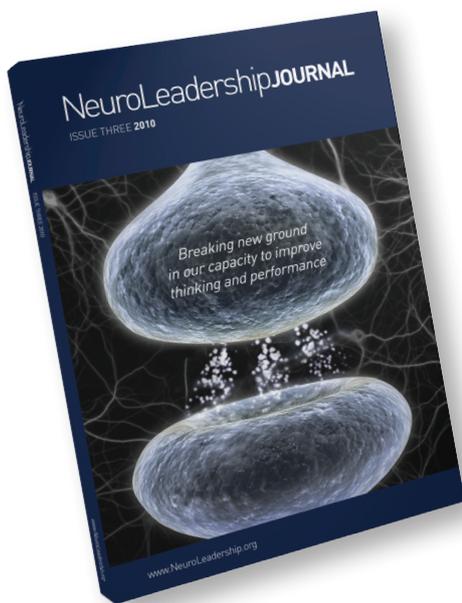# Learning that lasts through AGES

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Learning that lasts through AGES

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Summary

With more to learn than ever, faster innovation cycles, and reduced training budgets, organizations everywhere are trying to get more from their learning programs. However, to increase the effectiveness of learning, some of our intuitive understanding about learning may need updating. For example, while people generally predict that concentrated learning in one block of time is more effective, neuroscience research is clearly showing that it is far better to break up learning interventions to facilitate successful long-term learning.

This paper outlines recent findings from neuroscience research about how we learn, and how to optimize the formation of memory. These findings have been summarized into a four-part model for how to make learning stick: this is Attention, Generation, Emotion and Spacing, which we are presenting here as the AGES model.

So much to learn, so little time

Increased organizational change is increasing pressure on learning. Every new product, distribution model, partnership, or organizational structure comes with new information and processes to remember. As well as having more to learn than ever, there is less time to learn it in, driven by a desire to get to market quickly. Then there is the challenge of the nature of work itself, where distractions and multi-tasking inhibit the ability to focus sufficiently to learn something new. Finally, budgets for learning today are under significant pressure. In short, the pressure is on for employees to learn more, faster, under tougher conditions, and within tight budgets.

One outcome of these forces is simply shorter training programs. Training programs that used to be run over two or three days are now run in half a day, and a significant number of organizations are shifting training from a formal company-driven approach towards more social and informal learning methods (Bersin & Associates, 2011). Yet our ability to absorb new ideas is not dissimilar to our capacity to absorb food: there are physical limits to the digestion of both. To try to address this, more learning is being pushed to 'pre-work', in the hope that participants arrive at a training program already knowledgeable about core ideas. This works only partially due to the mixed level of focus people give to a pre-reading.

Increased organizational change is increasing pressure on learning.

Organizations are also experimenting with just-in-time learning, delivered by managers rather than trainers. The downside of this approach is that most managers are selected on their skill-set and are not always optimal teachers. However, organizations consciously investing

in their leaders to serve as trainers report good results (Bethof, 2009). Other organizations, noting the impact of follow-through on learning (Bersin & Associates 2011, Zenger & Folkmann, 2005), are creating internal coaches to drive embedding of insights: one study of 358 companies about their use of coaching, found that 67 perecent of organizations were now using internal coaches (Rule, Rock & Donde, 2011).

In summary, learning managers are attempting to evolve their learning offerings to meet the changed environment and needs. Yet, by and large, they are doing so based on guesswork, without a good theory to inform their experimentation.

Learning means retrieving easily

In the workplace much learning is declarative, or explicit learning, meaning information that needs to be recalled (Davachi & Dobbins, 2008). This kind of learning involves encoding information in the brain sufficiently well for easy retrieval. In any learning experience, whether learning a new product description or organizational chart, a key outcome of the experience is that information is remembered and can be recalled easily.

With just the right amount of attention, generation, emotion, and spacing, learners intensely activate their hippocampus...

Neuroscientists have discovered that the level of activation of a brain region called the hippocampus during an encoding task plays a significant role in whether people can recall what they learned (Davachi & Wagner, 2002). Many studies (e.g., Davachi & Wagner, 2002; Lepage, Habib & Tulving, 1998) have since been undertaken that explore the types of activities that do and don't activate the hippocampus. This new understanding of the biology of learning is providing rich insights into how we can more efficiently create long-term memories as part of a learning experience.

A number of surprises have emerged from this thread of research. It turns out that some of our long-held assumptions about learning, such as the importance of repetition, are incorrect. We have also begun to recognize the importance of overlooked factors in learning, such as the significant impact of spacing out a learning activity.

This paper draws together recent findings about memory formation into one easy-to-remember model, called AGES. This stands for Attention, Generation, Emotion, and Spacing. These four variables may be the key to maximizing learning interventions. With just the right amount of attention, generation, emotion, and spacing, learners intensely activate their hippocampus, which creates deep circuits for easy retrieval. This model can help learning designers improve their learning initiatives by focusing on, and experimenting with, the key variables to effective learning.
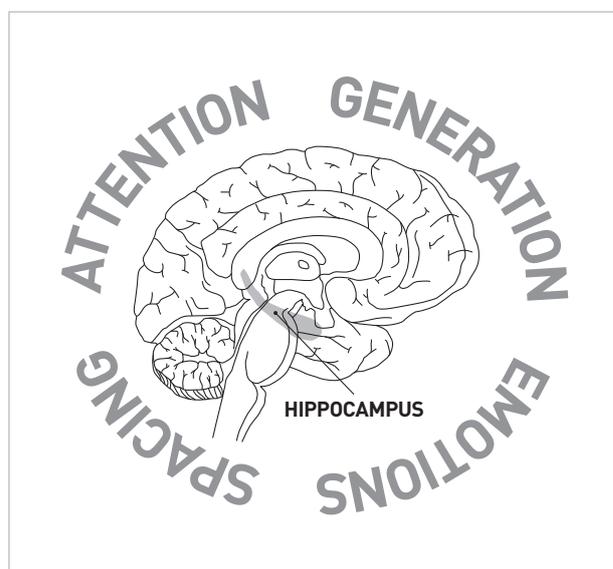
Figure 1: The AGES model for lasting learning impact.

Attention

For the hippocampus to activate sufficiently for learning to occur, the learner needs to be paying full attention to the topic being learned. In a world with so many distractions (e.g. phones and other devices), this is easier said than done. Dividing attention between two tasks significantly decreases the quality of attention, and the likely sustainability of any learning, because the hippocampus is not engaged when attention is divided (Kensinger *et al.,* 2003). This has been shown to occur with even small levels of distraction. Focusing on multiple streams of information, including trying to multi-task in the learning environment also results in neurons decreasing their firing, and, hence, learning decreases significantly (Arnsten, 1998/2003). Thus one of the foundational ideas for learning is ensuring you have 'undivided attention' – that people are focused closely on the learning task at hand.

In a classroom, this is easier to manage through activities that focus people's thinking in one direction. In online learning, with the possibility of distraction from other devices being 'on', or distractions inherent in the technology itself, attention can be harder to focus. The quality of attention paid, and how to ensure maximum attention during online learning, is an area for further research.

In order to pay close attention to something, the brain needs just the right amount of two important neurochemicals called catecholamines – specifically dopamine and norepinephrine, placed at huge numbers of synapses (Vijayraghavan et al., 2007). Dopamine is involved in a feeling of reward, of relevance, and is also released through novelty. It is released in the 'toward' state (Rock, 2008), when we are open, curious, in a goal-focused state, and/or working to gain something.

To increase dopamine levels in a learning situation the content needs to be relevant, i.e. the learner needs to see the value (e.g. potential reward) of focusing attention on the content. One way to do this is by making learning situations as 'real' and 'personal' as possible, such as with the use of advanced simulations, which also address other elements of AGES (e.g. increased arousal due to role-playing in front of a group).

Varying learning techniques provides additional novelty that can help raise dopamine levels to keep the learner's attention in the learning environment. For example, the presentation of information can be mixed with group discussions, role-playing, or scenario planning.

Norepinephrine affects the chemistry of alertness, of feeling aroused and focused. This neurochemical tends to be released in greater quantities in the 'away' state (Rock, 2008), when we are alert to threat and our senses are heightened. Norepinephrine may be released during competitive activities (Pierce, Kupprat & Harry, 1976), or when we feel under pressure to perform, perhaps by a deadline.

We need good amounts, but not too much, of both these 'chemistries' for good attention to be paid. Good learning states involve paying close attention to something relevant and interesting, with enough of a challenge to keep our attention. Both elements need to go hand-in-hand to allow an optimum level of attention. If an optimum attention level cannot be generated, the hippocampus will not fire sufficiently for memory encoding to occur. In short, making learning easy to digest, through chunking, visuals and stories, and making it interesting and engaging are critical for optimizing retrieval of information.

To improve at any skill or competency, it helps to be able to measure that competency. How can we measure 'attention' in learning? One approach comes from the idea of attention. Attention density technically means the number of observations (attention paid) to a particular idea per unit of time. Each time we activate a circuit this further wires together that circuit (Hebb, 1949).

Taking this idea we could, in theory and in time, be able to measure the quality of attention paid to specific circuits by measuring the level of activation of brain regions. While this would be cumbersome in a training room, it is technically feasible. For now, we could at least measure how long, perhaps in seconds, an idea is held in mind in the laboratory.

Varying learning techniques provides additional novelty that can help raise dopamine levels to keep the learner's attention in the learning environment.

This brings up an interesting question: how much attention is paid to a core idea in a class room, versus in other forms of learning, say in virtual learning, per hour spent in the learning experience? Counter-intuitively, some forms of classroom learning have a high distraction factor, where attention may go to what other people are doing and other social cues, rather than to the core ideas. On the other hand, some forms of virtual learning, such as games and other immersive experiences, can be more focused on the core ideas, but carry the risk that other distractions come into play (such as email or parallel internet usage).

If attention is a key to learning, a question raised is how do we maximize attention itself? The answer may come from research on the social brain (Lieberman, Eisenberg, 2008). Studies are showing that we feel strongest about, and pay most attention to, social issues (Jaremka, Gabriel & Carvallo, 2010). Making learning a greater social experience (e.g., learning from best practices through storytelling) in some way may be a key to improve learning effectiveness. There does appear to be a movement toward making learning more social (Bersin & Associates, 2010 & 2011), but it also questions the self-paced learning approach of pre-reading and online learning.

Generation

Information is not expressly stored in the hippocampus as discrete memories like in a hard drive. Instead, memories are made up of vast webs of data from across the brain all linked together (Davachi & Dobbins, 2008). The more associations (or in other words, entry points linked to the original information) connected to a memory, the thicker the web is, and, therefore, the easier it is to find a memory later. The hippocampus activates when we create these associations.

Once sufficient attention has been paid to a learning task and an idea is being held in working memory, the question becomes, how do we maximize the likelihood of memories forming? Despite being widely thought of as central for learning, research shows that repetition only has a limited impact on creating lasting learning (Woiniak & Gorzelanczyk, 1994). Repeating a new word 30 times does not necessarily add it to long-term memory. So what works?

Both psychological and neuroscientific research show that the key to optimizing learning and building long-term memory is to create 'ownership' of learning content (Jensen, 2005; Poldrack et al., 2001). This ownership or 'generation of own learning' occurs when an individual is motivated to understand, contextualize, retain, and apply knowledge in their own way. Therefore the learner should be encouraged to take in the presented information and personalize it by transforming it in a way that is meaningful for them. This act itself creates a rich set of associations, activating the hippocampus.

...memories are made up of vast webs of data from across the brain all linked together...

One way to generate associations is to encourage the learner to evaluate the meaning of the information and compare it to their existing knowledge, or to think about the information in a 'deep' as compared to a 'shallow' way (Davachi & Wagner, 2002; Craik & Tulving, 1975) (Figure 2).

One study showed a significant increase in memory when learners were asked to elaborate on three presented items, ordering them instead of purely rehearsing them. This enhanced memory was associated with greater activation of the hippocampus (Davachi &Wagner, 2002).
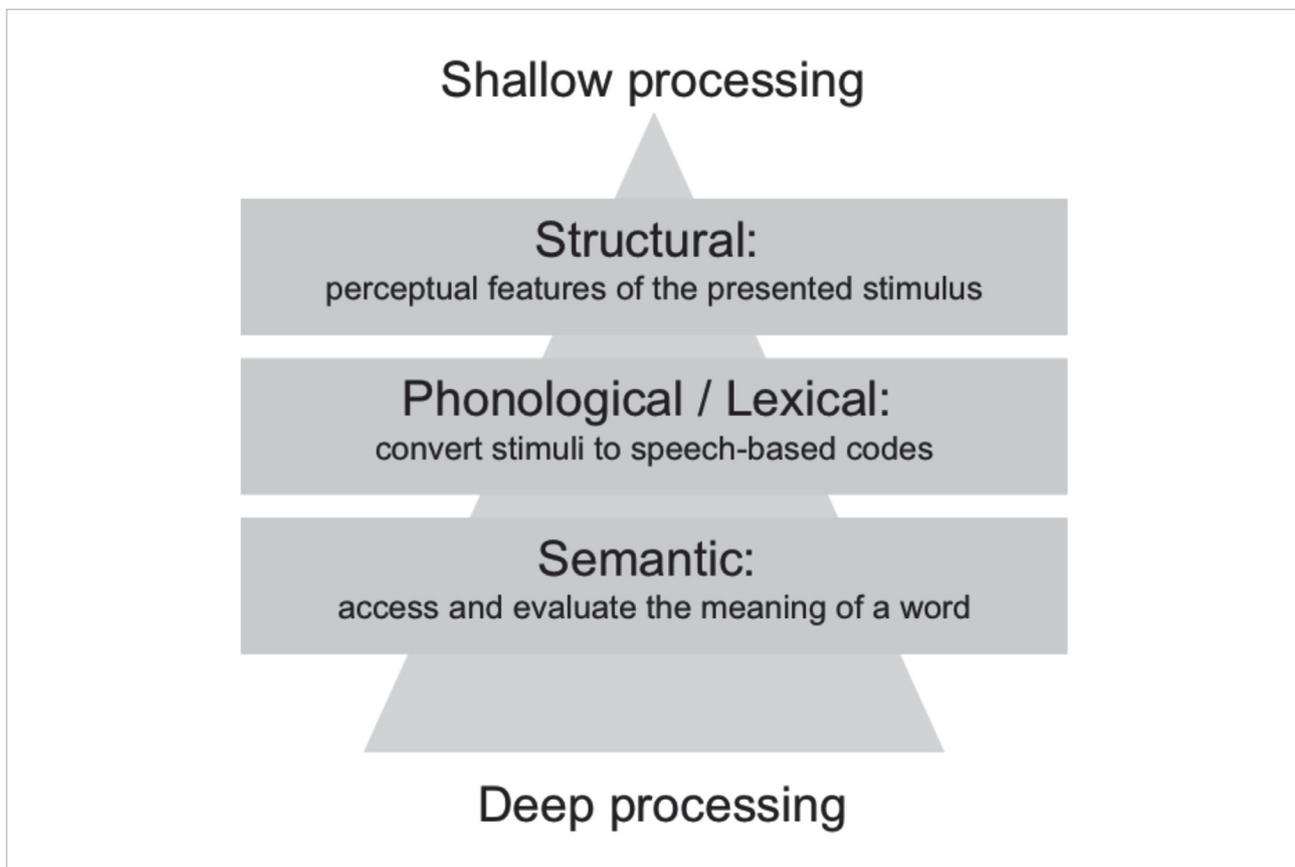
Figure 2: Levels of input processing.

Learners may gain greater value if they are presented with data and then asked to formulate, organise, or add their personal experience to the learning content (Jensen, 2002). For example, doing the final development of a leadership model within the training session instead of being presented with a pre-defined model.

If we work on the assumption that each brain is unique, and that people need to generate associations to learn, then all learning should be, to some extent, self-directed. Each individual must map new learning to their existing knowledge and experiences and generate their own meaning and ways to apply the new knowledge.

> *Questioning the learner triggers retrieval of the recently learned information and improves long-term retention.*

Questioning the learner triggers retrieval of the recently learned information and improves long-term retention. Asking the learner to visualize situations in which they could apply their new learning, or to make decisions within the context of the new data, also helps reinforce what has been learned. Again these tasks increase associations in the brain. Immediate feedback on any errors also significantly increases accuracy of future retrieval (Guthrie, 1971).

Structuring learning initiatives with these findings in mind might mean less teaching, or presentation of information, and more time dedicated to the self-generation of learning with the goal of building more personal associations with existing knowledge for easier retrieval. The more associations the learner generates, the higher probability over time that he/she will be able to find an access point to the data at a later date.

In terms of measuring the idea of generation, this is possible with current technologies, through looking into which regions of the brain are active during learning, specifically the level of hippocampal activity. However, this is too cumbersome to be helpful within a training experience itself. For now, we could use self-report to identify how actively a person may be thinking about an idea for himself/herself, versus just listening passively. Additionally, if generation is key, versus repetition or listening, then we can increase this by simply getting people talking to each other about ideas, versus just listening to presentations. We could measure the amount of 'listening' versus 'generating' in a classroom this way. Or we could encourage participants to invent their own terms and approaches based on the content learned and collect their ideas in order to measure the 'degree of generation'.

Emotions

Learning happens in many complex layers, with emotion being one of the more important regulators of learning and memory formation. Studies show that the correlation of vividness of a memory, and the emotionality of the original event is around 0.9 (Jensen, 2005).

The way in which emotion is thought to enhance memory is twofold. First, emotional content is thought to grab the attention of the individual, and, hence, help to focus attention on the emotional event or stimulus (LeDoux, 1994; Damasio, 1994). Second, it is known that emotion leads to activation of a brain structure called the amygdala which sits directly in front of the hippocampus and can help to signal to the hippocampus that a particular event is salient, and, thus, increase the effectiveness of encoding (Ochsner, 2000; Cahill *et al.*, 1994). When looking into current professional training design, emotions are a common tool used in behavioral change programs, such as leadership trainings (Kiefer, 2009).

> *...emotions are a common tool used in behavioral change programs, such as leadership trainings...*

Of course, one challenge of using emotion in a learning context is the difficulty of creating emotion-arousing events, especially ones that are positive. It is far easier to stimulate negative emotions, such as fear and threat (e.g. by presenting 360°-assessment tools and reports), than to create a joy/pleasure response – especially when confronting individuals with novelty (Kohlrieser (2006). Simply presenting angry faces, for example, has been shown to increase arousal and be highly effective in engaging attention (Ohman, Flykt & Lundquist, 2000). Generating strong negative emotions in a training program, such as fear, is a commonly used strategy for burning memories.

For example many sales, presentation and negotiation programs are based on videotaped sessions, which focus on the negatives of the presenter instead of their strengths. However, there are difficulties with using strong negative emotions to burn in memories: negative emotions also reduce creativity and innovation (Subramaniam *et al.,* 2009); so while people may learn, they are less likely to innovate. Also, the brain's organizing principle is to minimize threat and maximize reward (Gordon, 2000). As a result, people are not going to be inclined to turn up for training when the experience continues to use negative emotions, and they are likely to warn their colleagues to stay away too. However, if a learning experience is fun, they are likely to want to do more learning, and tell others about the positive event.

Based on the SCARF model... there are ways to generate strong rewards by increasing people's sense of status, certainty, autonomy, relatedness, or fairness.

While it is easier to invoke negative emotions, positive emotion can also be invoked in a learning experience. Based on the SCARF model (Rock, 2008), there are ways to generate strong rewards by increasing people's sense of status, certainty, autonomy, relatedness, or fairness. The easy domains to generate rewards in a training program are most likely to be status and relatedness. An increase in a sense of status, which activates primary reward functions (Zink *et al.,* 2008), can come from people learning new tasks and receiving positive feedback. It has been shown that positive feedback leads to an increase in dopamine neurotransmission that is thought to help learning stick (Schultz, 1997). An increase in relatedness, which also activates primary reward functions (Cacciopo & Patrick, 2008), can come from creating situations where people get

to connect deeply with others and experience emotional 'resonance' (Boyatsis, 2001), where they experience a sense of connectedness with others.

It may also be useful to have a training structure that includes novelty and entertainment, as this may be the way to stimulate positive emotions in the learner. There is also strong evidence that positive anticipation has an impact on the formation of new learning positively (Bradley & Lang, 2000), so a good aim is to make learning enjoyable instead of a mandatory event.

...positive anticipation has an impact on the formation of new learning positively ...so a good aim is to make learning enjoyable instead of a mandatory event.

In terms of measuring emotions, we can use self-report to measure the level of intensity of emotions, whether positive or negative. We can also use devices to measure heart rate, skin conductance and other biological markers for emotional arousal. For increasing emotions, as a general statement, social issues are the experiences we feel strongest about. Thus, clearly we should incorporate more social activities into learning experiences wherever possible. Positive social connections themselves may be one of the easier positive emotions that can be generated in a classroom setting.

Spacing

It has been known for some time that distributing learning over time is better than cramming learning into one long study session (Crowder, 1976). Massing, defined as large blocks of learning in short periods of time, increases short-term performance, which guides learners to rate the learning impact of massing as superior to spacing (Baddeley & Longman, 1978; Kornell & Bjork, 2008; Simon & Bjork, 2001; Zechmeister & Shaughnessy, 1980). However, distributing learning over time leads to better long-term memory, which is the ultimate aim of organizational learning.

Spacing information over time leads to higher retrieval rates of new information and seems to build stronger long-term memory (Litman & Davachi, 2008).

Given all the positive research on spacing, why is massing the more common approach to learning? Putting aside the financial benefits of delivering learning in one block, there are other likely reasons why massing is the dominant approach.

There is evidence that initial testing of newly learned items, with a small delay after the learning event, will further drive the building of long-term memory...

The positive attitude by learners to massing may result from experience with cramming for exams. Cramming information is a successful strategy for exams where minimal retrieval is required in the future. Learning in the workplace has a different aim, with participants needing to build contextual understanding of the information presented as well as learning how to apply the information in the future. Spacing also leads to forgetting and this can make the learning feel 'harder'. However, the more difficult the retrieval, the higher the learning effect (Bjork & Allen, 1970; Cuddy & Jacoby, 1982; Krug, Davis & Glover, 1990). There is evidence that initial testing of newly learned items, with a small delay after the learning event, will further drive the building of long-term memory as this causes an additional retrieval effort (Karpicke & Roediger, 2007).

In addition to the 'active part' of the learning, spacing allows the brain to further digest new content and over time build and wire new connections, even when learners are at rest (Spitzer, 2002; Tambini *et al.,* 2010). Spacing enhances memory performance and the rate of forgetting drops due to enhanced hippocampally mediated memory consolidation (Litman & Davachi, 2008). Another study showed that repeated testing is superior to repeated studying in the formation of maximum long-term memory formation (Roediger & Karpicke, 2006).

...repeated testing is superior to repeated studying in the formation of maximum long-term memory formation...

One question that is difficult to answer is whether there is an optimum timing of spacing between learning. The best take-home message is that any spacing (whether it be minutes, hours, or days) is better than no spacing at all. Cepeda *et al.,* (2008) examined the effect of this and suggest that the longer the gap between the first and second learning session ('the gap'), the higher the retrieval rate (1-5 years) after the learning event. In a recent study with 1,354 subjects the optimum gap lengths were examined in order to test subjects' recognition and recall rate. The project consisted of multiple combinations of gap lengths and RI (Retention Interval) lengths to examine the impact of the gap lengths on long-term memory foundation. For each RI, the recall and recognition performance rose with an increasing gap length and then decreased as the gap lengths further increased.

One question that is difficult to answer is whether there is an optimum timing of spacing between learning.

The Cepada study showed a significant improvement of the recall rate when spacing information compared with a zero-day gap (see Figure 3).

The Cepeda findings (Cepeda *et al.,* 2008) underpin the notion that defining the optimum spacing is quite complex, since a couple of constraints and factors influence the design:
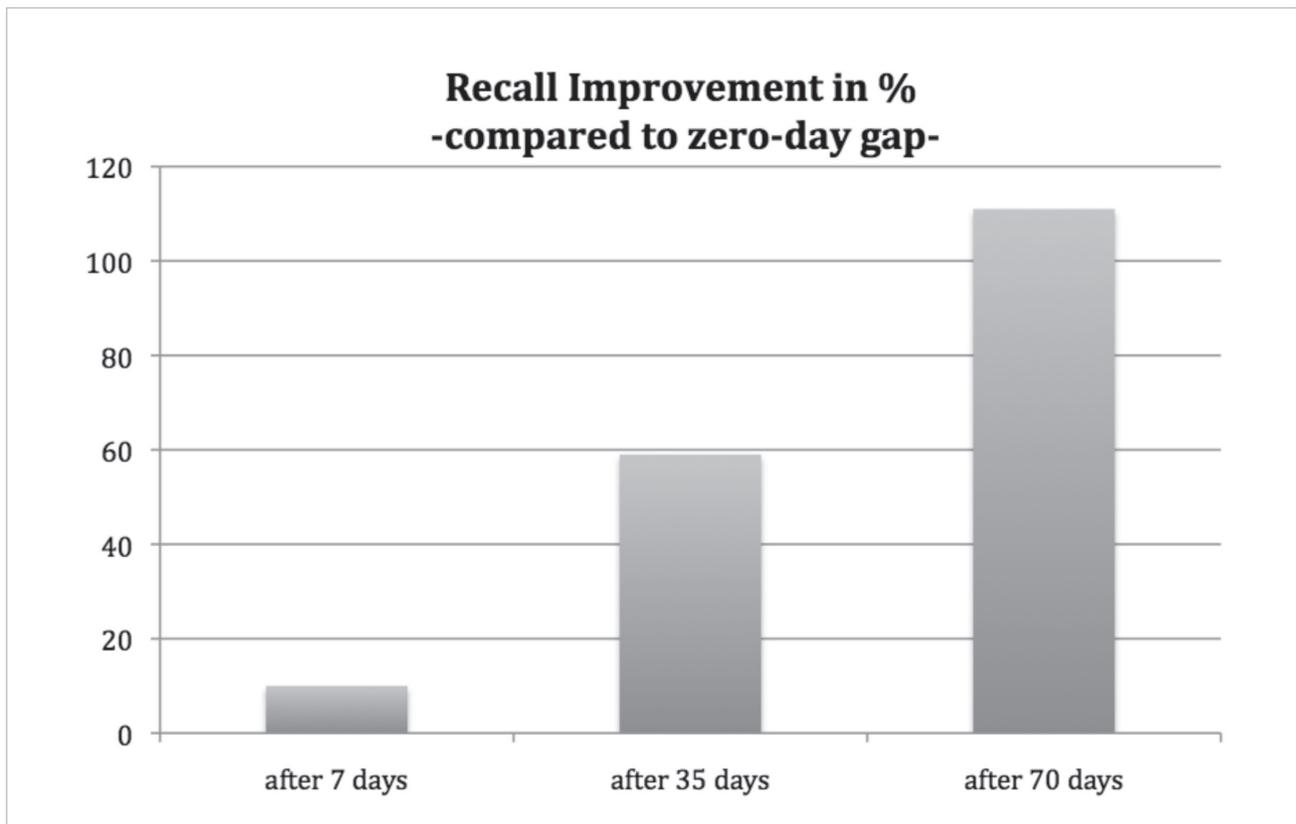
Recall Improvement in %
-compared to zero-day gap-

Figure 3: Spacing effect and learning improvement (recall improvement in % and days after initial learning).[1]
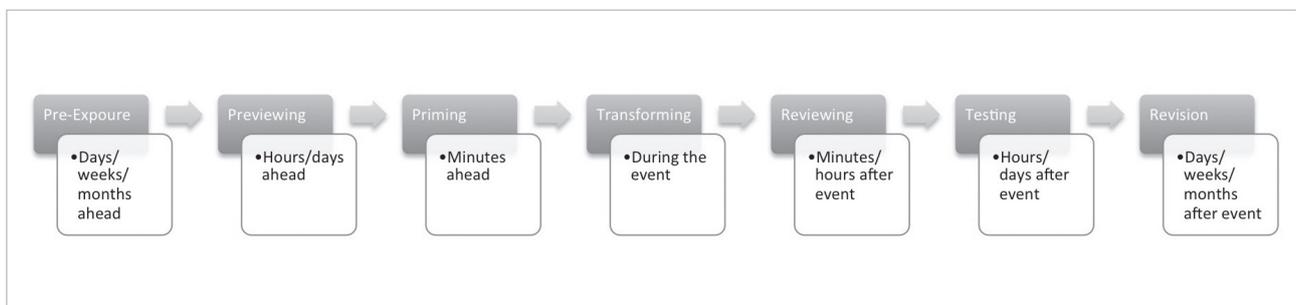

Figure 4: Spaced repetition (learning journey) and expansion of memory and associations.

1. The RI gap: depending on the estimated recall date, the gap length first increases and then decreases since forgetting learned content comes into play.
2. As RI increases, the ratio of optimum gap to RI should decline.

However, the data also suggest that it might be wise to avoid defining the 'one' optimum gap between learning events, since it significantly depends on the RI. In other words: the definition of how long you want to remember newly learned content determines the optimum timing of the learning gap and the time studying new content.

Many studies have been published on optimization of learning intervals (number of repetitions and spacing) to ensure learning. As mentioned earlier, repetition itself has a limited impact on creating lasting learning (Woiniak & Gorzelanczyk,

1994). However, repetition of new information, in a spaced manner, plays a role in building long-term memory. Taking the power of forgetting, and the power of transformational learning into account, we follow Jensen's (2005) approach in using a variety of techniques to leverage repetition as a learning instrument. Incorporating this lesson, we suggest a 'spaced repetition', which combines spacing and generating of learning over time.

Repetition itself is minimized since the content itself does not simply get repeated. Repetition happens through various techniques like priming, reviewing, or testing the content during new learning generation (Figure 4).

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[1] *The optimum learning gap defined as d=1 for 7 day recall test; d = 7 for 35 day recall test and d = 21 for 70 day recall test.*

Priming allows the brain to build the new concept into a larger contextual and semantic structure, increasing efficiency in learning (Martin & Van Turenout, 2002; Cave, 1997). Studies demonstrate that the use of priming as a repetition technique increases verbal fluency significantly (Mack & Rock, 1998).

Priming allows the brain to build the new concept into a larger contextual and semantic structure...

Most training programs mass information in one or two days, without much attention to follow up. This brings up the question of how much we should be breaking up learning and instead delivering smaller bites of learning over time.

There is no current recipe of how much content can be taught and learned in a specific amount of time.

This is an important area for future research, and we cannot find any formal studies as a guide here yet. However, it is important to note that brain function shows multiple constraints around learning limitations with regard to learning a lot of information, including:

- The limitations of the prefrontal cortex and its ability to process only 3-7 information chunks at any one time (Linden *et al.,* 2003).
- The time necessary to form new synaptic connections (Goda & Davis, 2003)
- If the synapse gets disturbed before it 'sets', the memory is lost (Milner, 1999).
- The 'rest-time' needed to allow the brain to recycle

protein in the neurons, which is crucial for building long-term memory (Bodizs *et al.,* 2002; Schroth, 2002).
- The 'digestion-time' needed for the brain to reorganize, distribute and consolidate new content through the hippocampus (Piegneux *et al.,* 2001; Stickgold, 1998; Siapas & Wilson, 1994; Walker & Stickgold 2006) and awake rested (Tambini *et al.,* 2010).

There is no current recipe of how much content can be taught and learned in a specific amount of time. However the indicators and data points are clear – building learning connections is time consuming and requires maintenance.

Areas for further research

There are many areas that deserve significant further investigation. Questions to explore about learning from the brain perspective include: which of the AGES variables is most significant, and what are the interactions between the variables? How much can people learn or digest at one time? What is the optimum interval period for spacing to maximize learning? What is the impact of positive versus negative emotions in learning events? Answering these questions and more will go a long way toward enabling us to improve the impact of learning experiences in organizations.

Summary

Adult learning is highly complex. How do we ensure people are interested in learning what is presented, and how then do we present the information to ensure that the knowledge is sustainable, accessible, and easily applied in adaptive and contextual ways?

We suggest that learning designers should focus on:

- Creating maximum **attention** with a greater focus on learner motivation, ensuring one focus during learning events, and utilizing more novelty and change during learning experiences.
- Encouraging significant **generation** of learning by participants when teaching new concepts to build learner ownership rather than using presentation of information.
- Creating a positive **emotional** environment with opportunities for people to gain positive feedback and connect deeply with others.
- Utilizing more **spacing** of learning instead of massing and repetition, with more dispersed content, such as turning a three-day learning event into six half-day events over a longer period.

We encourage chief learning officers, learning consultants and trainers to explore these new ways to reshape instructional design to ensure high-impact learning that lasts through AGES and that enables training departments to fully unleash the capabilities within their organizations.

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