From the Research: Myths Worth Dispelling

Seven Plus or Minus Two

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For over 50 years, *seven plus or minus two* has been a commonly used guideline for gauging how many chunks of new information should be presented at one time in learning and performance situations. Often cited as the limit of working memory, this guideline was created as a result of misinterpreting an article by Miller (1956). More recent studies suggest that the limit for working memory is more like three, and sometimes four, with various factors influencing the capacity of an individual's working memory. Given too much novel information at one time, learners and performers can be derailed by cognitive overload. Instructional designers and performance consultants can adjust the presentation of new information to manage intrinsic, extraneous, and germane cognitive load. This column provides suggestions about how to reduce cognitive overload to improve learning and performance.

Sometimes ideas that are in common use do not have the validity one might think given their ubiquity. It's fairly easy to be caught up in the belief that something that seems logical or has been repeated often enough has evidence behind it that we might respect—even when it does not.

The purpose of this column is to gently suggest that we examine our sources of evidence for some myths that have been repeated so often that they have become an accepted part of the landscape (at least for some practitioners). The reason for revisiting these ideas is so that we can avoid using myths as the underpinnings for design- and performance-oriented decisions. Instead, we can make decisions based on more current evidence that should provide a firmer foundation for the choices we make.

This column is offered without judgment toward anyone who has held an idea as true that was a misconception in the first place or that has been shown later to have little evidence to support it. Who has not been enamored with an idea that sounds so right but that later turns out to be something quite different?

In this regular column, you will find a series of topics and issues that performance improvement professionals should take into account as they make decisions about what to provide for their learners or clients. For the first topic, we will take a look at the capacity of working memory.

How often have you heard that we can hold seven items (plus or minus two) in our short-term memory? Short-term, or working, memory, is "the collection of mental processes that permit information to be held temporarily in an accessible state, in the service of some mental task" (Cowan, 1998, p. 77).

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Given a limit to our mental capacity, we run the risk of subjecting learners or employees to cognitive overload if we expect them to remember or to process too much at once. If you are worried about cognitive overload, some say, just limit the presentation of ideas (or chunks) to seven. Limit lines on a PowerPoint slide to seven. Note the number of digits in a telephone number—seven (plus one chunk of three for the area code). Give people seven action items to work on at a time. Organize a process so that it has seven steps. When something must be committed to memory, organize it into seven plus or minus two chunks.

Where This Came From

In 1956, George Miller wrote "The Magical Number Seven, Plus or Minus Two," an article in which he noted the many times the number seven occurs—for example, seven days of the week, seven wonders of the ancient world, and the seven seas. The recurrence of the number seven, along with the article's title, are commonly cited, and have become justification for creating rules for presentations, training, and other performance-enhancing programs. However, what tends to go unnoticed is Miller's conclusion that all these sevens are probably nothing more than coincidence (Thomas, 2005). Does Miller say that there is a limit to our capacity to process information? Yes. Does he say that there are seven, plus or minus two, slots in short-term memory? No. (See Shriffrin & Nosofsky, 1994, for a review.)

What to Consider Instead

More recent sources agree that, yes, there is a limit to how many new elements we can hold in working memory (Clark, 2010; Cowan, 1998; Luck & Vogel, 1998). However, they suggest that the limit is more like three or sometimes four items or chunks. Various factors influence working memory capacity (Kane & Engle, 2003; Shiffrin & Nosofsky, 1994), including the level of expertise of the learner or performer in a given domain (Ericsson & Kintsch, 1995).

Designers should keep in mind that the relative size and complexity of an element in working memory is vastly different for a novice than it is for an expert. For example, a novice at chess sees each separate piece as an item, whereas an expert may see the position of pieces on the entire board as one big chunk of information (Chi, 2006). Therefore, the mental effort required by one person to process a set of elements will be different—sometimes fundamentally so—from that required by another.

Keeping in mind individual differences and expertise, we should probably avoid creating a new doctrine ("three, sometimes four" versus "seven plus or minus two"). The more relevant rule is to avoid creating cognitive overload for learners and performers. Cognitive overload (Sweller, 1988) inhibits learning and problem solving, and it can reduce the available space in working memory enough to cause errors and reduce learning and performance.

Although working memory has no apparent limits when processing information that is already stored in long-term memory (Ericsson & Kintsch, 1995), it becomes overloaded when processing more than a few new elements at a time.

Yes, there is a limit to how many new elements we can hold in working memory.

Van Merriënboer and Sweller (2010) outline three types of cognitive load, along with suggestions for taking each of them into account when designing instruction:

1. *Intrinsic load* has to do with the ease (or difficulty) that an individual student has in processing novel information that is part of a learning task itself. For example, information related to completing the steps in a new procedure or troubleshooting software problems will be experienced as cognitive load by a learner depending on that learner's relevant prior knowledge. Various types of scaffolding can assist in managing intrinsic load.
2. *Extraneous load* occurs as a result of the way that new material is presented to the learner or performer (instructional design). For example, by giving novices unstructured problems to solve or by asking them to work on a new task that includes many substeps that they are not yet equipped to complete, a designer may inadvertently overload the learners' working memory. There are a variety of ways to reduce extraneous load, including streamlining the way information is presented and changing the nature of traditional learning tasks. (See also Kirschner, Sweller, & Clark, 2006.)
3. *Germane load* refers to the challenges to working memory from the learning task itself—for example, organizing new information into schemas, determining which of the new elements are structural features (active ingredients) and which ones are not, or making connections between new material and what the learner already knows. Decreasing extraneous load can optimize the amount of working memory available for intrinsic and germane load, which will enhance learning and performance. This is especially important for novel complex tasks, where intrinsic load is high.

Why We Care

Cognitive overload inhibits learning and performance. If we use seven plus or minus two as the standard for good presentation or for reasonable complexity in problem solving, then we can expect that our learners or performers may experience cognitive overload, which will likely result in diminished learning and performance. If we recognize that the relative capacity for working memory is more likely to be three or four items or chunks of new information, items, or chunks that will vary in size and complexity from individual to individual, and we take advantage of suggestions to avoid cognitive overload, then we can adjust accordingly, and learning and performance should improve as a result.

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