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ABSTRACT

This paper offers a description of the Ball-Stick-Bird reading system which has been used successfully to teach students with IQs as low as 20 to read with comprehension. A summary of research findings on this approach is presented as well as a discussion of these findings within a neurological/behavioral/evolutionary framework. A new theory of cognitive organization, the "story as the engram" theory, suggests: (1) the ontogeny of human logic; (2) the evolution of language development and the universality of certain parts of grammatical structure; (3) how the central nervous system has overcome the limits of chunk size during information processing; and (4) how contextual memory is stored and retrieved. This theory is seen to offer an explanation for the human species' sudden and meteoric intellectual development, as well as suggest possibilities for even greater achievement. (Contains 68 references.) (DB)

# TEACHING WITH THE STORY ENGRAM

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## Abstract

For almost two decades, the Ball-Stick-Bird reading system, an innovative approach to teaching, has enabled students with IQs as low as 20 to read with comprehension. Such unexpected results have raised profound questions about the nature of intelligence and IQ. What follows is a description of the pertinent variables of the system, a summary of the findings, and finally an attempt to understand the implications of these unexpected findings within a neurological-behavioral-evolutionary framework. This new theory of cognitive organization, the story-as-the-engram theory, suggests (1) the ontogeny of human logic - as well as the lack of it, (2) the evolution of language development, and the universality of certain parts of grammatical structure, (3) how the CNS has overcome the limits of chunk size during information processing, (4) how contextual memory is stored and retrieved. The theory also offers an explanation for our species' sudden and meteoric intellectual development, as well as the possibilities for even greater achievement.

The Ball-Stick-Bird reading system derives its name from the way it highlights alphabet configurations. The student is shown how all the letters can be built with three basic forms: a circle, a line, and an angle. These three color coded shapes, playfully called a ball, a stick, and a bird, are so basic to the human nervous system that a newborn can recognize them. Even an octopus can be trained to respond to them.

By building the letters with the three forms while giving their most usual sound, four sense modalities are tapped instead of the usual two. Further, the three basic forms highlight those parts of a letter that differentiate it from other letters, and clarify which aspects of a letter are pertinent and which are merely doohickeys.

Story reading, however, does not wait for alphabet mastery. The strategy is to get to contextual reading as rapidly as possible. To achieve this, the initial memory load is reduced as much as possible. Beginning reading is taught with capitals which have the additional advantage of avoiding letter reversals since in B-S-B letter building, the BIG STICK is always first (to the left). Also letters are known by their most usual sound, rather than by their alphabet names, again reducing the initial memory load. The eight aspects of the learning system that simplify and therefore reduce initial memory load are summarized on Table 1.

Already with the presentation of the second letter word building begins. With the presentation of the fourth letter the first science fiction story starts. To achieve such rapid immersion into story reading, the order of alphabet presentation is altered. The simplest and high frequency letters are presented first. Letters that make the same sound appear contiguously, while those with a similar look or sound are presented far apart to avoid interference.

Table 1.

Ball-Stick-Bird's simplifications of the mechanical aspects of reading which reduce initial memory load.

1. Alphabet discrimination is simplified by showing how letters can be built using three basic forms - circles, lines, and angles (called balls, sticks, and birds).
2. Color coding of the three basic forms makes the distinctive features of each letter more apparent.
3. The student builds each letter with the basic forms, utilizing four sense modalities instead of the usual two; thereby strengths in one area of functioning can compensate for deficits in another.
4. Beginning reading is taught with capitals. An additional advantage is that for capitals the BIG STICK is always to the left, and therefore letter reversals are avoided.
5. Letters are called by their most usual phonic sound rather than by their useless alphabet names.
6. Letters are taught in a meaningful sequence: (a) the simplest letters are presented early, (b) letters useful in word building are presented early, (c) letters that look or sound similar are spaced apart, (d) letters with the same sound are presented contiguously.
7. Modified phonics, not requiring fine sound discriminations, are taught. Since in English the correspondence between letter and sound is variable, the inaccuracy of human speech is used to the advantage of the reading process.
8. Word building requires that only two sounds be retained in short-term memory at a time.

Modified phonics are used which do not require fine sound discriminations. Since in English the correspondence between letter and sound tends to be sloppy, the inaccuracies of a students's speech are harnessed to the advantage of the reading process. These approximate soundings, because they are taught in the context of a story rather than word lists, have been surprisingly successful.

The initial memory load is also reduced for the word building process by using an approach which requires that only two sounds be retained in short-term memory. For example, the word "detective" is built as follows: D plus E makes it a DE word, to which is added a T making it a DET word, another E makes it a DETE word – by this time the student who is immersed in the context can usually guess that the word is DETECTIVE – which is what he is told he is. See TEACHER'S MANUAL (Fuller, 1974).

But Ball-Stick-Bird takes the detective game a step further by teaching "code approximation." The student is told that the letters are the clues that indicate what the word might be. But like all clues a detective has, they have to make sense in the context of the story. Because with "code approximation" reading is dependent on comprehension, "word calling" becomes all but impossible. As will be discussed in detail, it was the "code approximation" part of the learning system, which demands so much intellectual feedback, that should have been out of reach of the very young or the retarded. But quite the reverse turned out to be the case (Fuller, 1974, 1977).

To help reading comprehension, the beginning books of the system are composed primarily with nouns and verbs; gradually adjectives and adverbs are added. Only in later books are the more difficult parts of speech (the articles, connectives and prepositions) introduced. Unexpectedly, this developmental linguistic approach which had been intended merely to facilitate story comprehension produced results far beyond its original intent.

Story comprehension is further enhanced and facilitated in the beginning books by the layout. Each idea unit, comprising mainly of a noun and its action verb, has its own line. These idea units, representing sub-stories, are used to construct the bigger story, line by line. In this way the layout highlights story building, producing a graphic image of how ideas are put together, how a paragraph is developed. Comprehension can now become not only the purpose of reading, but via developmental linguistics, layout in idea units, and "code approximation," is used to help the student learn to read (Fuller, 1974, 1975, 1977). Table 2 summarizes the eight aspects of Ball-Stick-Bird that require extensive intellectual feedback and therefore were expected to be beyond the capacity of the severely retarded or the very young.

Summary of the findings.

The reading system, which had been intended for older non-readers with normal or superior IQ was successful far beyond this group. In a detailed study, a group of 26 institutionalized retardates with IQs as low as 28, who had previously been exposed to extensive educational intervention but in spite of this had not mastered most of the alphabet, easily learned to read - 24 of them with comprehension (Fuller, 1972, 1974, 1977).

Extensive testing of the 26, who ranged in IQ from 28 to 72, produced no correlation between their Stanford Binet IQs and either reading scores or rates of learning. Nor was the more than 40 point spread of IQ points correlated with scores on Vocabulary

Table 2.

Ball-Stick-Bird's techniques which utilize contextual cues and intellectual feedback.

1. Word formation begins with the presentation of the second letter; the science fiction stories start with the fourth letter.
2. The student is taught "code approximation" - that there is not a one-to-one correspondence between letter and sound, and therefore letters can at best only represent clues as to the word they will make, a word that must make sense in the story. With "code approximation," comprehension becomes an essential part of the learning process all but eliminating "word calling."
3. Developmental linguistics forms the basis for the vocabulary and grammar development of the series.
4. The layout of the beginning books is in idea units or story engrams. These idea units, representing sub-stories, are used to construct the bigger story, line by line.
5. Nouns and later adjectives are sported in their full multisyllabic glory in even the beginning books.
6. The action-packed space odysseys are arranged as "cliff hangers." In order to find out what happens next the student is encouraged to learn a new letter or reading principle.
7. However, if a new letter or reading principle has not been learned, the student can still move on to the next book which will repeat what has to be learned in the context of another science fiction adventure. Because immediate mastery is not required, the series can function as a no-failure system.
8. There is no drill.

tests, Story Comprehension test, Passage Reading tests, and Word List tests. These results were even more unexpected since half of the sample had IQs below 50.

Since my previous experimental studies with phenylketouria, for example Fuller & Shuman, 1974,1969, had found that IQ tests, specifically the Stanford-Binet, were remarkably accurate tools in predicting school performance, the above findings, which were repeated with every replication, were more than unexpected. They were not supposed to happen. For this reason the book which reported in detail the experiments with the 26 institutionalized retardates was entitled IN SEARCH OF THE IQ CORRELATION, (Fuller, 1977).

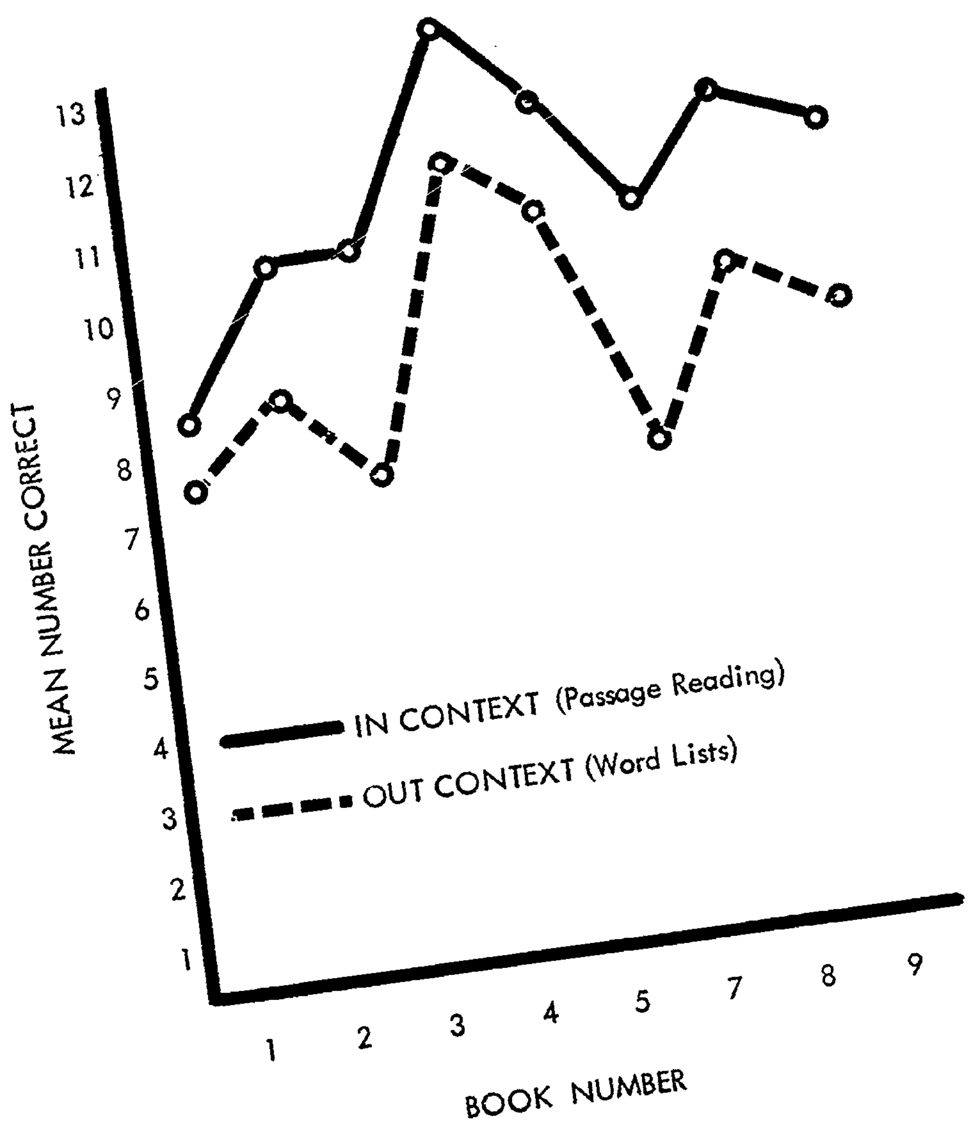
Adding to the data of unexpected results were, as seen in Figure 1, the difference scores between the Passage Reading tests and the same words in the Word List tests. These difference scores quantified that the students found it easier to read a passage than the same words on word lists. Further, the trend was that the lower the IQ, the better the performance on the Passage Reading tests compared to the same words on the Word List tests. Contrary to expectation, this trend indicates that the lower the IQ, the more important is the totality or context for the reading process. So much for drill.

The Passage Reading tests were an indirect measure of comprehension. A direct measure was the Story Comprehension test which required that the students answer questions about a lengthy passage they had just read. Again there was no statistically significant correlation with IQ scores, although this time the rank correlation was a positive r.54. Even so, two of the subjects with IQs in the 30s achieved some of the highest scores.

The Daily Rating Sheets, with their verbatim quotes, made it clear how well even students with IQs in the low 30s understood the gist of the stories they were reading. This comprehension was not restricted to manifest content, but included an in-depth understanding of the books (Fuller, 1988, 1989). However, when contextual cues were reduced, as in the case of word lists, or when beginning a new book, the students, especially the nine with IQs below 40, found comprehension considerably more difficult. In order to quantify the difference in reading ability for story versus non-story reading, the Following Written Directions test was developed. The test was deliberately linked to the Story Comprehension test, having almost identical vocabulary. We would now see if elimination of the story framework, thereby reducing contextual cues, would decrease the performance of our lowest IQ students. It did. The Following Written Directions test finally gave us a statistically significant correlation of r .73, at the $<.05$ level, with IQ scores. It is interesting to note that the Following Written Directions test is composed of tasks that are similar to some of the segmental tasks of our standard IQ tests. The implications of this reduction of contextual cues in finally producing a positive IQ correlation will be discussed in the next section.

Because IQ scores (with the exception of the Following Written Directions test) had failed to correlate with the various reading, vocabulary, and comprehensions tests, they had failed in their predictive validity or function. Would they also fail in their descriptive validity or function? Phrased in another way, would the increase in vocabulary, social communications skills, as well as reading and writing performance, that we had quantified in our students manifest themselves in a significant and meaningful increase in IQ?

Figure 1

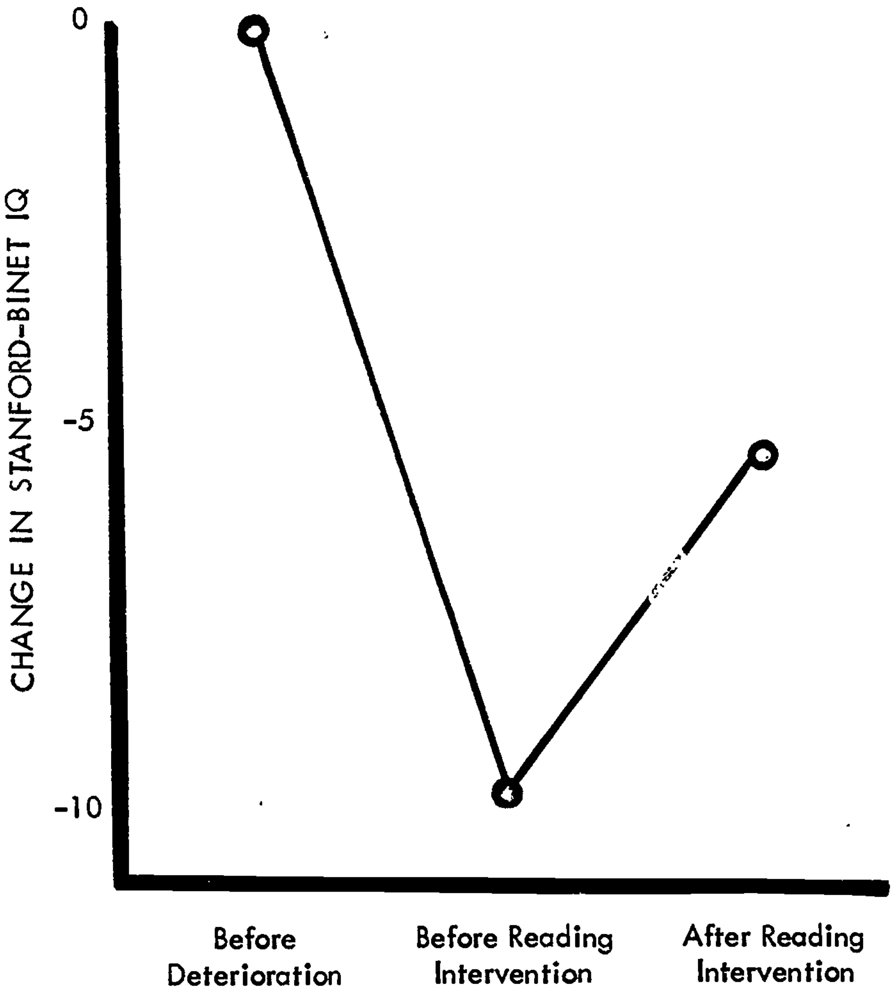

MEAN NUMBER CORRECT
13
12
11
10
9
8
7
6
5
4
3
2
1
IN CONTEXT (Passage Reading)
OUT CONTEXT (Word Lists)
1
2
3
4
5
7
8
9
BOOK NUMBER

In order to avoid a false positive we compared IQ scores five to ten years prior to intervention, and at reading intervention; not only for our sample, but for the whole institution. It was well that we did. For the population we had chosesn was, contrary to the average of the institution, on a downhill trend. Whereas for the rest of the institution the Stanford-Binet or WISC IQs showed an average rise of four points during the five to ten year period prior to Ball-Stick-Bird reading, that of our experimental sample, as can be seen in Figure 2, showed a drop of ten points.

The average institutional rise of four IQ points can probably be attributed to the outstanding intervention programs at the institution. However, these intervention programs had failed with our population. Even though our students had been exposed to some of the institution's best, such as talking typewriters, special teaching approaches, as well as individual instruction by Masters and even Ph.D. level teachers, they had not mastered most of the alphabet. These subjects were the failures of the institution. Although we had deliberately chosen them in order to test Ball-Stick-Bird's learning innovations, we had not realized that this failure was reflected in a downward spiral of IQ scores which was contrary to the rest of the population.

Our reading intervention did reverse this downward spiral: The students showed an average rise of 4.72 points in Stanford-Binet IQs, which is statistically significant at the $<.01$ level. But such a rise, despite its statistical significance, is hardly descriptive of our students' performance. Even with this rise, the majority of subjects were still in the severely retarded category, and the fact that they enjoyed reading magazines and sometimes even books, that they wrote letters to their relatives and social workers, did not fit what is meant by severely retarded. The IQ tests, which had failed in their

Figure 2


0
-5
-10
CHANGE IN STANFORD-BINET IQ
Before
Deterioration
Before Reading
Intervention
After Reading
Intervention

predictive validity, had now also failed in their descriptive, or face validity, as well.

Besides, more than reading had been learned. Our dwindling paper and pencil supply was the first indication of how much our students had become involved in the written communication process. Several, whose impaired psychomotor capacities obviated the use of pencils, used our typewriters instead. Then, because the use of typewriters had become the rage, we had to designate that one, and only one, of our office typewriters belonged to the students.

The effects on written communication, as they had on reading, bore little relation to IQ scores. Whereas one student typed out sophisticated letters of complaint to her aides and social workers, other students within the same IQ range wrote only halting notes. One of our most creative letter writers had an IQ of 35. Linda Campbell reported a similar case whose creative talents led him to write an autobiography (Campbell, 1986, 1988).

There were further profound cognitive changes which related only indirectly to IQ or mental age (Fuller, 1988, Fuller, Shuman, Schmell, Lutkus & Noyes, 1975). Prior to our intervention, none of our students had adequate speech. Tape recordings, before and after, show how much easier it was to understand the subjects after they had been reading about six months. This, in addition to their increased vocabulary and greater expressiveness, was reflected in a much increased capacity to communicate - both other communication and self communication, i.e. thinking. The effects on thinking and what that implies will be discussed in the next sections.

With increased verbal and therefore social communcation came changes in appearance. The film records are startling. Some of the subjects are hardly recognizable several months after intervention. There is a directness of gaze. The eyes are larger. The posture is straighter. They had become people. Why the other intervention programs, such as the special Olympics, appearances on TV, plays, etc., which the subjects had been exposed to, did not have this effect is intriguing. It will be discussed in relation to the effects on thinking in the next sections.

Unfortunately there were four unhappy endings. Political turmoil developed at the institution which became especially pronounced in the maximum security cottages. Finding that their three worst cases enjoyed going to Psychology for "some program," the cottage power structure insisted that going to Psychology be contingent on good behavior. It didn't work. The three had to be transferred to a correctional facility. One student after a traumatic visit home developed a full blown psychosis.

For the rest of the subjects the improvement in social communication skills created new and unexpected possibilities. By the end of the study five of the students were discharged from the institution. Another student became so attractive that he was adopted at the age of 16. Three could now be placed in semi-protected employment. Two, who had been deemed ineligible prior to intervention, were placed in an institution for self-care patients. Seven became candidates for vocational rehabilitation and were eventually discharged. Two found employment at the institution. Another student, a bedridden spastic quadriplegic, has undergone extensive and expensive surgery. The doctor accepted the case free of charge when he heard that the patient needed the use of his hands to hold the books he was reading. That subject is now discharged.

After the above results with the severely retarded, it was not unexpected that normal four-year olds became advanced readers with astonishing ease, and there was not a single case of dyslexia (Fuller, 1987). Adult illiterates became proficient readers in weeks instead of years (Fuller, 1988). Non-English speakers, the ESL (English as the second language) group, found the books an open sesame into English.

These findings with the very young and severely retarded are contrary to much of developmental theory. Even more unexpected is that they were achieved with a technology requiring extensive intellectual feedback and contextual understandings. The use of "code approximation," developmental linguistics, and layout in idea units, demand a knowledge of language that the very young, the severely retarded, the ESL group, are presumed to lack.

**What had the learning system tapped that was not being measured by IQ tests?**

Why had our low IQ subjects been able to learn to read advanced material with comprehension, and write such sophisticated letters and stories when they had previously failed after extensive intervention? Apparently the abstract operations that Ball-Stick-Bird requires are simpler for the human brain than the memorization of bits of unstructured material which have to be combined to make a coherent whole. Since such bits of information are similar to the segmental material that appears on IQ tests, this would explain why our subjects as their IQ demonstrated, performed poorly on both IQ tests and with previous academic instruction. It would also explain the high correlation between IQ and school performance that psychologists have come to expect. One such example is my own phenylketonuria data (Fuller & Shuman, 1965, 1971, 1974). But exactly which aspects of neural organization, which aspects of cognition, had the reading system tapped?

The first clue came with the difference scores between the Passage Reading tests, and the same words on the Word List tests. These suggested that story context and the anticipation of which words come next in the story was why "code approximation" had been so easy for even the severely retarded and the very young. The power of story anticipation would also explain why the other innovative techniques of the system, such as developmental linguistics, and layout in idea units, which facilitate story comprehension, had been so effective. Increasing contextual information, rather than creating confusion, helped even severely damaged brains and the very young understand a story.

The results from the Following Written Directions test produced the second clue which further confirmed the importance of story context for cognitive organization and learning. Since much of the vocabulary and sentence structure of the Following Written Directions test and the Story Comprehension test are identical, the poorer performance of our lower IQ students on the former test can probably be attributed to its reduced contextual cues. However, the Following Written Directions test is not completely without contextual cues, and therefore, although the test resembles some of the subtests of IQ tests, the performance of all our retarded subjects far surpassed their IQ expectations. Besides, our subject had been taught reading with a system that further honed their contextual capacities and skills.

The third clue as to what had the learning system tapped that was not being measured by IQ tests came in the form of Hal, whose brain damage gave us a clinical-physiological experiment. Hal's "partial cortical blindness" manifested itself in graphic aphasia. He became a living demonstration that increasing contextual information, i.e. story elaboration, can help even a severely damaged brain surmount its reduced capacity to recognize segmental information bits. For Hal, even the alphabet simplifications (building the letters with the color-coded circle - ball, line - stick, and angle - bird) failed to insure letter recognition. But "code approximation," and especially developmental linguistics, and layout in idea units, made it possible for him to become a fluent reader. However, fluent reading did not insure letter recognition. When shown identical letters side by side he continued to have difficulty in determining if they were the same or different. His scores on the Word List tests were abysmal, his Passage Reading test scores were excellent. With his achievements Hal answered the question: what had the learning system tapped that was not being measured by IQ tests? It was the human capacity for story comprehension. His success, however, posed another question: How does the human brain organize story cohesion so that it can compensate for decreased segmental or sensory input?

And what happens when story cohesion is impossible? We actually had two subjects, Ned and Gordy, for whom story comprehension was not possible (Fuller 1979, 1982, 1990 in press). They were our two failures, learning only survival reading, never understanding the story of even the first book of the series. Both Ned and Gordy had almost continuous petit mal seizures which probably prevented anything but small segments of information being retained in short-term memory. Ironically, Gordy showed a nine point rise in IQ following our intervention, one of the highest in the experiment. Gordy had learned a lot, and the Stanford-Binet measured it. But what he had learned was not reading with comprehension, and neither he nor Ned showed the farreaching cognitive changes of our other students. They still could not tell us what was happening in their lives, or anything that had happened yesterday or even today. They did not exhibit the changes in language or even appearance of the other subjects. There was no development in either social communication or self communication. They had not become the thinking people that our other subjects had become.

Ned and Gordy could succeed as long as nothing more was required than the learning of bits of information which had been simplified to the toddler level. This is what Ball-Stick-Bird does for alphabet recognition and word building. However, the story part of the system, which was so important to the other students, was meaningless to them. And because they could not remember and therefore follow a story, Ned and Gordy could not use contextual cues to help them learn.

Sometimes our failures tell us more than our successes. By being so unusual, by showing what someone whose brain is unable to follow a story can and cannot do, Ned and Gordy demonstrated how all-encompassing the effects of story comprehension are not only for learning, but also for human interaction and thinking. The other severely retarded students contrasted sharply in that despite their retardation they were story engrossed. They showed us that story comprehension is so fundamental and overrepresented in the human brain that even a severely damaged brain can almost always call on this capacity.

However, important as story comprehension is to our species, it is not an ability that is measured by IQ tests. Instead, IQ tests measure isolated bits of knowledge, and isolated analytical language and visualization skills. Historically, these are the skills that Binet and Simon (1905) found were necessary for successful performance in the early 20th century classroom. That these same skills still determine success in our present schools, explains why IQ tests continue to be useful predictors of school performance. However, our results have demonstrated that when teaching strategies are changed, and the power of story cohesion is used to facilitate learning, IQ tests lose their predictive and descriptive validity. Unintentionally our results have questioned not only the validity of IQ tests, but also much of today's educational practices to which these tests are linked.

**Is story organization the building block of human cognitive development?**

But what exactly is a story, and how does it come into being? When does story comprehension begin in child development, and what is it composed of? How did evolution build the story capacity and the need for story telling that is so characteristic of our species? And what is the relation of story cohesion to thinking, and therefore consciousness? It was the asking of these questions and my search for their answers that made me realize that the reading system must have tapped something basic in human cognitive organization, perhaps even the building block in the evolution of cognitive development.

Examination of the stories and letters written by our beginning readers furnished a curious clue. Line by careful line, these written communications were built with idea units in the style of the teaching system. At first these idea units were composed mainly with a noun and its action verb. Soon adjectives and adverbs were included. But even after having become advanced readers, and after having learned how to use articles, connectives, and most of the prepositions, the letters and stories of our subjects frequently showed traces of the original idea unit layout.

And when our retarded subjects talked with us they didn't use the haphazard techniques of the past. Instead they carefully put together what they had to say by first searching for the right noun, then the verb, gradually adding adjectives and adverbs. They were putting together idea units with which they built the bigger story. Sometimes our severely retarded students wrote out what they wanted to tell us. Again they mimicked the layout of the beginning books, and with idea units they constructed the bigger story, line by line. One of our students with a Stanford-Binet IQ in the 30s explained his reason for writing things out in this way with "It help you think."

With the "help you think" tool he was now able to scrutinize his own actions. Here was the explanation for our subjects' sudden demonstration of metacognition, and even philosophical understandings (Fuller, 1988, Knacke,1988). No wonder the power structure at the institution perceived our severely retarded subjects as patients who had "matured a lot lately." And small wonder that new and unexpected possibilities opened up for them (Fuller, Shuman, Schmell, Lutkus & Noyes, 1975). The other intervention programs at the institution had not had anything approaching these unexpected affects or effects. But then, they had not taught thinking, and thereby also social communication skills. On the other hand, our subjects had, in the process of being taught reading, learned how to use language to build idea units with which to think. With this ability they were now able to scrutinize their own actions, and frequently change them.

A more recent student, Bill Knacke, described the emotions these cognitive changes generated in his autobiography, THE INSIDE WORLD (Knacke,1988). Having spent most of his life in an institution for the retarded, Knacke was filled with a rage which he neither understood nor could put into words. As he later described, he was puzzled at his own violence which just seemed to happen. Within months after B-S-B intervention this world of speechless violence was irrevocably altered. The acting out stopped, replaced by simple declarative sentences that were built primarily with nouns, action verbs, and some adjectives describing his anger and his hopes. He now was able to communicate with himself, and therefore with others. And with this capacity came a surprising self awareness, a self consiousness. Like so many of the students in the original study, Knacke developed an identity. He had become "cogito ergo sum."

Once I realized that the fundamental unit of cognitive organization that had been tapped was the idea unit, which is actually a miniature story, the next question was how did evolution build the idea unit? At what stage does it appear in mammalian development, and in child development? Does ontogeny recapitulate phylogeny in this behavioral manifestation as it does so frequently in physiology and morphology? And how curious that this idea unit or miniature story has, as our severely retarded subjects demonstrated, the mass action characteristics of Lashley's memory engram (Lashley, 1950, 1963).

Lashley, with his surgical ablation techniques had sought to isolate what he called the memory engram in experimental rats. However, after years of effort he was unable to isolate this engram, and therefore suggested mass action of cortical tissue as the explanation for his lack of success (Lashley, 1950, 1963). The idea unit, or miniature story, resembles Lashley's memory engram in that it also can function despite extensive neurological damage. With the exception of Ned and Gordy, all of our severely (neurologically impaired) retarded subjects were able to recognize, and to communicate with miniature stories. But even more important, they were able to use these idea units as building blocks for bigger and bigger stories.

Although the mass action characteristics of Lashley's engram is not readily explainable, the all-pervasive aspects of story engrams offers an easier explanation. Miniature stories by their very nature have numerous affective and factual associations. They must therefore be represented in numerous and different areas of the brain. Nor is this neurological representation restricted to cortical areas. Even a one-word story engram, as will be discussed in the next section, frequently has powerful affective components. These affective components are a reflection of the cortico-limbic or even cortico-thalamic representations (Pribram, 1971; MacLean, 1978). Because of the ubiquitous neurological representation of idea units, even a severely damaged brain will usually have enough functioning areas so that some story engrams can be established. It evidently requires continuous electrical discharge, as in the cases of Ned and Gordy, which presumably blocked memory consolidation, to interfere with neural encoding of most story engrams.

But how did this story engram come into being? How did such a powerful cognitive building block evolve? And is one of its strengths that it is not readily destroyed with neurological impairment or damage?

The idea unit as the story engram.

Evidence for the evolution of the idea unit, or story engram, with which humans build bigger stories, is an incomplete but tantalizing story of its own. Seyfarth (Seyfarth, Cheney &Marler, 1980; Seyfarth &Cheney, 1982) reported that wild vervet monkeys have different calls for different preditors (nouns) which require different responses (verbs).

Here we see the simplest idea unit, with its strongly affective component. Since these sounds are involved with a fight-flight reaction, one would expect a contico-limbic-thalamic relationship in this early story engram.

Developmentally, considerable learning appears to be required for the correct usage of the vervet monkey sounds. Young monkeys generalized the leopard alarms to various other mammals, eagle alarms to many birds, and snake alarms to various snakelike objects (Seyfarth, Cheney & Marler, 1980). The similarity of these monkey sound to human language development was also observed by Snowden. Infant marmosets and tamarins "exhibit an early 'babbling' stage much like that of the human infant, during which imperfect versions of the adult calls are given in inappropriate contexts and sequences." (Snowden, 1982, p.212).

On a neurophysiological level there are further indications as to how the story engram developed. Like humans, Japanese macaques are better able to discriminate two "linguistic" elements when they are presented to the right ear than to their left (Petersen, 1982; Heffner & Heffner, 1984). "Nonlinguistic" discriminations do not show this right ear advantage. Further, it is species specific. "The left temporal lobe seems to play a predominant role... Such results are consistent with the notion that Japanese macaques possess an area analogous to Wernicke's area." (Heffner & Heffner, 1984, p. 76).

On a personal level, many of us have known dogs that recognize the names (nouns) of certain objects like ball, stick, slipper; and verbs like sit, fetch, bark. An occasional dog, I had one, responds to selected nouns and verbs that have been combined to form a new conceptual unit. Here again we see the simplest idea unit, the beginning of the story engram.

Attempts at deliberate language training of primates produced the now famous sign-language experiments. The Gardners (1969, 1978) showed that chimpanzees are able to learn selected nouns and verbs. The experiments were continued and elaborated by Fouts (1972), and with the gorilla by Patterson (1981), although the criticism of Terrace (Terrace, Pettito, Sanders & Bever, 1979) is typical of what followed. Patterson (Patterson & Linden, 1981) claims that Koko, the gorilla, understands stories. My own conversation with Koko took an engrammatic form: mainly nouns with their action verb, usually in present tense, and some colorful adjectives. According to Patterson (Patterson & Linden, 1981) Koko has since mastered most of the prepositions and connectives. This would imply that Koko now knows how to use story engrams to build the bigger story.

Roger Fouts (personal communication) tells of restraining one eager chimpanzee from going into the next room by signing to her that there was a dangerous monster on the other side of the door. The chimpanzee's reaction was reminiscent to that of our own children. She requested that he sign "the story" again and again, shrieking with delight at every repetition. Here the comprehension level indicates that the animal understood the bigger story which is built with the story engram units.

Although the picture is far from complete, the data suggest that the evolution of the story engram in higher mammals resembles its ontogeny in the developing child. "The child's earliest words are overwhelmingly nouns that encode simple concrete objects, verbs that encode activities tend to appear later, and verbs that encode mental states later still; finally adjectives which encode properties of things are later than all the others..." (Gleitman, 1986, p. 126). At 18 to 24 months, children combine some of these nouns and verbs, making their first story engrams. Roger Brown (1974) described these story engrams as "the 'telegraphic' essentials of a sentence." These "sentences the child makes are like adult telegrams in that they are largely made up of nouns and verbs (with a few adjectives and adverbs) and in that they generally do not use prepositions, conjunctions, articles, or auxiliary verbs." (Brown, 1973, p. 74). Bar Adon (1971) made a similar observation in children learning Hebrew.

Even after the child has graduated to full-fledged sentences, the original story engram organization is what is most easily remembered. When asked to repeat a sentence, especially younger children remember the nouns, verbs, and adjectives, tending to omit articles, prepositions, and auxiliary verbs (Brown & Fraser, 1963). Chafe noted that in the telling of narratives there is "a segmentation into intonation units that can be interpreted as the verbal expression of idea units." (Chafe, 1990, p. 97). This bears a striking resemblance to our severely retarded subjects when they mimicked the layout in idea units of the Ball-Stick-Bird teaching system.

Also as with our severely retarded subjects, language comprehension in all children is more advanced than language production. By the time children can produce "telegraphic" speech, their comprehension capacity makes them able to follow "well-formed commands " (Shipley, Smith & Gleitman, 1969), and they are able to comprehend grammatical relations that are more complex than they can express (Brown, 1973). But more important, comprehension as to how story engrams are used to build bigger stories has progressed to the point that half of the two year olds can respo: .o "tell me a story." (Ames, 1966).

Once such story elaboration has begun, after language production has reached three word sentences, "speech undergoes an explosion of complexity." (Pinker, 1989).

The children have learned how to use story engrams not only to think and communicate, but they now also have a powerful vocabulary-building tool. When normal four to seven-year olds are taught with B-S-B, parents and teachers frequently report that there is another language explosion (Fuller, 1988). These children, like our retarded students, mimic the layout in idea units (story engrams) in their first written communications. Ball-Stick-Bird, by presenting in graphic form what the human brain does naturally, facilitates an understanding of how language and therefore thinking are built. Even adults of normal IQ who, because they were illiterate, were taught reading with B-S-B, demonstrate this explosion in verbal-thinking communication skills.

The story engram as cognitive organizer.

The story engram as the fundamental unit of information processing is not the only way that information storage and processing could have evolved. An example of a very different way is that of the bees. Their cognitive organization is highly efficient, requiring the investment of only a tiny nervous system. In contrast, the mammalian brain is an exceedingly expensive energy investment. And it becomes progressively more energy expensive as one goes up the phylogenetic scale.

However, gauging from the success with which we have overpopulated this planet, this energy expensive brain had an evolutionary advantage. My thesis (Fuller, 1972, 1977, 1979, 1982, 1990 in press) is that this advantage was achieved by the mammalian brain having evolved a cognitive building block, the story engram, which allows for the organization, the storage and retrieval, of an astonishing volume of information that can be combined in an unexpected number of different ways. It allows us to draw swift conclusions about complicated interlocking stimuli. Such an organization overcomes the problem raised by George Miller (1956) and Herbert Simon (1979) who pointed out that the memory for unstructured bits of information is limited to about the lowly number seven - if we're lucky. The story engram, with its capacity for story elaboration, allows not only for a phenomenal increase in memory storage and retrieval, but more information can be processed and retrieved per unit of time. Story engrams represent the "tricks to enlarge memory and speed computation" that Edward O. Wilson (1984) was so sure had to exist.

But the story engram does more. By imposing a structure on reality it determines how we humans perceive our world. The cause and effect relationship, the either / or phenomena, the dichotomies, the explanations, are imposed by an engram that derives its structure from the noun-action-verb ontogeny, which made rapid decisions and communication possible. This story engram structure determines the nature of human logic - or the lack of it. An example of the latter; how often do we confuse a correlation with a causal relationship which, given the history of the story engram, is the easier story, the easier reality. Even sophisticated researchers have been known to assume that the correlation between a disease and certain behaviors imply a causal relationship, when both the disease and the behaviors may have the same etiology, and hence their correlation. Another example is our human propensity for finding direct causes, when there are multiple or indirect causes, or even reciprocal relationships. These comprehension difficulties in human logic stem from a story engram that evolved from a noun-action-verb structure which made emotion-laden rapid action possible.

The emotional component is with us even when story engrams are expected to be "rational." How often do serious scientists go through contortions to make data fit a theory (another name for story engrams). These contortions can be quite funny – in retrospect. If new data come in, and a shift in story engrams, i.e. scientific hypotheses, becomes necessary, this can be both emotionally and intellectually wrenching as Kuhn (1970) has chronicled. The streng.th of emotional attachment we have for our story engrams probably reflects their noun-action-verb ontogeny, and their feedback loop into the limbic system (Fuller, 1979, 1982), as well as the neuro modulatory system described by McGaugh (1990). Which explains why our stories can make us cry, laugh, or produce any other emotion that belongs to us, including the proprietary emotions of scientists for their theories. Rico (1983), using her clustering technique which elicits story engrams has demonstrated the clinical and cognitive power of this feedback loop.

The power of the story engram determines not only how we organize our world cognitively, but it has also made us a story-telling-thinking species. We try to explain, react, deal with the world around us by imposing a story structure on it. Gazzaniga's (1983, 1988) split-brain experiments are a demonstration of the workings of this "neural interpreter" as it tries to make sense of both its own functions and the outside world. In their struggle to explain what had occurred we see Gazzaniga's patients use story engrams to structure their conscious reality in what sometimes bears only a tangential relationship to the actual stimuli.

As the congitive building block, the story engram is so fundamental to our thinking that it is difficult to imagine an alternative way of perceiving the world. even the aliens of our science fiction almost invariably communicate in story form – this despite the numerous life forms on our own planet that have evolved alternative ways of information processing. Yet concomitant with the difficulty of imagining an alternative way of structuring reality is a lack of awareness of the importance that story organization has for our cognitive and emotional life. A striking example of such lack of awareness comes from the field of experimental psychology which, until very recently, acted as though humans were storyless creatures. This despite the deep emotional attachment we have for our cognitive organizer to whose manifestations and elaborations we devote much of our waking lives.

When we measure our species' intelligence, there is no attempt to measure story building and comprehension abilities. The classical work on memory is that of Ebbinghouse (1885) with nonsense syllables. Bartlett's (1932) experiments showing the power of meaning for memory, and his development of schema theory, and English's experiments (English, Welborn & Killian, 1934) which demonstrated that forgetting of meaningful items does not follow the Ebbinghouse curve, were all but ignored. Ausubel's (1963) work on the importance of "higher-order structure on which to attach the details that are to be remembered" also had little effect on intelligence theory and American psychology's conceptualizations of the human mind.

The same fate befell the Gestaltists, including the breakthrough experiments of Catherine Stern (1971) in the teaching of arithmetic. A sample of why this work is of special interest to this discussion is "I openend Washburne's INDIVIDUAL ARITHMETIC and read the problems one after the other; the children sat spellbound (they were first graders and could not as yet read) and gave the answers to these new riddles without trouble. According to Philip, they had no arithmetic that day - 'just marvelous stories!'" (Stern & Stern, 1971, p. 132). The price millions of schoolchildren have had to pay for this work being ignored demonstrates a pathological aspect to psychology's preoccupation with out of context, emotionless, bits of information.

The beginning of the paradigm shift occurred at the same time, and probably as a results of, computer programming. The programs gave a graphic demonstration how higher order functioning could be programmed, built, with simple on-off building blocks. No homunculus was required. As a result schema theory was finally freed of what many had seen as its biggest defect, the curse of the homunculus. Cognitive science had come into being, and Bartlett's and English's works were rediscovered (Mandler, 1978, 1979).

But Mandler went further. Noting similar patterns in "story grammar" in different cultures she concluded that "such remarkable consistency suggests that the operation of a story schema may be a universal kind of functioning... If we have indeed tapped a universal aspect of cognitive functioning, then it is not surprising that qualitative developmental and individual differences are minimized." (Mandler, 1982, p. 311). The "qualitative developmental and individual differences" were indeed minimized in our severely retarded population that had been taught with the story engram (Fuller, 1972, 1974, 1977). But these discussions and results have still not had an effect on theories of intelligence and intelligence testing.

Schank also stressed universality: "because people could easily translate from one language to another and, in a sense, think in neither, there must be available to the mind an interlingual, i.e., language-free representation of meaning." (Schank, 1980, p. 244). And he wonders why, when "people do not understand sentences in a null context ... why then do our theories deal with sentences out of context." (Schank, 1980, p. 253). And Mancuso and Sarbin point out that "Given two or three sensory inputs, a human being will organize them into a story, or, at least, the framework of a story. When one probes into the ordered or patterned perceptual response it becomes immediately apparent that a plot is imposed on the disparate inputs." (Mancuso & Sarbin, 1983, p. 234). Are these signs that the paradigm is finally shifting, that psychology has ceased to see our species as storyless creatures? I hope so, because without a paradigm shift the results with our severely retarded subjects will continue to be incomprehensible to many psychologists: even though already in 1972, APA devoted a whole symposium to B-S-B and its results.

Cognitive science came even closer to the story engram with Kintsch's suggestion "that propositions represent ideas, and that language (or imagery) expresses propositions, and hence ideas. Thinking occurs at the propositional level; language is the expression of thought." (Kintsch, 1974, p. 5). Thorndyke (1977) takes these concepts further still by postulating a "hierarchical organizational framework of stories in memory.", and Rumerlhart and Ortony state that "it is easier to understand a story whose structure closely matches that of the story schema." (Rumerlhart & Ortony, 1977, p. 131). As cognitive science continues to develop, up-to-date reviews appear at ever more frequent intervals, for example Sanford (1985), and Bransford, Adams & Perfetto (1989). The paradigm that is emerging is more and more in line with the B-S-B results and the theory these results have engendered.

Note: definition of paradigm, another name for story engram - used by scientists.

**Metacognition and teaching with the story engram.**

The intellectual history of our species, an achievment of only a few thousand years, is deeply entwined with the development of the story engram as our cognitive organizer. With it we have transmitted from generation to generation the successes and failures of the past as well as the explanations and hopes for the future. These transmissions could be built with practical, i.e. factual, engrams: what to eat, plant, or hunt. They could also be mythical or allegorical engrams that put into words the hidden facts of feeling, suspicion, and longing. The stories these latter engrams built are described by Campbell as "those holy tales and their images (that) are messages to the conscious mind." (Campbell, 1972, p. 86). The advent of literacy formalized this transmission, and with this formalization came further changes.

The linkage between literacy and the intellectual explosion of the last six-thousand years is no accident. Writing down, or reading what others have written, makes it possible (even though not as clearly as when the layout is in idea units) to see how engrams are put together to build the bigger story. It also facilitates the isolation of engrams, allowing the writer to headline or highlight an idea unit as a concept or construct. And with that it becomes easier to codify law, producing a dramatic change in what it means to be human. Both the Romans and the Hebrews must have been aware of the implications of the new technology of reading and writing. Both made literacy a mandatory requirement for their populations, although for superficially different reasons. They must have observed that literacy helps people think. But as Scribner and Cole (1981) discovered with the Vai of Liberia, in order for literacy to have its cognitive effect there must be books and newspapers to read. The Hebrews of course had the Bible, a most-thought provoking book. The Romans developed a literature ranging from poetry to philosophy, from law to history. They even had cook books!

Learning to read and write helped newly educated humans to develop complicated ideas, i.e. to think. As it did for our subjects, these literate intellectuals had learned (albeit implicitly) how to isolate engrams and determine how well these imposed a structure on the chaos of life. Here we have the beginning of hypotheses and constructs. With these intellectual developments came the realization that engrams which cannot be validated may give the wrong structure with which to think, and that accurate engrams can become tools for further understandings.

It is the validation of engrams that brought about our age of science - an age that is just a few hundred years old. In these last few hundred years we have learned that accurate engrams can indeed be scaffoldings for marvelous edifices of the human mind. How very ironic that it was our severely retarded subjects, not an intellectual elite, who recapitualted this historical process and showed that knowing how to structure story engrams, and using them for further building of bigger stories and ideas, brings with it an intellectual and emotional metamorphosis.

The intellectual metamorphosis came about in part because learning to use engrams made transfer to other areas of cognition possible. That is one of the effects of the "it help you think" tool. How very different this is from so much of education where the learning in one classroom has little effect on what happens in the next, and even less effect on what happens in "the real world." In our experiments we saw just the reverse. Reading intervention was followed by improvements in math, speech, social communication, and above all thinking.

(Fuller, 1974, 1977; Fuller, Shuman, Schmell, Lutkus & Noyes, 1975). The first transfer effect we saw was the obvious one from reading to writing. However, in many schools even this obvious transfer frequently fails to occur. And so colleges have special courses for their numerous freshman who cannot write a simple essay; essays that some of our 35 IQs were able to produce.

To counteract the limited transfer effect of much of education, Sternberg "argues for training at the metacognitive as well as cognitive levels." However, he cautions that "we are only beginning to identify metacognitive skills to be trained...." (Sternberg & Wagner, 1984, p. 213). Stitz joins with " inadequate metacognitive skills are responsible for an inability to transfer strategies." (Stitz, 1986, p. 212). Our subjects had learned the metacognitive skill of story engram isolation, and the building of bigger stories with story engrams. These skills they used for tasks that were strikingly varied. Some would say our subjects had learned to learn. But I like the way I first heard it, "it help you think."

There is another aspect to metacognition that goes beyond knowing how to learn, how thinking can be used to learn more. It is the use of the story engram to explain us to ourselves. The severely retarded students showed the unexpected power of using story engrams in this way. As they haltingly asked - "Why did I do that? Do I really want to do that? What do I want to be?" - they began to achieve a consciousness, a self awareness, and then an identity. They, who had literally been blithering idiots, now knew who they were, and also who they wanted to become. As Vitz (1990) pointed out, "the use of stories in moral development " has a long human history.

Our species is still very much in the state of becoming. With the story engram we have a powerful metacognitive tool for self understanding. The story engram by bringing reality into consciousness, gives us a chance at conscious control of that reality. Is that not the most important aspect of metacognition? It makes possible a level of moral development that is essential for the survival of the species.

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