anticipating material that is about to come. When writing a particular word, we already have the next few words stored in our minds, ready for production. We will look more closely at this process in Section C7.

Motor processes

Studies of typing patterns offer insights into the last (motor) stage of the writing process. Average typing speed is 7 to 8 strokes per second. The way in which the typist processes linguistic information is shown by the length and regularity of the intervals between these finger strokes. The following findings appear to be important:

1. In terms of rhythm, the unit of typing seems to be the word rather than the phrase or sentence.
2. Intervals between strokes are greatest at the beginnings and ends of words.
3. Intervals between strokes are longer for letter strings which occur infrequently.
4. Syllabic boundaries appear to have some effect; the frequent sequence -th- is typed faster in pathetic than in pornhole.
5. Performance declines with nonsensical letter strings, but not with non-words that bear a resemblance to existing ones.

This may tell us something more about the way in which words are retrieved from the brain, or it may simply tell us something about the typing process itself. Typing is clearly an activity that demands a great deal of conscious control at the outset, but that gradually becomes proceduralized into a set of automatic keystroke sequences—particularly for very frequent words such as the. It may be that the keystrokes made by a typist are stored as an independent set of procedures (accounting for faster performance with more frequent letter sequences), or it may be that they are linked to a visual representation of each word, or indeed to a phonological representation.

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EYE MOVEMENTS IN READING

Activity

Here are some assumptions that are sometimes made about reading as a process—especially in 'speed reading' literature. Do you agree or disagree with them?

1. Efficient readers do not need to read all the words in a text. They predict many words from the context in which they appear.
2. Efficient readers make large sweeps with their eyes as they read along lines of text.
3. Words can be identified by their overall shapes. So longer words often take the same time to read as short ones.
4. A slow reader is one whose eyes do not move fast enough from left to right. Increases in reading speed can be achieved without loss of comprehension.

Reading involves a series of rapid eye movements (known as saccades) along the line of print or writing, followed by periods of fixation when the eye rests upon a point.
in the text. A saccade typically lasts from 20–30 milliseconds while a fixation can last from 150 to 500 msec and sometimes longer. At the end of a line, the reader makes a return sweep on to the following line.

Experiments have learnt a great deal about lower level reading processes thanks to equipment which enables us to track the movement of the reader’s eyes across the page. By comparing the eye movements of skilled and less skilled readers, we can get a clearer idea of what makes for efficient reading. We can also get an idea of what aspects of a text cause processing problems.

Figure B1.1 above is based upon eye movement data published (1989) by reading researchers Keith Rayner and Alexander Pollak of the University of Massachusetts. The dots above the text mark the fixation points and the figures show how long in milliseconds each fixation lasted. The saccades move in a left-to-right direction except where an arrowhead indicates a regression (with fixations shown on a higher line).

Study the figure to find out:

1. How many fixations are there on average per line?
2. Where do they fall in relation to the words?
3. How many letters on average does a saccade move across?

<table>
<thead>
<tr>
<th>266</th>
<th>221</th>
<th>246</th>
<th>277</th>
<th>256</th>
<th>233</th>
<th>214</th>
<th>188</th>
</tr>
</thead>
</table>

Roadside joggers endure sweat, pain and angry drivers in the name of fitness. A healthy body may seem reward enough for most people. However, for all those who question the payoff, some recent research on physical activity and creativity has provided some surprisingly good news. Researchers report:

<table>
<thead>
<tr>
<th>204</th>
<th>66</th>
<th>201</th>
<th>188</th>
<th>203</th>
<th>220</th>
<th>217</th>
<th>288</th>
<th>212</th>
<th>75</th>
</tr>
</thead>
</table>

hundreds of aerobic exercise may also help spark a brainstorm of creative thinking.

Figure B1.1: Fixation sequences and fixation durations
Source: Adapted from Rayner and Pollak (1989: 116)
Fixations usually fall on the early part of a word (about a third into longer words) – which suggests that their position may be partly determined by the spaces between words. The reader has a perceptual span of about fifteen characters to either side of the fixation point. But the words that are furthest away are processed at a lower level of attention. Producing a long word may sometimes involve two fixations and long words generally demanded more fixation time than short ones. A return sweep typically starts about 5–7 characters from the end of the line and the new fixation point is close to the beginning of the new line.

Saccades cover no more than about 7–9 characters (fewer in logographic writing systems), with the result that almost every word is fixated. In all, this means about 80 per cent of content words and 60 per cent of function words. The few words that are skipped are short, frequent or highly predictable from the context; but the skipping of so many function words suggests that this class of items may be recognized in a highly automated way and accorded less attention than content words.

Figure 8E.2 below was composed by reading researchers Marcel Just and Patrick Carpenter (1987) using eye movement research data. It shows how the same text was read by a skilled and a less skilled reader. The saccades move from left to right unless otherwise indicated. Ovals indicate the fixation points and the figure inside
they show how long the fixations lasted. What does the figure tell you about the differences in the way the two readers processed the text?

It was once believed that reading efficiency could be improved if the records of weak readers were made longer. However, the evidence shows that good readers start off with about the same number of fixations as poor ones. What marks out less skilled readers (and reading in the early stages of acquiring a second language) is a much higher level of regression. Regression in an average reader only adds about 30 per cent to the fixations; in an unskilled reader, it accounts for much more. And whereas regression in skilled reading is often connected with building higher level meaning, regression in unskilled reading usually serves to check that words have been correctly decoded. Less skilled readers often have longer fixation times, especially when processing long or unusual words.

Relate these eye movement findings to the assumptions you discussed at the beginning of this section.

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**CATEGORICAL PERCEPTION**

We saw in Section A9 that the 'non-invariance' problem is a difficult one to settle. In this section, we assume that there is indeed some kind of physiological representation which enables us to discriminate between, for example, occurrences of /pa/ and occurrences of /ba/, and we look more closely at how this kind of distinction is made.

Traditional phonological accounts describe the sound /p/ as 'voiceless' and the sound /b/ as 'voiced'. In fact, the major difference lies in how quickly the voice begins for the vowel that follows. With a sequence such as /pa/, there is a gap lasting from 25 to 80 milliseconds between /p/ and the voice of the vowel. With a sequence such as /ba/, the onset of voicing coincides with the /b/ or occurs no longer than 25 milliseconds afterwards. It is Voice Onset Time (VOT) which enables our ears to distinguish between the two sounds.

The VOT distinction has enabled researchers to manipulate speech sounds by computer. They can produce a synthesised range of consonant-vowel sequences which proceed in regular steps from a sequence with a VOT of 0 (clearly identifiable as /p/) to one with a VOT of 80 (clearly identifiable as /b/). Subjects are asked to report what they hear (by discriminating same or different) between two exemplars within a category range (say within 0–25 milliseconds); and to discriminate between two exemplars on different sides of the category boundary.

Interpret the results obtained which illustrate what is known as categorical perception.