greater population densities are associated with low wind speed and, as would be expected, light sky cover. These field measurements are consistent with laboratory observations that N_2 fixation occurs in the central cells of *O. erythraea*.

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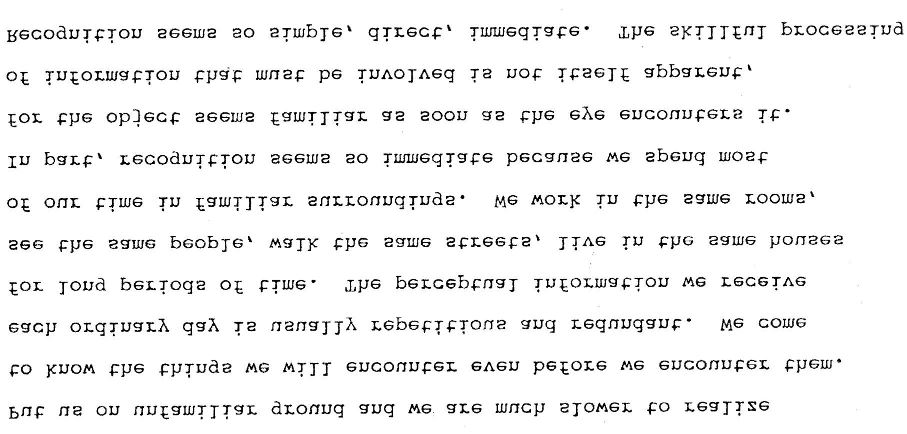
Pattern-Analyzing Memory

Abstract. *College students reread text after an interval of 13 to 15 months more rapidly than they read new matter taken from the same sources. The results implicate a memory system at the level of pattern analysis that seems to be distinguishable from memory of syntactic and semantic features of text.*

Most reading is directed at the semantic content of text. The reader usually wants to know what he is reading about, what the message is; except for such specialists as the compositor concerned with typography and layout and the proofreader concerned with orthography, the semantic aspect is considered to be the message of the text. So pervasive is the concern with the semantic aspect of literacy that most modern theories are directed at it almost exclusively (*1*). The pattern analysis that the skilled reader applies to text has, therefore, often been overlooked as a significant aspect of literacy. A common view emphasizing the semantic component is that the skilled reader extracts the semantic content of the text, reduces it to its propositional form, and stores for the longer term only that form, discarding other aspects of the text. This view has been challenged by demonstrations that typographic features of text can be found in memory of college student readers many days after reading even in the absence of instructions to attend to them (*2*); it is further challenged by this report of an aspect of memory for visual pattern analyzing operations.

In an earlier study eight college students each read 160 pages of typographically unfamiliar material, acquiring considerable skill at the task. Initially, they required about 15 minutes to read a page, compared to about 1.4 minutes to read a page of normally oriented text, on the average. The 160th page of transformed typography was read in 1.7 minutes, however, more than a ninefold increase in reading speed (*3*). After 13 to 15 months, six of the eight students read 98 pages in the transformed typography, 49 for the first time, the other 49 from the set of 160 that had been read earlier. This report concerns both overall performance on the second testing, and the differential performance on pages read for the first and second times.

The participants in the test were male undergraduates at the University of Toronto. They were assessed for lateral dominance by tests of sighting for eyedness and questions regarding preferred hand for eating, writing, and throwing, and preferred foot for kicking; in all, the right side was dominant. The typography they mastered was connected English discourse, each line



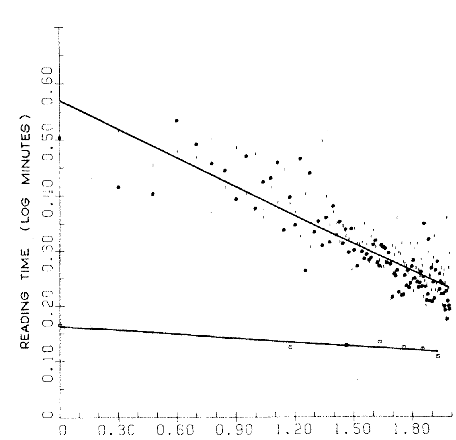


Fig. 1 (left). An example of geometrically inverted text. Fig. 2 (right). The logarithm of reading time plotted against the logarithm of successive pages for inverted text (inclined line) and normal text (line parallel to abscissa). One page of normal text was read at the beginning of each test session; these are shown at abscissa values corresponding to the 1st, 15th, 29th page, and so on. Strokes represent pages read for the first time in this experiment; closed circles represent pages first read a year earlier and reread in this experiment. Each point on the inclined line represents between one and six observations, and the line is the least-squares fit of the data points.

of which had been rotated around its own horizontal axis (see Fig. 1). The text all came from popular psychology sources [described in (*3*)]. On each of 7 days each of the six male readers read 14 pages of this inverted text, 7 pages from the set of pages read previously, and 7 from the same sources, but of material not read previously. The order of pages was scrambled from reader to reader, with the proviso that the reread pages on each day sampled the range of page orders previously used. This proviso eliminated any differential bias in the results attributable to special practice. A single page in normal typographic orientation was read at the beginning of each test session. The material was read aloud into a tape recorder and was timed with a stopwatch.

Performance on the task of reading transformed typography aloud improves in a regular fashion, following the form of the standard learning curve (*4*). When the logarithm of the time taken to read a page of text is plotted against the logarithm of the number of pages read, the data appear as straight lines (Fig. 2). From an initial 4 minutes per page (the antilogarithm of 0.6) the readers improved to a terminal 1.7 minutes per page, on the average. The rate of learning was less than that for the same subjects when they had been without practice (*3*), but their initial reading speed in the present test, about 4 minutes per page, was considerably less than the 15 minutes first measured; that is, they revealed a marked savings of the skill acquired earlier.

The difference between the times to read new pages and pages read earlier is shown by the different symbols associated with the learning curve for inverted typography. Many more strokes (new pages) appear above the least-squares line, and many more closed circles (repeated pages) appear below it. (As the order of pages was scrambled from reader to reader, a particular position in the order could be filled by an old page for one reader and a new page for another. Hence usually two observations appear for each value of the abscissa, one for pages read for the first time and the other for reread pages.)

Reading time was subjected to an analysis of variance that partitioned performance into the learning component, a component that evaluated the difference between pages read previously and pages read for the first time, and an error term. All of the readers revealed very large learning effects, as reported previously (*3*). In this experiment the difference in speed for pages read for the first time and pages reread after 13 to 15 months was significant ($P < .0001$).

One view of my results could be that the readers recognized the semantic content of the pages and that this recognition facilitated speed of reading the text. Such a view was tested and found wanting in a study that compared the relative worth of semantic and pattern-analytic practice at reading (*5*). An alternative implicated here is that the skills involved in literacy are associated with pattern-analyzing operations that are directed at the surface lexical features of text; the encoding operations that acquire these features for the reader are themselves modifiable; moreover, they are "remembered." The memory is seen in a general way in the learning curve, and specifically in the differential performance on old and new pages (Fig. 2). This operational memory is to be distinguished from memory for the results of encodings, the semantic or other grammatical content of text that is the subject of most contemporary studies (*1*). Models directed only to an account of the semantic and syntactic relations of text miss this crucial feature of performance and, hence, may overestimate the more conscious component of reading skill.

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REM Sleep Induction by Physostigmine Infusion During Sleep

Abstract. *Physostigmine (an anticholinesterase agent that increases acetylcholine at the synapse), in a dose of 0.5 milligram, was given intravenously to seven normal human volunteers. When injected during rapid eye movement (REM) sleep, physostigmine woke the subjects, and when injected during non-REM sleep, it induced REM sleep. This result suggests that cholinergic mechanisms play a role in the induction of REM sleep and in modulating cortical arousal mechanisms.*

Rapid eye movement (REM) sleep is distinguished from non-REM sleep and wakefulness on psychological and physiological grounds. It is closely, although not exclusively, associated with dreaming (*1*). Unlike the other two states, REM sleep is characterized by the combination of tonic components [such as loss of muscle tone and low voltage, fast, desynchronized brain waves as seen on the electroencephalogram (EEG)] and phasic events [such as rapid eye movements, variability of autonomic functions, penile erections, and, in animals, monophasic sharp waves occurring in the pons, lateral geniculate body, and occipital cortex (ponto-geniculo-occipital, or PGO, spikes)].

Differing biochemical control mechanisms of the three states of consciousness have been proposed (*2*). Although most research has focused on the role of biogenic amines (particularly serotonin and norepinephrine), laboratory studies of animals also suggest cholinergic modulation of REM sleep. The evidence is that (i) during REM sleep, increased amounts of acetylcholine are released from the neocortex (*3*) and caudate nucleus (*4*); (ii) REM sleep is induced by application of carbachol (a cholinomimetic drug) and physostigmine to the brainstem area in normal cats (*5*) or cats with pontine sections (*2*); (iii) REM sleep is inhibited, and EEG synchronization is induced by administration of hemicholinium-3, an inhibitor of acetylcholine synthesis (*6*), and by anticholinergic agents (*7*); and (iv) both tonic and phasic components of REM sleep are modified by cholinergic influences. Behavior resembling catalepsy has been induced by focal injection of cholinergic agonists in the brain (*8*). Bursts of REM and PGO spikes, as well as phasic suppression of spinal reflexes, have also been reported with administration of physostigmine to decerebrate cats (*9*).

In spite of these animal studies, few attempts have been made to demonstrate cholinergic mechanisms in human sleep. The anticholinergic agents scopolamine (*10*) and atropine (*11*) delay the onset and reduce the amount of REM sleep. Anticholinesterases, which enhance cholinergic activity, produce subjective reports of excessive dreaming and nightmares (*12*). Moreover, EEG sleep records from per-