *Journal of Psycholinquistic Research,* 1980, 9(1), 41–57.

Frankel, D. G., & Arbel, T. *Probabilistic assignments of sentence relations on the basis of differentially–weighted interpretive cues.* In preparation, 1980.

Frankel, D. G., Amir, M., Frenkel, I., & Arbel, T. A developmental study of the role of word order in comprehending Hebrew. *Journal of Experimental Child Psychology,* 1980, in press.

Greenberg, J. M. Some universals of grammar with particular reference to order of meaningful elements. In *Universals of Language,* Cambridge, Mass.: M.I.T. Press, 61.

Irwin, O. C., & Chen, H. P. A. A reliability study of speech sounds observed in the crying of newborn infants. *Child Development,* 1941, 12, 351–368.

Irwin, O. C. Reliability of infant speech data. *Journal of Speech Disorders,* 1945, 10, 227–235.

Irwin, O. C. Infant speech; the problems of variability and the problem of diagnosis. *Journal of Speech Disorders,* 1947, 12, 287–289.

Irwin, O. C. Infant speech: the effect of systematic reading of stories. *Journal of Speech and Hearing Research,* 1960, 3, 187–190.

Johnston, J. R., & Slobin, D. I. The development of locutive expressions in English, Italian, Serbo–Croation and Turkish. *Journal of Child Language,* 1979, 6(3), 529–545.

Juczsyk, P. Infant speech perception: a critical approach. In *Perspectives on the study of speech,* Hillsdale, N.J.: Lawrence Erlbaum Associates, 1980.

Lewis, M. M. *Infant speech: a study of the beginnings of language.* London: Routledge Kegan 1936.

MacNamara, J. Cognitive basis of language learning in infants. *Psycholinguistic Research,* 1972, 79(1), 1–13.

Maratsos, M. Children who get worse at understanding the passive: A replication of Bever. *Journal of Psycholinguistic Research,* 1974, 3, 65–74.

McGraw, M. B. Maturation of behavior. In *Manual of Child Psychology,* New York: Wiley, 1946.

McNeil, D. *The conceptual basis of language.* Hillsdale, N.J.: Lawrence Erlbaum Associates, 1979.

McNeill, D., & Lindig, K. The perceptual reality of phonemes syllables words and sentences. *Journal of Verbal Learning and Verbal Behavior,* 1973, 12, 419–430.

Mehler, J., & Bertoncini, J. Infants and perception of speech and other acoustic stimuli. In *Psycholinguistics Series II,* The Hague: ELLK Science Books, 1978.

Mehler, J., & Bever, T. G. A cognitive capacity of young children. *Science,* 1967, Oct. 6th, 141–150.

Osgood, C., & Bock, J. Salience and sentencing: some production principles. In *Sentence production: Developments in Research and theory,* Hillsdale, N.J.: Lawrence Erlbaum Associates, 177

Piaget, J. *The psychology of intelligence.* London: Routledge & Kegan 1950.

Savin, H., & Bever, T. G. The nonperceptual reality of phoneme. *Journal of Verbal Learning and Verbal Behavior,* 1970, 9, 295–302.

Sinclair, H., & Bronckart, J. P. SVO a linguistic universal? A study in developmental psycholinguistics. *Journal of Experimental Child Psychology,* 1972, 14, 329–348.

Slobin, D. I., & Bever, T. G. *Children use canonical sentence schemata.* (In preparation) 1980.

Tighe, L., & Tighe, T. J. Discrimination Learning: two views in historical perspective. *Psychological Bulletin,* 1966, 66(5), 353–370.

Townsend, D. J., & Bever, T. G. Interclause relations and clausal processing. *Journal of Verbal Learning and Verbal Behavior,* 1978, 17, 509–521.

Townsend, D. J., Ottaviano, D., & Bever, T. G. Immediate memory for words from main and subordinate clauses at different levels. *Journal of Psycholinguistic Research,* 1979, 8(1), 83–101.

Turner, E. A., & Rommetveit, R. The acquisition of sentence voice and reversability. *Child Development,* 1967, 38, 649–660.

Turner, E. A., & Rommetveit, R. Experimental manipulation of the production of active and passive voice in children. *Language and Speech,* 1967, 10, 169–180.

Turner, E. A., & Rommetveit, R. Focus of attention in recall of active and passive sentences. *Journal of Verbal Learning and Verbal Behaviour,* 1968, 7, 543–548.

Weir, M Developmental changes in problem-solving strategies. *Psychological Review,* 1964, 71(6), 473–490.

Werner, H. The concept of development from a comparative and organismic point of view. In *Concept of Development,* Minneapolis: University of Minneapolis Press, 1957.

Wundt, W. *Volkerpsychologie & Erster Band: Die Sprache.* Leipzig: Verlag von Wilhelm Engelman 1911.