Miller's Magic Number

7 ± 2

"The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information" is one of the most highly cited papers in psychology. It was published in 1956 by the cognitive psychologist George A. Miller of Princeton University's Department of Psychology in Psychological Review. It is often interpreted to argue that the number of objects an average human can hold in working memory is 7 ± 2. This is frequently referred to as Miller's Law.

Miller's article

Number of judgments

16

8

4

2

0

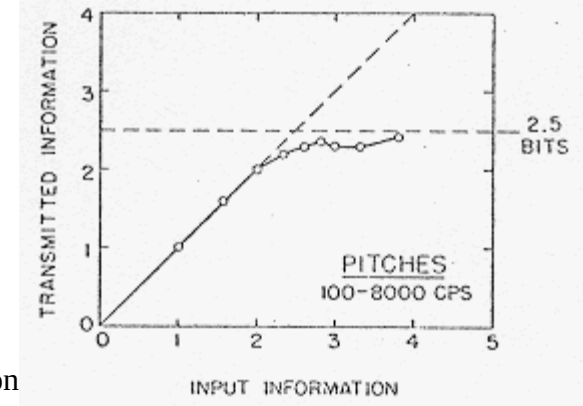

FIG. 1. Data from Pollack (17, 18) on the amount of information that is transmitted by listeners who make absolute judgments of auditory pitch. As the amount of input information is increased by increasing from 2 to 14 the number of different pitches to be judged, the amount of transmitted information approaches as its upper limit a channel capacity of about 2.5 bits per judgment.

In his article, Miller discussed a coincidence between the limits of one-dimensional absolute judgment and the limits of short-term memory. In a one-dimensional absolute-judgment task, a person is presented with a number of stimuli that vary on one dimension (e.g., 10 different tones varying only in pitch) and responds to each stimulus with a corresponding response (learned before). Performance is nearly perfect up to five or six different stimuli but declines as the number of different stimuli is increased. The task can be described as one of information transmission: The input consists of one out of n possible stimuli, and the output consists of one out of n responses. The information contained in the input can be determined by the number of binary decisions that need to be made to arrive at the selected stimulus, and the same holds for the response. Therefore, people's maximum performance on one-dimensional absolute judgment can be characterized as an information channel capacity with approximately 2 to 3 bits of information, which corresponds to the ability to distinguish between four and eight alternatives.

Number of judgments

16

8

4

2

0

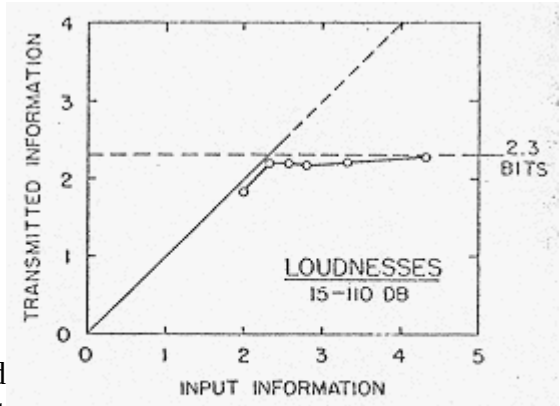

FIG. 2. Data from Garner (7) on the channel capacity for absolute judgments of auditory loudness.

The second cognitive limitation Miller discusses is memory span. Memory span refers to the longest list of items (e.g., digits, letters, words) that a person can repeat back immediately after presentation in correct order on 50% of trials. Miller observed that memory span of young adults is approximately seven items. He noticed that memory span is approximately the same for stimuli with vastly different amount of information—for instance, binary digits have 1 bit each; decimal digits have 3.32 bits each; words have about 10 bits each. Miller concluded that memory span is not limited in terms of bits but rather in terms of chunks. A chunk is the largest meaningful unit in the presented material that the person

recognizes—thus, it depends on the knowledge of the person what counts as a chunk. For instance, a word is a single chunk for a speaker of the language but breaks down into as many chunks as the word has phonetic segments for someone who is totally unfamiliar with the language.

Miller recognized that the correspondence between the limits of one-dimensional absolute judgment and of short-term memory span was only a coincidence, because only the first limit, not the second, can be characterized in information-theoretic terms (i.e., as a roughly constant number of bits). Therefore, there is nothing "magical" about the number seven, and Miller used the expression only rhetorically. Nevertheless, the idea of a "magical number 7" inspired much theorizing, rigorous and less rigorous, about the capacity limits of human cognition.

The "magical number 7" and working memory capacity

George A. Miller

Later research on short-term memory and working memory revealed that memory span is not a constant even when measured in a number of chunks. The number of chunks a human can recall immediately after presentation depends on the category of chunks used (e.g., span is around seven for digits, around six for letters, and around five for words), and even on features of the chunks within a category. Chunking is used by the brain's short-term memory as a method for keeping groups of information accessible for easy recall. It functions and works best as labels that one is already familiar with—the incorporation of new information into a label that is already well rehearsed into one's long-term memory. These chunks must store the information in such a way that they can be disassembled into the necessary data. The storage capacity is dependent on the information being stored. For instance, span is lower for long words than it is for short words. In general, memory span for verbal contents (digits, letters, words, etc.) strongly depends on the time it takes to speak the contents aloud.

(Source: Wikipedia, Miller 1956)