Some experiments are summarized which employ the procedure of briefly exposing a word followed by a masking pattern. These studies show that under appropriate conditions, while people are unable to tell that anything has been shown before the mask, the meaning of the word has been analyzed and influences their behaviour. There is thus a distinction between (a) the availability of a word to consciousness or as a vocal response and (b) its having been read in the sense of lexical and semantic identification. In addition to its theoretical and methodological importance, this suggests re-evaluation of methods of assessing reading. Further, the techniques have been useful in investigating acquired dyslexia and understanding the cerebral organization of reading and language production.

This article is the text of a paper given to the British Association for the Advancement of Science in September 1976. More detailed presentation of the techniques, results, and theoretical discussion can be found in Marcel (1978a, b) and Marcel and Patterson (1978).

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Unconscious Reading: Experiments on People Who Do Not Know That They Are Reading

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The work reported in this paper is theoretically, methodologically, and practically relevant for reading in particular and perception in general. It is relevant theoretically because it forces a distinction between conscious and unconscious processes. It is relevant methodologically because it suggests the importance of investigating perceptual processes in an indirect way. It is relevant practically because assessment of reading ability often relies on oral performance and this may turn out not always to reflect what we mean by "reading."

The phenomenon which I have examined was discovered by accident and suggests that psychologists have been misinterpreting a certain specialised experimental technique. The technique is called "masking," specifically "pattern masking." One may expose briefly a visual pattern — such as some letters or a word as in Figure 1 — and then ask a person to tell you what he or she has seen. If it is shown fairly briefly people may say, "Well, I saw U, Z, and I think R. I know there were more things there, but I can't seem to tell you what they were."

If we follow a stimulus like this with a second meaningless jumble of lines, as in Figure 2, then the shorter the time between the onset of the first stimulus and the onset of the second stimulus, the less the observer can tell you of what had been shown in the first display. The second stimulus is called a pattern mask because it seems to interfere with perception of the target stimulus by virtue of the pattern on it. This term is also used to differentiate it from another type of visual interference called brightness masking. This is different in several ways and does not yield the effects reported here for pattern masking. The effectiveness of a pattern mask in interfering with perception of the preceding stimulus is increased if the thickness and shape of the lines are similar to those in the initial stimulus. Thus the best mask for letters is letters or cut-up letters of the same typeface. The phenomenon of masking has been widely used and interpreted by psychologists as an interference with the process of visual analysis that leads to identification (Sperling, 1976; Turvey, 1973).

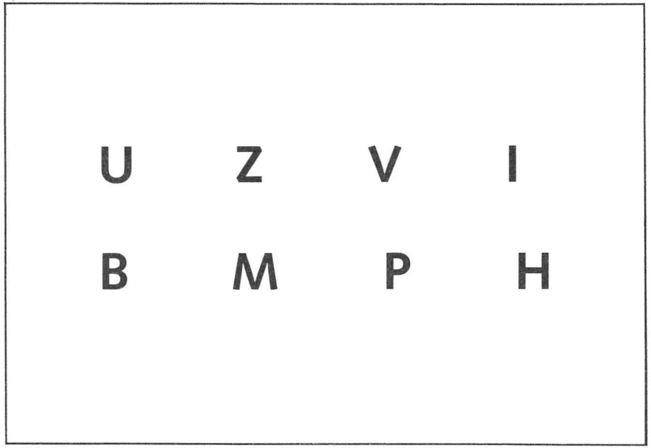


Figure 1.
Example of a test display of letters.

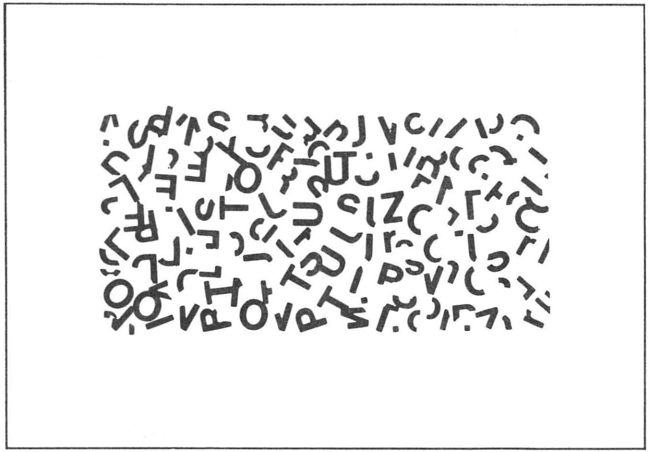


Figure 2.
Example of a pattern whose strokes and structure would be effective in backward masking of the display in Figure 1.

This and several other theoretical assumptions were called into question by some odd data. I was carrying out an experiment where I was briefly exposing single words to children and adults who were supposed to tell me what they could see — if not words, then letters — and indeed people are usually inclined to say only something which does not violate their visual impressions. However, several responses seemed to bear no visual or sound-like relation to the stimuli, but did show a striking relationship in meaning. For example the response "king" was made to the stimulus **queen,** and "yellow" to the stimulus **green.** This was reminiscent of two other phenomena. One is the responses of this type often given by certain aphasic patients when asked to read single words (Marshall and Newcombe, 1973). The other was some work on the thorny issue of subliminal perception. In both cases the point is that people seem to have understood the meaning of a stimulus word without being able to tell you exactly what it was. I will not dwell on the details of the particular research on subliminal perception, but it struck me as rather poorly controlled. For this reason I decided to try to redo the experiments in a more controlled way. What I did was the following.

I exposed either a single word or a blank card followed by a pattern mask. After each trial the subject had to make one of three decisions: (a) was there anything before the mask or not? (b) given two words, which of them was more similar visually to what had been presented? (c) given two words, which of them was more similar in meaning to what had been presented? The exposure duration of the field before the mask was kept the same for a number of trials and then lowered. So gradually the pre-mask duration became extremely brief.

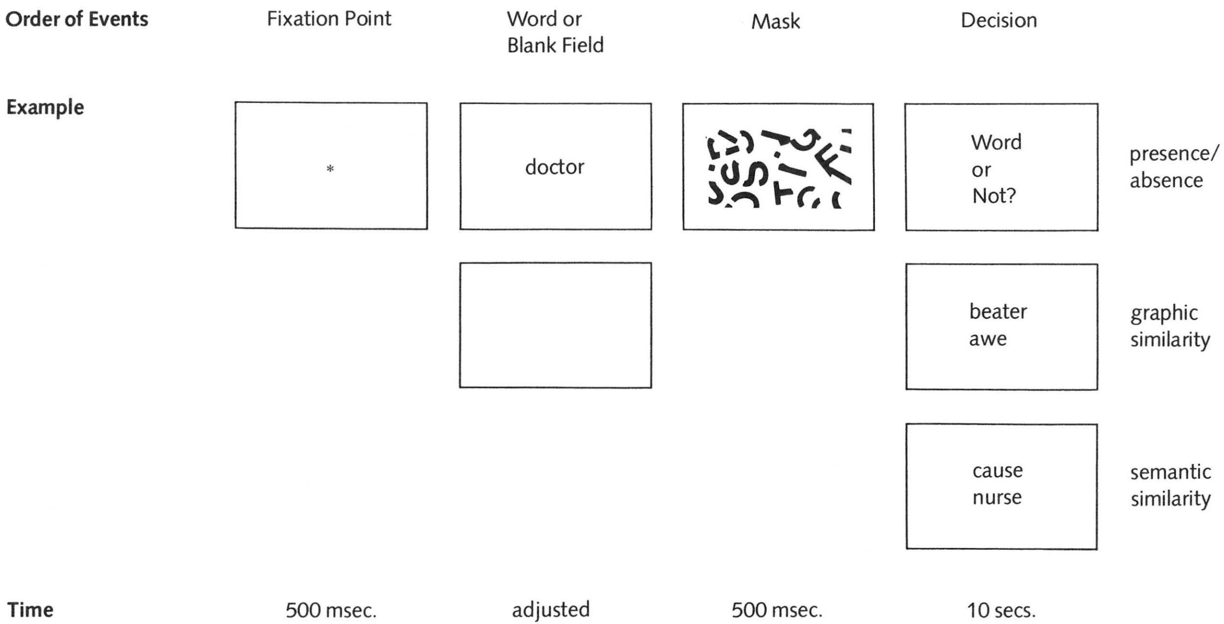


Figure 3. Example of sequence of events on a trial to assess effect of stimulus-mask asynchrony on presence, graphic, and semantic decisions.

Examples of the sequence of events on each trial are shown in Figure 3. Then, for each exposure duration, I looked at the data to see to what extent each type of decision was correct or whether they were random guesses, predictable only by chance. Some subjects refused to go on when they could no longer see anything. Some others said afterwards that when they could no longer decide whether they had seen anything, they had thought the whole thing silly but had continued answering the other questions (about appearance and meaning) by inventing a strategy, like thinking of a word or a face and judging on the basis of that. Obviously the experiment was rather odd. It is bizarre to ask someone to make a judgement about something of whose presence he is not aware. However, about two thirds of the people said that although they could not see the point, they had just carried on guessing. These people produced some interesting results.

	Stimulus	Response
Word	PARTY	Yes
Non-Word	PRAIN	No

When they reached chance performance on the presence/absence judgement, they were all still guessing correctly above chance on the other two decisions. They all reached chance next on the graphic similarity decision, but were still guessing above chance on the judgement of meaning. Eventually, of course, they reached chance on that decision too. It is to be noted that all subjects while guessing correctly, claimed that they could not see anything!

As mentioned above, dramatic as the results were, they were not true for all of the subjects, and that is because I had asked people to make a judgement **directly** about the stimulus of which they were not aware. All the other experiments which followed overcame this problem by only looking at the effect of the meaning of the masked word on **another** task with related words.

I will describe an experiment which exemplifies this. The task I used is called "lexical decision." This involves presenting a string of letters to the subject who has to decide as quickly as possible whether it is a word or not. When it is not a word, in the experiments reported here, the letter string obeys the rules of English spelling and is pronounceable. In the example in Figure 4 you would respond "Yes" to PARTY and "No" to PRAIN.

One can also give two trials in fairly quick succession. It is known that if both strings are words, the decision that the second is a word is faster if it is associated in meaning with the first than if it is not (Meyer, Schvaneveldt, and Ruddy, 1972). Examples of the types of pairs of letter-strings are shown in Figure 5.

In order for this to happen the first word must have been identified at least to a level where it is associated with other words, if not to its meaning. This effect is called the "association effect" or "asso-

Figure 4.
Examples of letter strings in lexical decision task.

ciative priming." Here, then, is a task where the meaning of one word has an effect on a second, separate decision.

The method of the crucial experiment was to compare the effects of associated words on lexical decision time (word or not) when the first letter string is either left unmasked or pattern masked. Before carrying out the experimental session I first found out the time before the mask onset at which each subject individually was no longer able to detect the presence of a word above chance. I then asked each subject to carry out the lexical decision task under each of the two conditions. Subjects were not required to respond to the first pattern or letter string, but were told that it could be used as a temporal warning for the stimulus that they had to classify and that sometimes it might help them. Under the masking condition they were told that this was a control session, i.e., no first word.

Type of Pair	Letter String 1	Letter String 2	Number of Trials
Nonword-Nonword	WOOT	GLAYER	45
Word-Nonword	STREET	GLAYER	45
Nonword-Word	WOOT	INFANT	30
Word-Word Unassociated	STREET	INFANT	30
Word-Word Associated	CHILD	INFANT	30
	No response	RT (Word/Nonword)	

Letter String 1 is either (a) Left Unmasked or (b) "Pattern" Masked

Figure 5. Examples of pairs of letter strings used to assess effect of word association in lexical decision task.

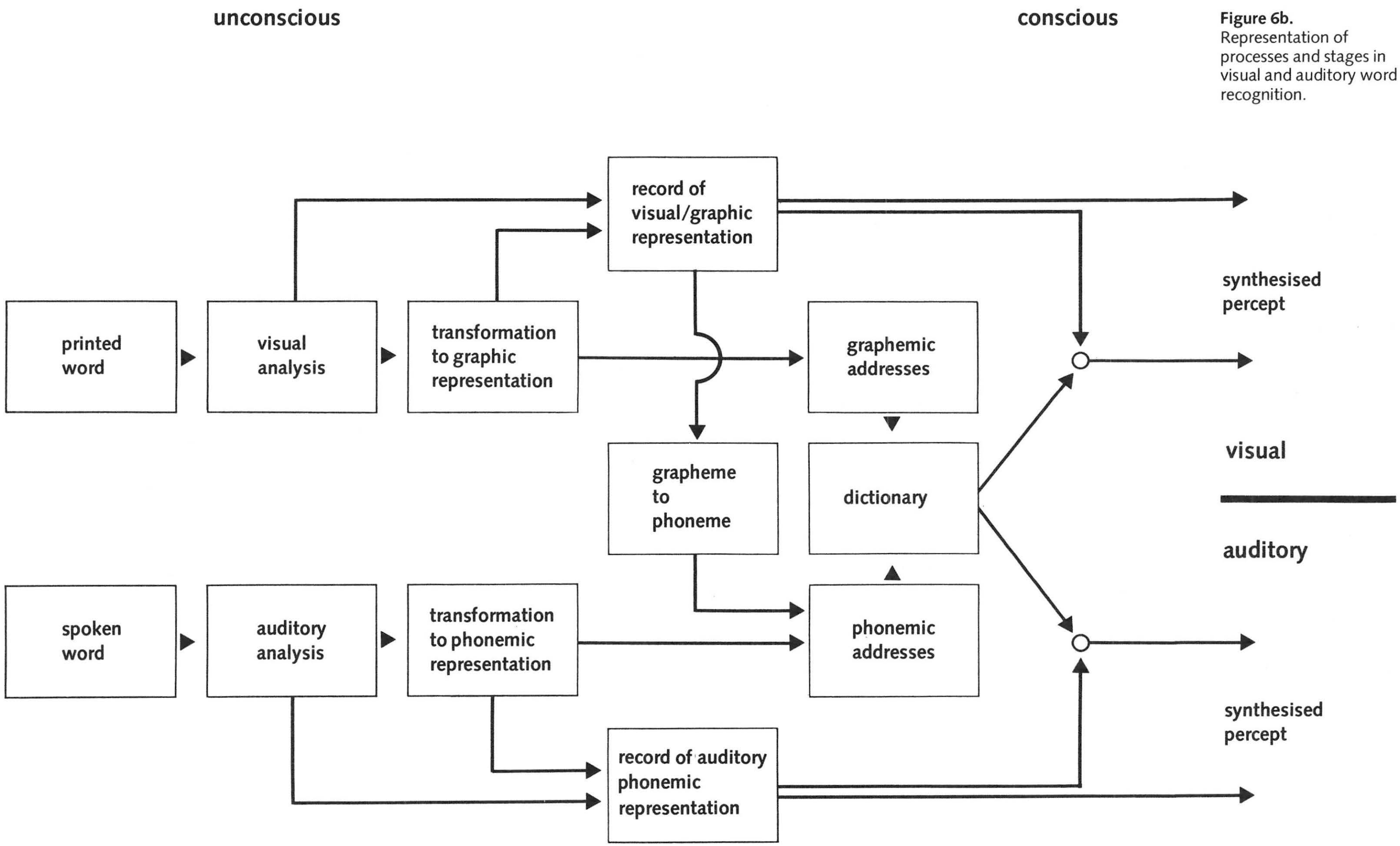
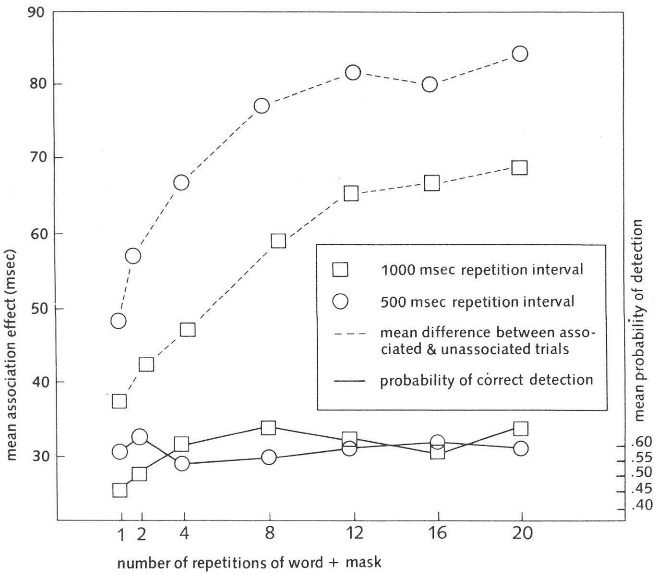


Figure 6b.
Representation of processes and stages in visual and auditory word recognition.



What the experiments seem to suggest is that all the processes up to the dictionary are unconscious. Now, the mask must be having its effect at the level of either the visual representation or the graphic representation. But, since this is evidently not preventing access to the dictionary, I suggest that for us to be conscious of a stimulus we have to have a **record** of the visual pattern and it is with **this** that the mask interferes.

Evidence that the pattern mask is having its effect non-peripherally, or fairly high up the system, is that it works if the target stimulus is presented to one eye and the mask is presented to the other. Therefore the location of the masking effect must be at least beyond where information from the two eyes is combined.

I am proposing that we separate **processing** of information which transfers it to different codes or representations, and **records of the results** of such processing at each stage. In order to reach consciousness the output from the dictionary is not enough: we also need information from the record of the visual or graphic representation. That this is so is suggested by another experiment I have done. A word is masked so that it is not seen, and then that combination of word-followed-by-mask is repeated within a short space of time. The more times you repeat the masked word the greater is the effect of its meaning on lexical decision to an associated word immediately following the last repetition. But repetition makes no difference to the probability that the subject can report its presence or say the word. The results of such an experiment are shown in Figure 7.

Figure 7.
Effect of repetition of masked word on (a) size of the association effect, and (b) probability of presence-absence discrimination.

This implies that however strong is the unconscious representation of a stimulus, it will not become conscious unless the record is available. Conscious representation appears to be qualitatively different in its requirements from non-conscious representation. Another experiment illustrates a further way in which conscious perception differs qualitatively from non-conscious perception, which is the limited capacity of consciousness. In this experiment lexical decision was required to the first and third of three letter strings. When all three were words, the second one was a polysemous word like PALM (which has two meanings). This could be followed by a word associated to one of its meanings (WRIST) and preceded by a word related to the same meaning (HAND), a different meaning (TREE) or to neither meaning (SPEED). The second word was either masked to prevent awareness or left unmasked. When people were aware of PALM, it only aided the processing of WRIST if it was preceded by HAND. However when PALM was masked, it helped WRIST **whatever** preceded it. Thus it seems that both meanings are activated simultaneously non-consciously, but only one is activated consciously. This is consistent with the idea that only one interpretation of an event can be entertained by consciousness, and prior context (the first word) only selects the appropriate interpretation when a choice becomes necessary, i.e., if the representation can become conscious.

These experiments have some important implications. Firstly, it looks as if much of perception, even to high interpretive levels, is automatic and independent of intention or consciousness. For example, if you turn over a page of a book and are reading the top line, something right at the bottom of the page may "catch your eye." But this is only possible if its meaning has been analyzed independently of where your attention is directed. Another example is when you are following one of several conversations. You may be unaware of what your neighbour is saying, but will turn round if your name is mentioned. Consciousness is a "late" stage. Once you have learnt to read and understand speech, the analytic process itself is automatic and "unstoppable." Of course, analyzing the meaning of individual words is separate from the meaning that comes from combinations of words in particular sequences. This refers to sentence syntax, or the difference in meaning between "John hit Mary" and "Mary hit John." We intend to carry out experiments to see if that sort of analysis, too, is automatic and unconscious. However, there are empirical and theoretical arguments which suggest that this will not be the case (MacKay, 1973; Kleiman, 1975).

As far as cases where we want to **assess** someone's reading ability are concerned, the experiments give us a cautionary message. If a person is asked to read a passage or a series of single words, as in the Schonell test of reading ability, an error or a failure to give a response does not necessarily mean that he cannot or has not read the word. By "reading" we often mean computing the identity and the meaning of the word, and we often assume that if this is done there should be little difficulty in producing the word. In silent reading and speed reading we are not concerned with the production of the word. But, more crucially, the present experiments suggest that the production of the word may involve problems that have nothing to do with articulation, even if the word has been identified.

Although we should be wary of generalizing too quickly to the **teaching** of reading, let us take an example from the classroom. When children are asked to read aloud, they often come to words that they are unable to produce, and they stop. At least two strategies are open to the teacher. One is to try to get the child to go back to the elements making up the word (e.g., letters and graphemes or phonemes) and try to synthesize it. Another is to encourage the child to guess, in the belief that they can get him or her to use contextual information. The appropriate choice must depend on the particular stage the child is at. Although one should not make broad generalizations, the present experiments give a basis for using the second strategy. If on some proportion of cases the word has already been analyzed to the level of meaning, the added semantic or syntactic information given by context could, in those cases, operate at the appropriate level to help mobilise the response.

A further illustration of the point comes from certain cases of acquired dyslexia among aphasic patients, those whom Marshall and Newcombe (1973) call "deep dyslexics." These people have brain damage on the left side of the head and have speech problems. They make several interesting types of errors in reading single words. One of these is to produce semantically related words, e.g., "dream" for **sleep,** "horse" for **paddock**. Another is the relative inability to read "function" words or prepositions, e.g., they cannot read **in** or **be**, but can read **inn** and **bee**. Another is the reduced probability of correctly reading more abstract words. All of these problems have nothing to do with the physical characteristics of the words (e.g., shape, spelling, sound) but are connected with the **meaning** of the word. Incidentally, if you say the word and ask the patients to repeat it, they have no trouble. Therefore the problem is not in articulation. It is more likely to be in getting from the meaning to the specific instructions for saying the word, or in the representation of word meanings itself.

I have studied with Karalyn Patterson patients of this kind, and we have been trying to see if we can reproduce their performance in normal people. The patients all have damage to the **left** side of the brain. We have found that normal people show some of the same effects of the type of word as the patients, if one exposes single words briefly, ensuring that they are received first by the **right** cerebral cortex. (This is possible because nerves from the right halves of the eyes go to the right side of the brain, and vice versa.)

That is, people are much worse at perceiving abstract than concrete words when they are projected to the right half of the brain, but not much worse when they are projected to the left half of the brain.

But this is only so if we ask the subjects to **report** the word. If the word is masked so that it cannot be reported and one looks at the effects of its meaning on other words, as was described above, the results suggest that the meaning of different types of words is analyzed as effectively whichever cerebral hemisphere the word is sent to first (Marcel and Patterson, 1976). These experiments suggest to us that words are understood in both cerebral hemispheres, but that it is the **production** of speech — the putting of an idea into words — that seems to depend mainly on the left side of the brain. In most studies of the two cerebral hemispheres this distinction between recognition and production is not drawn. This is one way that the technique is helping us to understand normal and pathological processes.

But as has been implied, the techniques described here are relevant not only to reading and speech. It is usually assumed, quite reasonably, that if a person can make some judgment about a stimulus then he or she has processed it, and that such processing is synonymous with conscious attention. The converse, however, is not true. Not only is much processing done non-consciously, but also it appears that the results of processing often differ qualitatively depending on whether or not the person is aware of the stimulus. In carrying out experiments, we must be careful to separate the automatic aspects of perception and understanding from the contributions of consciousness and the demands made by the responses required, which usually involve conscious deliberation and volition.

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