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DIVIDED ATTENTION

People can learn to do two complicated things at once and neither activity has to suffer.

Common wisdom has it that "you can't do two things at once," but people do combine activities all the time. They walk and talk, eat and listen, drive and think. When two things are done simultaneously, must one or both suffer? Do the tasks interfere with each other? Must one of them be done unconsciously? Are they somehow fused?

Questions like these are often answered on the basis of assumptions about the nature of consciousness and the limits of mental capacity. We believe, however, that they deserve experimental study. We also believe that they have no single or simple answers. Every human activity is flexible; with practice, each becomes smoother and faster. Combining two skilled activities is itself a skill that will change as it is mastered. By studying the development of such skills, we have been able to test and refute some widely held assumptions about human intellectual limits and capacities.

It is fashionable nowadays to treat the brain as if it were a computing machine and to equate the central processing unit of that computer with consciousness. Such an analogy clearly suggests that people should be limited to doing one thing at a time, at least when doing things that require central processing. We believe that the computer analogy is misleading. Mental processes change so fundamentally with practice that no assumption involving fixed structures and fixed capacities can be correct. To make this point, we trained people to combine two very complex activities. They learned to write from dictation while reading stories, and they learned to understand both what they were reading and what they were writing.

The task is a difficult one and required a great deal of practice to master. We deliberately chose this level of complexity in order to push the question of divided attention to its limits. So long as activities are simple, almost anyone can learn to combine them. Indeed, every human activity involves the coordination of many different actions. In walking, for example, you must lift one foot while placing the other, swing your arms, correct your balance, and watch for obstacles.

Most people have no trouble doing all these things together; they can even chew gum at the same time, and perhaps carry on a conversation as well. To reconcile such achievements with the notion of an indivisible consciousness, or of a limited central capacity, psychologists appeal to the concept of automatism. Automatic activities are said to by-pass the central processor, so that any number of them can be combined.

If activities are automatic, they are not conscious; the individual is not aware of them. Such activities must also be relatively simple so that they require no consciousness or action by the central processor. The theory we are considering implies that complex actions, like understanding ideas or making decisions, can

In 1896 Gertrude Stein and Leon Solomons conducted the first experiments in divided attention.

Air-traffic controllers, who must keep the position of several planes in mind at one time, probably have mastered the skills described in divided attention experiments.

never be automatized. Thus walking can become automatic with practice, as can some kinds of talking, but not comprehension or thought. Without this restriction the notion of a limited capacity would be meaningless.

Our research concentrated on the simplicity of automatic activities rather than on the lack of awareness of them, because existing methods of studying consciousness are unsatisfactory. To know whether an individual is aware of something, you must wait for him to tell you about it. By that time he may have forgotten what it was really like. His introspective report will be based at least as much on what he happens to believe about the psychology of consciousness as on what he experienced. (The same thing applies to the experimenter, of course, if he decides to act as his own subject.)

Moreover, to be conscious of something is not an all-or-none affair. You can be aware that you are walking but oblivious to the motion of your left foot, or you can be conscious of your foot's movements without being aware of walking. Finally, it is clear that no aspect of mental life is fully open to introspection. Even creative thinking, the least automatic of activities, involves a great deal of unconscious work. For these reasons, the simplicity of automatism seems more open to experimental test than does the lack of awareness. Since automatic activities must be simple, it should be out of the question to do two complicated things at once. Is it?

Many experiments have seemed to confirm that it is indeed impossible. Psychologists have always observed a decline in the efficiency of at least one activity when someone tried to recite poems from memory while doing mental arithmetic or to shadow (repeat back) one spoken passage while attending to another. But the results are less conclusive than they seem because the people in these studies rarely practiced the dual tasks for very long. In many activities a skilled practitioner can do what seems impossible to the novice. Because we believed that this principle would apply to dual tasks as well as to single ones, we studied people as they learned to read and write simultaneously.

We were not the first to undertake a study of reading while writing. The earliest attempt, so far as we know, was made by Gertrude Stein, working at the Harvard Psychological Laboratory while still an undergraduate. In 1896 she and Leon M. Solomons reported extensive studies in what they called automatic writing. They had conducted these studies with themselves as subjects. As one of them sat silently reading a short story or a novel, the other would dictate words and phrases. The reader copied the dictated material on a sheet of paper while continuing to read. The task was difficult at first but eventually became easy. Solomons and Stein reported that the act of writing became unconscious, or "automatic," in the later stages of practice.

The work of Solomons and Stein had none of the precision associated with modern experimental psychology. They did not record reading speeds, comprehension scores, dictation rates, or writing errors. They described only their own introspections, which—as noted already—are a peculiarly unreliable kind of data. Indeed, when June Downey and John Anderson attempted a similar experiment at the University of Wyoming in 1915, they came up with exactly the opposite result. Solomons and Stein had said that the act of writing disappeared from consciousness, but Downey and Anderson maintained that they remained aware of what they were writing throughout the experiment.

To clarify these issues, we conducted several new studies in which we trained people to read while writing. We avoided the temptation of using ourselves as subjects and made no systematic attempt to obtain introspective commentary. Instead we measured reading speeds and reading comprehension throughout and took advantage of various indirect measures to determine whether our subjects understood what they were copying. With the help of Celia Reaves of Cornell University and George Caharack of Ithaca College, we have completed three such studies. In the first two, people read while copying single words dictated to

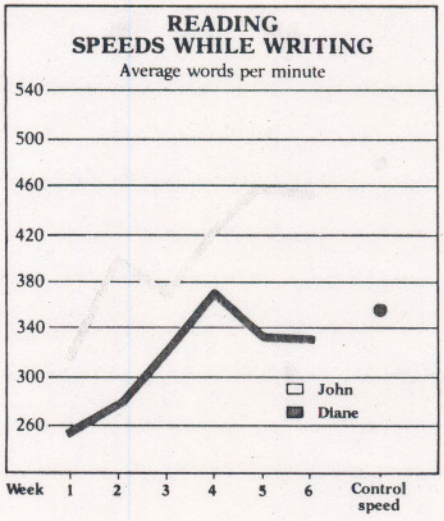
While John and Diane read short stories, they copied unrelated words from dictation. Each week their reading speeds increased until they approached their normal rates.

them; in the last experiment, they copied entire dictated sentences.

The first study involved two students, Diane and John, who worked an hour a day for about 17 weeks. During a six-week training period, Diane and John read three short stories per session; we gave them works by such authors as Saki, W. Somerset Maugham, and Katherine Mansfield. As the students read, they copied dictated words on a conveniently placed sheet of paper, moving down the paper as they wrote and flipping to the next sheet when they reached the bottom. Each word was dictated as soon as Diane or John had finished writing the preceding word.

After Diane and John had finished each story, we gave them comprehension tests to make sure they understood what they were reading. Their understanding of plot and character was assessed on the basis of their answers to eight to 15 simple short-answer questions. In later practice sessions we sometimes used more rigorous comprehension tests, based on the ideas included in some selected passage from a story.

The students' performance improved dramatically with practice. Although they found the dual task impossible at first, it eventually became easy, and their reading speeds reached normal levels in about six weeks. At this point, comprehension was just as good when John and Diane read while writing as when they read without writing. They wrote at a fairly steady rate (about 9.5 words per minute) with few omissions or misspellings. Their handwriting, which had deteriorated badly during the first week of practice, became normal again by the fourth week.



John and Diane were now reading and writing at the same time, and we wanted to find out whether they understood the words they wrote. To do this we constructed special lists that included related words. Without warning the pair, we dictated three lists that each included 20 consecutive words from a single semantic category (dog, cat, pig, bear, porcupine). Over the next several days, the special lists formed sentences (boys, hate, older, girls). After these tests, we asked Diane and John whether they had noticed anything special about the lists. They had not. By the fifth day, when we introduced a series of words that rhymed (spleen, ravine, green, scene), both noticed immediately.

These results suggested that at this stage of practice John and Diane were copying words automatically without noticing what they meant. To induce them to notice meanings, we informed them that special sublists would occasionally be included on subsequent tests, and we asked them to report whenever they noticed one. Both subjects found this easy, but their reading speed declined the first few times they worked under this new instruction. To see whether poorer reading was a necessary accompaniment to perceiving meaning in dictated words, we devised a new task. We formed lists in which all the words fell into one or the other of two categories—20 animal names and 20 kinds of furniture, for example. Before each test, we told the students which categories would be used and asked them to write the appropriate category instead of the dictated word.

The experiment was successful. After additional practice, John and Diane learned to read normally even while understanding and reporting the semantic content of the dictated words.

These findings suggest that it is possible to attend to two meaningful tasks at the same time; but there are alternative explanations. It might be argued that categorizing words is a relatively simple activity; perhaps it can be carried out automatically. Another possible weakness in our experiment was that John and Diane might not have actually been reading and writing simultaneously. Perhaps they were merely switching back and forth between the two tasks in some efficient way that our measurements did not detect.

Because everyone has occasionally tried to cope with two tasks by alternating between them, time sharing has often been suggested to explain what seem to be simultaneous performances. We designed separate studies to test these objections, the first to see whether time sharing is what really underlies the skill of reading while writing and the second to see whether this task had been so simple that it could indeed be automatic.

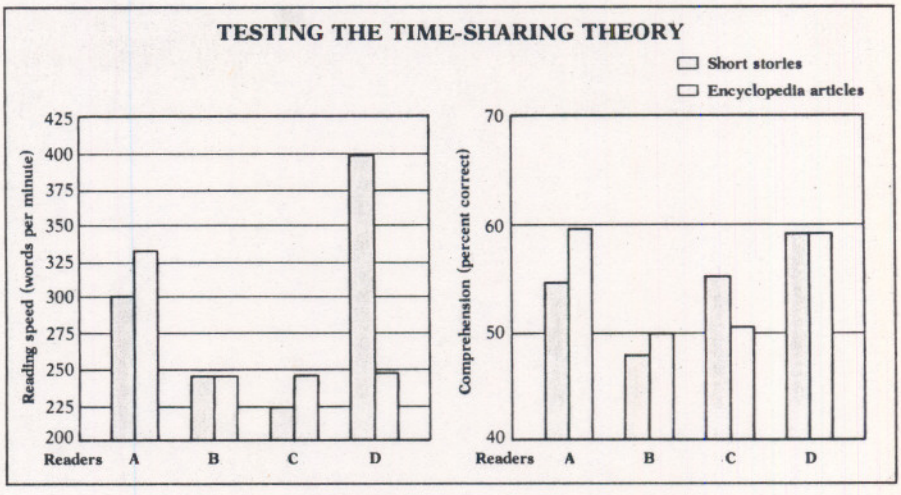
At first thought, the time-sharing hypothesis seemed wildly implausible. How could anyone repeatedly switch at-

When readers were shifted from short stories to articles that demanded full attention, in most cases neither comprehension nor speed suffered. It was apparent they were not switching between the tasks.

tention away from a text and back again without some loss of speed or comprehension? There seemed to be only one possible way. Advantage might have been taken of the redundancy of the text. John and Diane might have learned to switch away from the stories at a point where they were so redundant as to require no attention. It has often been suggested that efficient readers do this anyway, skipping over words that need not be read because they are entirely predictable from the context. Perhaps John and Diane read and wrote alternately, fitting the writing task into the brief extra moments offered by the redundancy of the stories they were reading.

Our next study tested this hypothesis by using reading material at two different levels of redundancy. One level was represented by short stories like those Diane and John had read, the other by articles from the *Encyclopaedia Britannica* or the *Encyclopedia of the Social Sciences*. The encyclopedia articles were less redundant than the stories. They seemed harder to skim, and it was more difficult to guess words that had been randomly deleted from them. If mastery of the dual task really depends on the redundancy of the stories as the time-sharing hypothesis suggested, switching readers from simple stories to more difficult reading material should have led to a sharp drop in the level of performance.

Four new individuals were trained to read short stories while writing single dictated words, just as Diane and John had been. Three started out by reducing their reading speed to well below normal while maintaining a satisfactory level of comprehension; the fourth kept up her usual reading speed but understood almost nothing of what she read. As their performance began to improve, the four showed wide variations in reading speed and comprehension.



These changes probably reflect changes in the strategies the individuals used to manage the task. Despite the differences during training, all of them eventually learned to read while writing. By the eighth week, all four had met our stringent criterion: five consecutive days during which speed and comprehension when reading while writing were essentially equal to speed and comprehension when simply reading.

As each individual mastered the dual task with short stories, we switched him to encyclopedia articles and tested again. Three of the four transferred their skill perfectly to the new material. Without any additional training, they could write while reading articles from the encyclopedia just as they had been able to write while reading short stories. The fourth, however, showed a substantial loss of reading speed when switched to the articles. Although this student may have been using the redundancy of the stories to write while reading, the other three evidently had not. They had mastered the skill in some other way.

The outcome of this study shows that reading and writing can be genuinely simultaneous. Dual performance is not just a matter of switching back and forth at moments of redundancy. (Some theorists might argue that switching occurs nevertheless, at an undetectably high rate and in a manner that does not depend on the nature of the reading material. We regard this suggestion as empty, since it is forever untestable. It is really nothing but a grudging way of admitting that the activities are simultaneous.) One other hypothesis remained to be tested: whether dual performance depends on performing one of the activities in an automatic way. To solve this problem, we devised a dictation task that could not be called automatic by any stretch of the imagination: copying dictated sentences and understanding what the sentences mean.

First we had to teach people to read while copying sentences. As it turned out, this goal was not easy to achieve. We started out by hiring two new students and presenting them directly with the task. Every day they wrote a great many

three-word sentences, dictated while they were reading short stories. Each sentence was dictated in a single burst and copied by the student; then the next sentence was dictated. After eight weeks of practice, neither student had been able to master the task.

They read the stories more slowly and understood them less well when they copied sentences than they did when they simply read the stories. We kept on trying. For 13 more weeks we gave the subjects a smorgasbord of tasks that included copying sentences of various lengths, answering questions in writing, and even copying single words. They did not succeed at any of these tasks. Even the single-word copying that had been mastered by everyone in our first two studies was too difficult for them, perhaps because we introduced it too late in the training period.

We finally gave up on these students and started over. To increase our chances of success, we recruited two of the people who had successfully completed the second study. They already knew how to read while writing single words; now we would see if they could learn to write sentences under similar conditions. The results were mixed. One made little progress with the new task and quit the experiment after 17 weeks of practice. The other, a student named Mary, was more successful. She practiced persistently, and after 14 more weeks she learned to read normally while copying the dictated sentences. After further practice, she was able to do this even when the dictated sentences were five words long.

At this point Mary was joined by Arlene, who had shown a striking aptitude for reading while writing in a separate pilot experiment that had dealt with reading while copying dictated numbers. She had mastered that task in one week. By the end of the following week she could read while copying single dictated words. These results encouraged us to try her with the three-word sentences that had stymied three previous people and had been so difficult for Mary. Arlene needed only two weeks to master this new skill.

We finally had found two people who could read normally as they copied dictated sentences: three-word sentences in Arlene's case and five-word sentences in Mary's. Now we were ready to determine whether they understood what they were copying.

Although the aim of the testing phase was to see whether Mary and Arlene understood the sentences, we never directly asked them if they had. Their primary task was still reading while writing: to read the stories with normal speed and comprehension as they copied what was dictated. They continued to do this successfully throughout the testing phase, which lasted five weeks. We tested their understanding of the dictated material indirectly, in three different ways. First, we determined whether they were using the structure and meaning of the sentences to help identify individual dictated words. Second, we tested their memory for what had been dictated to see whether they could use that structure and meaning as a memory aid. Finally, we prepared special dictation lists in which successive sentences were related, and used a different memory test to see if Mary and Arlene had noticed the relationships and their implications.

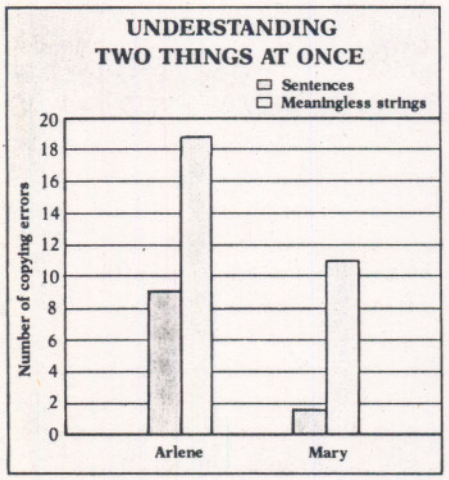
Our first method was based on the fact that context helps people to identify words that would otherwise be ambiguous. Under ordinary circumstances a person is in no doubt whether a speaker is saying "to," "two," or "too"; "sum" or "some"; or "would" or "wood." Certainty depends on grasping the meaning, or at least the syntax, of a sentence as a whole; homonyms cannot be distinguished when they are heard in isolation. We wondered whether Mary and Arlene would write down the correct versions of dictated homonyms while they were reading stories. In addition, context can help people to identify words other than homonyms: words that may not have been spoken clearly in the first place, for example.

These considerations led to a simple prediction. If sentences were dictated on some trials and meaningless strings of words on others, listeners would copy the former more accurately than the latter. We verified this prediction by testing people without having them read simultaneously. Would it also hold for Mary and Arlene, who were reading stories as they copied?

It did. They copied sentences much more accurately than random strings. Evidently they were sensitive to the structure or meaning of the sentences and used it to help establish the individual words they heard.

Our second method of testing Mary's and Arlene's understanding was based on tests of recall. Here, too, we made use of a familiar difference between real sentences and random word strings of equivalent length. Sentences are much easier to remember, mostly because their structure and meaning sharply limit the number of alternative words that can possibly occur at any given place. This principle applies, however, only if the listener grasps the structure or

Mary and Arlene copied dictated sentences and unrelated words while they read stories. Because their errors dropped when they copied sentences, it was plain they understood what they heard.



meaning in the first place. (It would not hold if the sentences were spoken in an unfamiliar language.) To find out if it would hold for Arlene and Mary, we introduced trials in which we substituted a test of their memory of the dictated material for the usual test of reading comprehension. Some of these recall trials were given when genuine sentences had been dictated, and others when random strings of words had been dictated. Mary and Arlene never knew in advance whether a trial would end in a story-comprehension test or a sentence-recall test. They were told that their primary responsibility was still to read and comprehend the stories; the data show that they continued to do so. In addition, Mary and Arlene demonstrated by their recall that they understood what they were copying. They remembered many more words from the dictated sentences than from the random, meaningless strings.

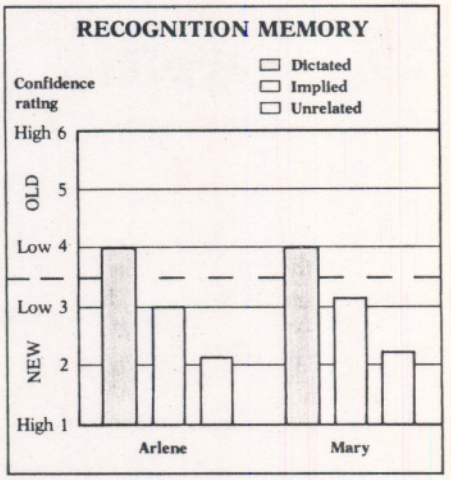
The third test provided the most dramatic evidence that Mary and Arlene understood the material they copied. It was based on a familiar phenomenon. When you listen to ordinary speech and understand it, your understanding is not limited to the specific words that are uttered. Rather, you know and remember the ideas that those words express. Often you integrate information across several sentences. If you hear that "Henry is Joe's doctor," for example, and then that "Joe's doctor performed the operation," you will realize and remember that Henry performed the operation. After a while you may even believe that you heard the sentence, "Henry performed the operation," although you did not. If Arlene and Mary could integrate semantic information in this way while they were also reading stories, we would have answered the major criticism of our first study.

Without warning Mary and Arlene of any change in procedure, we prepared a special list of 10 sentence groups, each made up of three sentences. Every triplet consisted of three closely related sentences. The list was dictated as usual while the subjects read a story and was followed by a surprise test of memory. In this test, our readers were presented with 30 test sentences and asked whether they recognized each one—that is, whether they thought it had been dictated to them while they read the story.

Dictated sentences
"An active volcano was nearby."
"It began to rumble yesterday."
"The people became very quiet."
Test sentences
Old: "It began to rumble yesterday."
Implied: "The volcano began to rumble."
New: "The volcano was very quiet."

This recognition list consisted of 10 sentences that had actually been dictated, 10 that had not been dictated but were implied by the dictated triplets, and another 10 that were unrelated to the meanings of the triplets although they were formed from words that had been included in the dictation list.

Mary and Arlene recognized related sentences with more confidence than they showed regarding unrelated sentences. Mistaken recognition of implied sentences indicated they grasped what they had heard.



In addition to judging whether each of the test sentences had been dictated earlier, Mary and Arlene indicated their confidence in every judgment, using a six-step rating scale that ranged from "certain it was dictated" to "certain it is new" After the first surprise session, we gave the pair similar lists and tests on nine separate occasions.

The experiment was successful. Mary and Arlene recognized the dictated sentences with more confidence than they had concerning the unrelated sentences. They could not have done this by recognizing individual words, because all the sentences were made up of words that had been given during dictation. This finding confirms what our other two tests had also demonstrated: Arlene and Mary were picking up and retaining information about the dictated sentences as wholes.

Second, and more important, Mary and Arlene indicated a high degree of recognition for the implied sentences. Like the people in the control study, our readers found the implied sentences

Translators at the United Nations apparently have learned to divide their attention, for they must translate as rapidly as the speaker talks, reporting one thought while listening to the next.

more familiar than the unrelated ones. Of course all recognitions of the implied sentences were mistaken, for they had not actually been dictated. These recognitions are, therefore, highly significant because they can only have been based on a grasp of the implications themselves. Arlene and Mary were sensitive not only to the structure and the meanings of individual sentences, but also to meanings that they had to infer across a number of sentences taken together. In this important sense, our subjects understood what they were writing as well as what they were reading.

These results show clearly that the concept of automatism used in current theories of information processing is an inadequate explanation of how people do two things at once. If automatic activities must be simple, then our subjects combined reading with writing without reducing either activity to automatic status. If their writing is to be considered automatic on the other hand, then there is no apparent limit to the complexity of automatism.

Our research leaves many important questions unanswered. We do not know why it is so hard to learn to combine reading and writing or, more generally, why some mental processes are easy to combine and others difficult. Nor do we know what role, if any, conscious awareness plays in the acquisition of skill. If complex activities can indeed be automatic, then we need a new definition of automatism.

We think our research has far-reaching implications, but they are more theoretical than practical. We are not presenting any new method of expanding human consciousness nor selling a technique for squeezing two hours of work into one. Simultaneous reading and writing will probably never become a popular pastime if only because it is so difficult to learn. But the mere fact that it is possible undermines many currently popular conceptions of the human mind. The acquisition of a new cognitive skill does not involve finding ways to circumvent central processing limits; it is an organic growth building on experience. Some skills are developed much more slowly than others, but an inability to do something at one stage of development or practice is no proof that it cannot be accomplished later on. The impossible, as the saying goes, may just take a little longer. □

For further information:

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