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Frequency Effects in Word Recognition

A word's *frequency* is a measure of how commonly it is used. Most often, it is expressed as a relative frequency, such as occurrences per million words in a large corpus of written or spoken language. Generally, higher frequency words are recognized more quickly and/or accurately than lower frequency words, although processing is simultaneously affected by many lexical characteristics (such as word length, spelling-sound regularity, and number of phonologically and semantically similar words). While corpus frequency provides only an estimate of the average person's experience, it correlates strongly with an individual's subjective frequency estimates and is one of the best predictors of word recognition facility. This entry briefly reviews basic phenomena of frequency effects and mechanisms proposed to account for them.

Phenomena

In a basic study of frequency, the experimenter tests performance on sets of low- and high-frequency words. The experimenter must operationalize "low" (perhaps 1 to 10 occurrences per million words) and "high" (perhaps greater than 50 or 100 occurrences per million, but specific levels vary between studies). Log frequency predicts performance better than raw frequency, such that the effect of a constant difference in raw frequency diminishes as word frequency increases (e.g., a difference between 1 and 20 per million has a stronger effect than a difference between 101 and 120 per million). One can also study frequency using a regression approach and test performance on words with a continuous distribution of frequencies. In such studies, frequency tends to account for 5% to 15% of the variance in performance when other lexical characteristics are controlled.

The basic frequency effect is easily replicated, both in the rarefied conditions of isolated word processing as well as in more ecologically valid tasks, such as reading and following spoken instructions to interact with objects in a visual display. In reading, for example, fixation time on a word is inversely proportional to its frequency. Frequency can also influence performance on processing speech sounds. For example, categorical perception of a spoken phoneme continuum such as /b/ to /p/ shifts if the continuum is between a high- and a low-frequency word, as in "best-pest" (shift toward /b/) versus "pray-bray" (shift toward /p/). Frequency also interacts with other lexical characteristics such that effects of other variables (e.g., spelling-sound regularity and neighborhood) are more pronounced in low-frequency words than in high-frequency words.

Basis

A very basic question about the basis of frequency effects is whether the causal factor is cumulative frequency of exposure (as implied by using corpus estimates) or some aspect of experience. For example, high-frequency words also tend to be words that are acquired early by children, suggesting that early age of acquisition might afford a privileged status in memory and raising the possibility that frequency effects might best be understood as effects of age of acquisition. However, behavioral studies and simulations with connectionist models have established that age of acquisition and cumulative frequency both influence lexical representations. A related question concerns the impact of long-term cumulative frequency versus that of recent changes in frequency. Although changes in recent experience can make frequency effects disappear quickly (e.g., as low- and high-frequency words in a closed or fixed set are repeated, performance on low-frequency words quickly catches up to performance on high-frequency words), such effects dissipate without continued support for short-term changes in frequency. This suggests differential weighting of long-term and recent experience.

Three Classes of Proposed Mechanisms

One possibility is that frequency constantly and directly affects a word's availability. For example, the lexicon might be organized like a file drawer with entries sorted by frequency. Similar behavior would be predicted in a connectionist framework by making the "resting level" (default level of activation in the absence of bottom-up support) of the node or network representing a word proportional

to frequency. Availability mechanisms predict constant frequency advantages throughout the time course of processing a word.

A second possibility is that experience connections from phonemes or letters to words could be proportional to each word's frequency (so the connection from *b* to *bed* would be stronger than its connection to *bench*). Such a mechanism can be instantiated in a connectionist network with "hard-wired" connections, and frequency advantages of this sort also emerge naturally in learning networks (where connections are strengthened whenever they are used). Like availability, a sublexical-lexical connection strength mechanism predicts a frequency advantage throughout the time course of word processing but with the subtle difference that the magnitude of a frequency advantage depends on the amount of bottom-up activation flowing through the frequency-weighted connections. So in the early time course, the frequency advantage will be modest because the bottom-up activation passing through sublexical-lexical connections is still weak. As bottom-up support increases (either as more of a spoken word is heard or as more time elapses during reading), so will the frequency advantage.

A third possibility is that rather than being an intrinsic part of the mechanisms for lexical access, frequency is integrated at a decision stage after the evidence for a word has been perceived. Such proposals treat frequency like knowledge that is retrieved as a result of lexical access and subsequently acts as a decision-level bias. If frequency effects cannot "kick in" until a word form has substantial bottom-up support, such proposals predict that frequency effects should be absent in the early time course of word processing.

Temporal Locus

Note that the three mechanisms make distinct predictions about when, during processing, frequency effects should be detectable. A decision mechanism predicts late effects, availability predicts continuous effects of a fairly constant magnitude, and connection strength mechanisms predict constant effects that strengthen as a word is processed. Two recently developed techniques have made it possible to examine these predictions at a fine time scale. First, a method for tracking the time course of spoken language processing was developed by Michael Tanenhaus and his colleagues. In their "visual world paradigm," subjects' eye movements are tracked as they follow spoken instructions to move objects in a visual display. Fixations are remarkably strongly time locked to fine-grained phonetic details, with only about a 200 milliseconds delay between a phonetic detail and its impact on gaze. When this technique was applied with low- and high-frequency words, the time course was like that predicted by a connection strength mechanism: Frequency effects were immediate but initially subtle and strengthened as a word was heard. Converging evidence has been reported for both visual and spoken word recognition in a dual-task paradigm where frequency effects are present prior to the occurrence of a "dual-task bottleneck" (the point where performance on each task begins to suffer from interference from the other). Performance prior to such a bottleneck is presumed to depend only on highly automatic processes, suggesting an early and automatic locus of frequency effects.

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See also Word Recognition, Auditory; Word Recognition, Visual

Further Readings

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