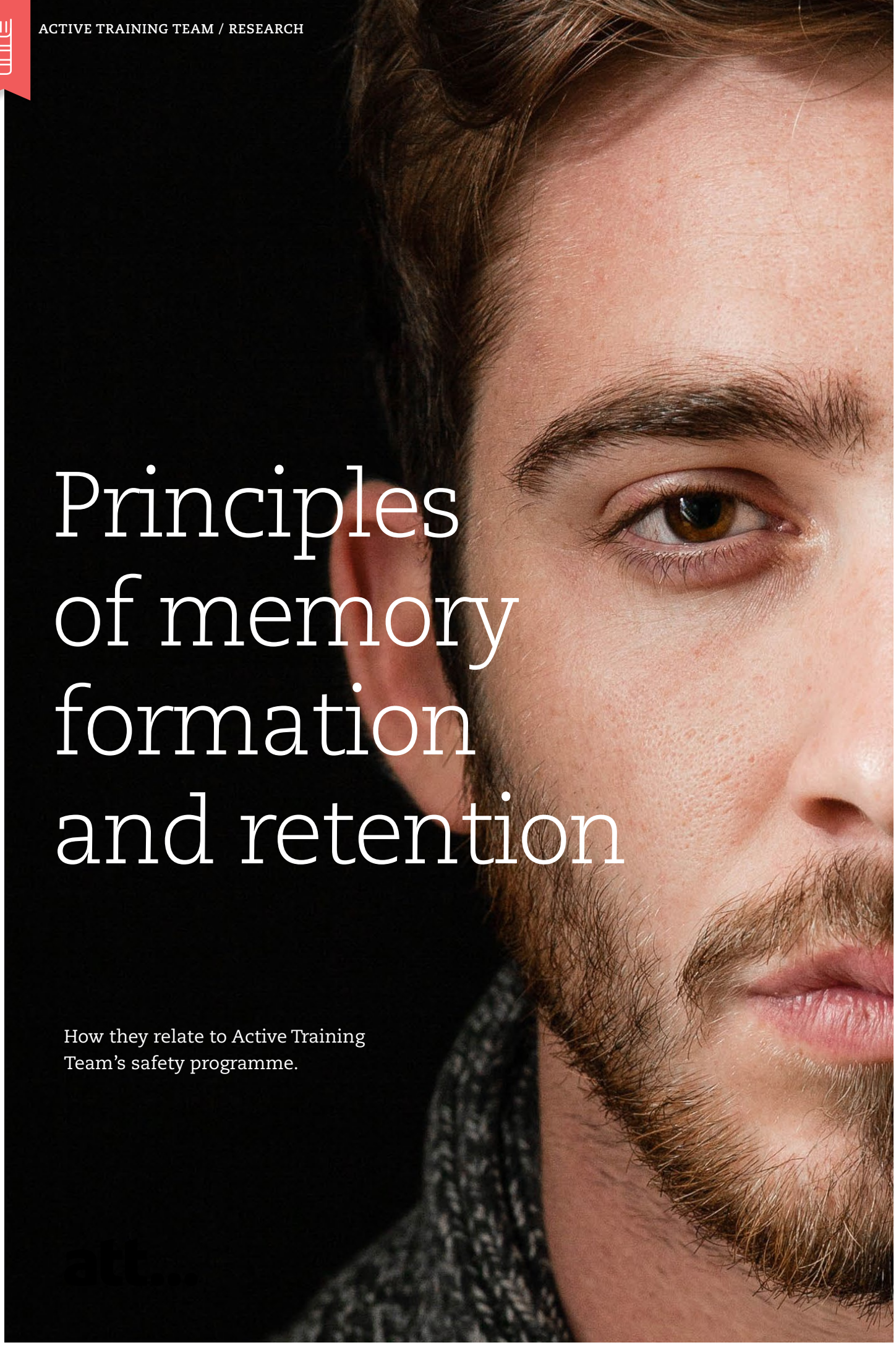

Principles of memory formation and retention

How they relate to Active Training Team's safety programme.

What is memory for?

A main function of our brain is to **learn and remember** information about the world around us. Brains create and maintain **internal representations**, or models of the world, in order to successfully guide decisions and actions. In a sense, past memories exist to serve the present and future. The role of **learning and training** is to adapt the internal representations to a changing environment. These internal representations are models of the world encoded in neurons, the specialised cells in the nervous system, which embody information and knowledge in the precise location and exact timing of their activity, in other words the spatiotemporal pattern of neuronal activity.

The role of memory is to retain these updated representations over time, so they can be used and put in practice in the future (Dudai 2004).
In addition to directing decisions and behaviour in the present and future, two other important functions of human memory are to create self-continuity and self-image (autobiographical memory), as well as to enable social bonding(collective or social memory). In this paper, I will concentrate on the first function of memory.

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Types of memory

There are many different ways to classify memory, based on whether it refers to events about our life (episodic memory), such as where we celebrated our last birthday; knowledge about the world (semantic memory), for example which city is the capital of Peru; or things we remember, but we do so without consciously thinking about them, such as skills and habits (e.g. riding a bike), or emotional reactions (e.g. fear of snakes or spiders).

What all these long-term memories have in common is the way they are formed. Creating long-term memories can be broken down in three stages: **encoding** (capturing the information to be remembered), **storage** (maintaining the information in the brain), and **retrieval** (recalling the learned information). All three stages are important, and if any of them goes wrong, then we are not able to remember the information and use that memory in the future. Crucially, these stages of memory formation can be modified by factors such as emotional engagement, multisensory integration and active decisions and participation, enhancing how much, how well and for how long we remember particular experiences. These are principles incorporated in the ATT training programme, giving participants the best chance to immerse themselves in the learning experience, and form robust and long-lasting memories of the lessons learned on the day.

How are memories formed?

The contents of short-term memory can be rehearsed, repeated and strengthened, and ultimately transferred to long-term memory, which can last a lifetime.

The most influential memory model, proposed in 1968 by Atkinson and Shiffrin, postulates that the brain has multiple sensory systems working together to manage the transfer of information from the world around us to permanent memories inside our head (Atkinson and Shiffrin 1968). We are constantly surrounded by a stream of sensory information, including images, sounds, tastes, smells, internal body sensations and so on. A fraction of this will be fleetingly processed by our senses (sensory memory), and only what we pay attention to will be committed to short-term memory, while the rest will be forever lost and forgotten. The contents of **short-term memory** can be rehearsed, repeated and strengthened, and ultimately transferred to **long-term memory**, which can last a lifetime.

The process of funnelling information from the senses to long-term memory depends on attention and rehearsal, so information and experiences that stand out and are rehearsed have a better chance of being consolidated in long-term memory. The immersive, multisensory environment created during the ATT training programme both captures one's attention and requires the engagement of multiple senses, giving the information encoding and storage stages the best possible chance for the creation of vivid and lasting memories. A further powerful factor that enhances the likelihood of strong memory formation is the emotional content of the material. **Emotional stimuli automatically draw our attention** (e.g. emotional facial expressions or tone of voice) compared to neutral stimuli (Medford et al. 2005). Many scientific studies have shown that **emotional content (both happy and sad) is encoded more strongly compared to neutral content**, and affects many parts of the brain involved in memory, as well as sensory processing, e.g. (Kensinger and Ford 2020). An additional factor that helps remember the information learnt on the day is **the active element of decision-making**. The participants make choices, act in different scenarios and decide how to intervene

in a given situation; in short they are active, which further improves memory encoding and retention (Murty et al. 2019). Information encoded in long-term memory can be recalled back into the short-term memory whenever needed. While the information is in short-term memory, it can be further elaborated with new associations and meaning, and returned to long-term memory, strengthened and better embedded in the web of memory traces. Revisiting information, techniques and story lines multiple times during the training day ensures the strengthening and embedding of the newly formed memories. **The emotional content also affects how frequently the memories are revisited, and how vividly they are experienced** (Kensinger and Ford 2020). Importantly memory for neutral information presented in an emotional context confers an advantage for remembering the neutral information as well (Kensinger et al. 2002). This means that **all information, not just the emotional content, learnt on the training day, has better chances of being remembered for longer**. The additional associations and meaning the information acquired while recalled back in short-term memory can protect the memory trace from fading away and being forgotten, and make it more resilient to decay. Long-term memory has in theory infinite capacity, so there is no known limit to how much information we can learn and remember. It is also able to store memories for an unlimited period of time.

How memories are stored in the brain: Hebbian learning

The biological processes that make permanent records of our learning and our memories are still under investigation by hundreds of researchers around the world. However, we do know that neurons physically change their structure and function, as well as the way they communicate with other neurons, as a result of learning. This is a process that was imagined and postulated by a Canadian psychologist, Donald Hebb, in 1949, long before it was possible to experimentally confirm it (Hebb 1949).

His original hypothesis was that if a number of neurons were repeatedly activated at the same time by an environmental stimulus, e.g. a meowing kitten, then consolidation of this memory, that meowing is associated with kittens, would occur by a physical growth process between the specific activated neurons, making their connection reciprocal and more effective. Reciprocal would mean that if any subset of the neurons were active, they could activate the whole group of relevant neurons; he called that group of neurons the **cell assembly**. In other words, once the consolidation has happened, hearing meowing, activates the association with kittens, and looking at kittens activates the association with meowing. This memory is robust, efficient and specific for the associated information.

Hebb summarized the rule for this crucial functional and structural change as follows: "Let us assume that the persistence or repetition of a reverberatory activity (or "trace") tends to induce lasting cellular changes that add to its stability.… When an axon of cell A is near enough to excite a cell B and repeatedly or persistently takes part in firing it, some growth process or metabolic change takes place in one or both cells such that A's efficiency, as one of the cells firing B, is increased" (Hebb 1949). Carla Shatz, the first woman to receive a PhD in neurobiology from Harvard university, summarized the **Hebbian theory of learning** in

the well-known phrase: **“cells that fire together, wire together”** (Shatz 1992). In other words, learning and remembering, physically changes the structure of our brain.

Unsurprisingly, along with this important mechanism for strengthening the connections between neurons (synaptic connections), there is a separate mechanism that weakens connections between neurons that are not active synchronously and contribute to noise rather than signal in the brain. Twentyfive years after Hebb’s publication, Gunther Stent, a Professor of Neurobiology at University of California, Berkeley at the time, predicted an extension of Hebb’s rule, which would help fine-tune synaptic connectivity by weakening and eliminating connections between neurons that do not fire at the same time (Stent 1973). This mechanism facilitates forgetting and ensuring that the stronger, more relevant connections win the competition, and contributes to better signal to noise ratio in the information processing in the nervous system. It can be summarized as **“cells that fire out of sync, lose their link”.**

The combination of strengthening and weakening synaptic connections in the nervous system, as predicted by Hebb and Stent, is the main way by which our experiences shape and change our brain throughout our life. The ability of the brain to respond to the changes in our environment is called **plasticity** or **neuroplasticity.** Although our brain is more plastic, able to learn and change, in childhood and adolescence (Fuhrmann et al. 2015), we now know that the brain retains that ability throughout our life (Leuner and Gould 2010). This is a basic principle of neuroscience, and means we are all equipped to learn, remember, and change behaviours throughout our life. In fact, making sure we continue to learn in mid-life and beyond, e.g. by exploring new hobbies, meeting new people, and traveling, can be a major protective factor for maintaining optimal cognitive health and reducing the risk of cognitive decline in later life (Chan et al. 2018).

How memories are stored in the brain: long-term potentiation (LTP)

At the level of the cells in the nervous system Hebbian learning involves a barrage of repeated activations of neurons at the same time. This makes the relevant synaptic connections stronger, and the neurons that have undergone this change, termed long-term potentiation (LTP), respond more forcefully to incoming signals.

The neuronal functional changes that result from LTP and learning involve a large number of molecules, such as neurotransmitters and their receptors, the chemical signals involved in neuronal communication. The neurotransmitter receptors increase in numbers and efficiency at communicating signals from the outer membrane surface to the cellular machinery inside the neurons. In the cells processes such as protein synthesis, phosphorylation, and gene transcription take place and can be up or downregulated, making the cells adaptive and responsive according to demands in the environment. While the strengthened activity levels between neurons (LTP) last in the order of hours, the changes at the levels of proteins and genes can last for months and years, and by continually replicating themselves as necessary, the changes can last a lifetime. The strengthened synaptic connection between the neurons that have undergone LTP can after some time be seen as a structural change as well. These connections, called perforated synapses, are large and horseshoe-shaped, and effectively increase the total active contact surface between neurons, facilitating the information flow between them (Greenough et al. 1978). They are a structural correlate of the stronger synaptic connection (Buchs and Muller 1996) (Neuhoff et al. 1999). The exciting experimental results that first showed these changes in the brain were published in 1973 by Timothy Bliss and Terje Lomo (Bliss and Lomo 1973), almost a quarter of a century after Donald Hebb had suggested such a mechanism as the basis of learning and memory; the technical advances required to test theories often lag behind human imagination. LTP and the resulting perforated synapses are the structural change in the brain that follows successful learning and memory formation, and can last a lifetime with repetition and recall.

How remembering works: reactivation

Bringing a memory trace back from long-term storage to short-term memory, requires reactivating that particular trace, in a process that is meant to match as closely as possible the activation state of the relevant neurons during the encoding stage, when the memory was formed or more recently elaborated (Wheeler et al. 2004) (Rugg et al. 2008).

This process is called **recapitulation**. When it is successful, we have the subjective sense of a vivid memory. When we cannot remember something, there is no matched activity, and recapitulation has failed. Each time a memory is reactivated, it is at the same time strengthened and embedded in larger brain networks. In the context of the ATT training programme, recapitulation happens throughout the day when revisiting the scenario from different angles, and discussing techniques of effective leadership and challenging. Because of the multisensory nature of the scenarios, as well as the emotional content of the training materials, the memory traces reactivated are numerous. Their activation in turn affects larger parts of the brain, creating stronger and more vivid memories, associations and meaning likely to last a long time. Further activation, and opportunities for the memories to remain robust and change behaviour in everyday life, is also elicited with the accompanying ATT mobile app, which is further discussed later in this document.

In the initial stages of memory encoding and consolidation the **hippocampus**, a structure deep in the middle of the brain that looks like a seahorse, is crucial for committing new information in long-term memory. We learnt this by studying a particularly unfortunate patient, H.M., who had his entire hippocampus removed at the age of 27 to control severe epileptic seizures that did not respond to medication (Scoville and Milner 1957). The seizures were partially controlled, however H.M. became unable to form any new memories following the surgery. He could no longer recognize people involved in his everyday care, find his way around familiar surroundings, or remember any new events. This was in stark contrast with his intact memory for events that had happened earlier in his life, before his entire hippocampus had been removed. This crucial observation led researchers to realize that although new memories require the hippocampus to be consolidated, established

memories are stored in other parts of the brain (Milner et al. 1968) (Corkin 1984). These other parts of the brain generally refer to the neocortex, which is the large, surface part of the human brain, and is crucial for higher cognitive functions, such as attention, decision making and reasoning (Lui et al. 2011) (Semendeferi et al. 2002).

As the memory traces become reactivated, they continue to be strengthened, to be distributed across the hippocampus and the neocortex, and become more accessible and robust. These reactivations can be particularly fertile opportunities that enhance the memory traces and their relevance to guide future decisions and behaviours (Tambini and Davachi 2019). Even if details of the training scenarios are lost, the gist, the important messages about personal responsibility, leadership and ensuring standards, will become part of the web of associations and affect decision making. This point is particularly relevant for the last question we ask on p. 10 about how the new learning can be translated in to everyday practice. Intriguingly, relevant prior knowledge, with which new information can be associated and integrated, is also a strong predictor of improved memory, and correlates with how actively the hippocampus and neocortex work together to represent the updated internal representations (Tompary and Davachi 2017).

Active training principles and immersive learning

Immersive learning and simulation training have been used for some time in professions where the stakes are high, where training under real conditions comes with high risk for health and life, such as pilot training (Landman et al. 2018), emergency medicine (Russell et al. 2018), surgery (Liu and Curet 2015), and mining (Grabowski and Jankowski 2015).

From the information presented so far, it has hopefully become clear that the quality and richness of the learning experience will greatly influence what, how well, and for how long new information will be encoded, stored and retrieved in a relevant future situation. Presenting immersive, multisensory, emotionally charged, relevant information in an active, participatory way is much more likely to capture our attention, to be remembered better, and for longer, and influence decisions and behaviours in similar real world scenarios.

The immersive training provided by Active Training Team incorporates a wealth of features that make the experience believable, memorable and meaningful at multiple levels:

- **Immersive**: the learner finds themselves situated in the epicentre of developing events, be it amongst actors, called up for an interview at a police station, or being asked to intervene in the office of a grounds foreman.
- **Multisensory**: the high quality sensory information ensures the learner's attention is captured and the situation feels realistic, for example: high quality visual and auditory depiction of lifelike scenes with the aid of live actors, surround sound system and wide screen (4.2 x 23.83 meters, H x W), the same actors used in film and real life scenarios, floor vibrating when a train goes past on the large screen.
- **Emotionally charged**: getting to know the lives of the people involved in the training scenarios, followed by the shock and the consequences of things going wrong at work, creates emotional arousal that can change the learner's physiology (e.g. heart-rate, breathing), and make the whole experience more memorable and remembered more vividly for longer (Kensinger and Ford 2020) (Bhandari and Hallowell 2017).
- **Relevant**: the scenarios and the narrative provide context specific learning, which connects the training more closely to the work environment and the learner's prior experience and knowledge; this also makes it more likely to influence future behaviours and translate into changes in everyday work practice.
- **Active**: another crucial feature of this programme that sets it apart from other types of safety training delivery is the fact that the learners get involved in a number of expertly led practical workshops, where they actively participate, make choices, engage in role playing and decide how to intervene in a given situation, which also improve memory encoding and retention (Murty et al. 2019).

Recent attempts to create a theoretical framework that incorporates all relevant factors that contribute to successful safety training and transfer to the workplace, emphasize that safety training engagement involves emotional, cognitive and behavioural components (Casey et al. 2021). Active Training Team's programmes integrate all three dimensions. The first component is the emotional aspects of the narrative, the cognitive elements are taught in concise sessions that focus on communication skills, and the beliefs that underpin our behaviours, while the behavioural component is embodied in the practical workshops and active participation.

Does the training work for everyone?

The training programme is designed according to sound neuroscientific, psychological and learning theory principles. As a learning experience, it has great potential to capture the attention of an adult learner, engage and challenge them, and create long lasting memories that can lead to behavioural changes and better decision making in the workplace.

This can be the case for every learner, irrespective of their day-to-day work responsibilities: the principles of how our brain processes, stores and retrieves information, and how emotion and active participation can enhance these abilities are the same for all. In a remarkable neuroimaging study, where we are able to study the brain in action in real time, researchers asked participants to simply watch a 30-minute segment of the classic 1966 film The Good, the Bad, and the Ugly, and wondered if one person's brain activity would predict the activity levels in another person's brain. Astonishingly they found that about a third of the activation of one participant's brain could be predicted by the neuroimaging signals from someone else's brain, as long as they had both watched the same segment of the film (Hasson et al. 2004), (Pessoa 2004). The authors of the study interpreted this highly correlated activity as evidence that our individual brains "tick together" in synchronized spatiotemporal patterns of activity when exposed to the same situation, in this case watching a film while lying inside a scanner. The attentional and emotional content of the film affected the different individual brains in remarkably similar ways, in a scenario that shares some similarities with an immersive training context.

At the same time, it is well recognized that the individual trainees work and operate within wider organisations with specific safety cultures and climates, which play a significant role in subsequent application of the training in the workplace. Whether speaking up and stopping an unsafe action is something that is valued, conducting the training with whole teams (see point on p.3 about social memory and bonding), and supervisor encouragement for applying the training are all example factors that influence the transfer and application of safety knowledge (Casey et al. 2021) (Tracey et al. 1995) (Burke et al. 2008)

Will the training stick?

Assuming a rich, immersive training programme, as well as a positive safety culture and climate at the trainee's organization, it is still worth asking how the learning outcomes of the training day can be best turned into everyday practice in the workplace. The answer to this question takes us back to the neurobiological and psychological principles of memory consolidation (see pp. 6–7). By repeatedly reactivating memories, following for example targeted cues on a mobile application following the training, the memory traces become stronger, they move away from the hippocampus, where they are initially created and stored, and become embedded in robust and rich webs of associations of relevant knowledge, termed schemas, in the neocortex.

Regularly prompting those memories with relevant cues that encourage some form of engagement other than simply going over the same information again, bestows a benefit in how easily accessible and robust the memory trace is, and how well it can be integrated in decision making and behaviours.

Mobile learning on smart phones has come a long way since its early days over ten years ago (Macdonald and Chiu 2011). Currently the bulk of mobile phone apps that target behavioural changes have to do with fitness, physical and mental health (Milne-Ives et al. 2020). However, it is a matter of time before sophisticated apps for behavioural interventions become commonplace at work, and in that sense, the Att mobile app is ahead of the curve.

References

Atkinson RC, Shiffrin RM (1968) Human memory: A proposed system and its control processes. In: Spence KW, Spence JT (eds) The psychology of learning and motivation: Advances in research and theory, vol 2. Academic Press, New York, pp 89–195

Bhandari S, Hallowell MR (2017) Emotional Engagement in Safety Training: Impact of Naturalistic Injury Simulations on the Emotional State of Construction Workers. J Constr Eng M 143 (12) doi:Artn 04017090 10.1061/(Asce)Co.1943-7862.0001405

Bliss TVP, Lomo T (1973) Long-Lasting Potentiation of Synaptic Transmission in Dentate Area of Anesthetized Rabbit Following Stimulation of Perforant Path. J Physiol-London 232 (2):331–356. doi:DOI 10.1113/jphysiol.1973.sp010273

Buchs PA, Muller D (1996) Induction of long-term potentiation is associated with major ultrastructural changes of activated synapses. Proceedings of the National Academy of Sciences of the United States of America 93 (15):8040-8045. doi:DOI 10.1073/pnas.93.15.8040

Burke MJ, Chan-Serafin S, Salvador R, Smith A, Sarpy SA (2008) The role of national culture and organizational climate in safety training effectiveness. Eur J Work Organ Psy 17 (1):133–152. doi:10.1080/13594320701307503

Casey T, Turner N, Hu XW, Bancroft K (2021) Making safety training stickier: A richer model of safety training engagement and transfer. J Safety Res 78:303–313. doi:10.1016/j.jsr.2021.06.004

Chan D, Shafto M, Kievit R, Matthews F, Spink M, Valenzuela M, Henson RN (2018) Lifestyle activities in mid-life contribute to cognitive reserve in late-life, independent of education, occupation, and late-life activities. Neurobiology of Aging 70:180–183. doi:10.1016/j.neurobiolaging.2018.06.012

Corkin S (1984) Lasting Consequences of Bilateral Medial Temporal Lobectomy - Clinical Course and Experimental Findings in Hm. Semin Neurol 4 (2): 249–259. doi:DOI 10.1055/s-2008-1041556

Dudai Y (2004) Memory form A to Z. Oxford University Press

Fuhrmann D, Knoll LJ, Blakemore SJ (2015) Adolescence as a Sensitive Period of Brain Development. Trends in Cognitive Sciences 19 (10):558-566. doi:10.1016/j.tics.2015.07.008

Grabowski A, Jankowski J (2015) Virtual Reality-based pilot training for underground coal miners. Safety Sci 72:310–314. doi:10.1016/j.ssci.2014.09.017

Greenough WT, West RW, DeVoogd TJ (1978) Subsynaptic plate perforations: changes with age and experience in the rat. Science 202 (4372):1096–1098. doi:10.1126/science.715459

Hasson U, Nir Y, Levy I, Fuhrmann G, Malach R (2004) Intersubject synchronization of cortical activity during natural vision. Science 303 (5664):1634–1640. doi:DOI 10.1126/science.1089506

Hebb DO (1949) The organization of behavior: a neuropsychologcial theory. Wiley, New York

Kensinger EA, Brierley B, Medford N, Growdon JH, Corkin S (2002) Effects of Normal Aging and Alzheimer's Disease on Emotional Memory. Emotion 2 (2):118-134. doi:10.1037//1528-3542.2.2.118

Kensinger EA, Ford JH (2020) Retrieval of Emotional Events from Memory. Annual Review of Psychology, Vol 71 71:251-272. doi:10.1146/annurev-psych-010419-051123

Landman A, van Oorschot P, van Paassen MM, Groen EL, Bronkhorst AW, Mulder M (2018) Training Pilots for Unexpected Events: A Simulator Study on the Advantage of Unpredictable and Variable Scenarios. Hum Factors 60 (6):793-805. doi:10.1177/0018720818779928

Leuner B, Gould E (2010) Structural Plasticity and Hippocampal Function. Annual Review of Psychology 61:111-140. doi:10.1146/annurev.psych.093008.100359

Liu M, Curet M (2015) A Review of Training Research and Virtual Reality Simulators for the da Vinci Surgical System. Teach Learn Med 27 (1):12-26. doi:10.1080/10401334.2014.979181

Lui JH, Hansen DV, Kriegstein AR (2011) Development and Evolution of the Human Neocortex (vol 146, pg 18, 2011). Cell 146 (2):332-332. doi:10.1016/j.cell.2011.07.005

Macdonald I, Chiu J (2011) Evaluating the Viability of Mobile Learning to Enhance Management Training. Canadian Journal of Learning and Technology 37 (1)

Medford N, Phillips ML, Brierley B, Brammer M, Bullmore ET, David AS (2005) Emotional memory: Separating content and context. Psychiat Res-Neuroim 138 (3):247-258. doi:10.1016/j.pscychresns.2004.10.004

Milne-Ives M, Lam C, De Cock C, Van Velthoven MH, Meinert E (2020) Mobile Apps for Health Behavior Change in Physical Activity, Diet, Drug and Alcohol Use, and Mental Health: Systematic Review. Jmir Mhealth Uhealth 8 (3). doi:ARTN e17046 10.2196/17046

Milner B, Corkin S, Teuber HL (1968) Further Analysis of Hippocampal Amnesic Syndrome — 14-Year Follow-up Study of Hm. Neuropsychologia 6 (3):215-&. doi:Doi 10.1016/0028-3932(68)90021-3

Murty VP, DuBrow S, Davachi L (2019) Decision-making Increases Episodic Memory via PostencodingConsolidation. Journal of Cognitive Neuroscience 31 (9):1308-1317. doi:10.1162/jocn_a_01321

Neuhoff H, Roeper J, Schweizer M (1999) Activity-dependent formation of perforated synapses in cultured hippocampal neurons. European Journal of Neuroscience 11 (12):4241-4250. doi:DOI 10.1046/j.1460-9568.1999.00856.x

Pessoa L (2004) Seeing the world in the same way. Science 303 (5664):1617-1618. doi:DOI 10.1126/science.1096416

Rugg MD, Johnson JD, Park H, Uncapher MR (2008) Encoding-retrieval overlap in human episodic memory: a functional neuroimaging perspective. Essence of Memory 169:339-352. doi:10.1016/S0079-6123(07)00021-0

Russell E, Hall AK, Hagel C, Petrosoniak A, Dagnone JD, Howes D (2018) Simulation in Canadian postgraduate emergency medicine training – a national survey. Can J Emerg Med 20 (1):132–141. doi:10.1017/cem.2017.24

Scoville WB, Milner B (1957) Loss of Recent Memory after Bilateral Hippocampal Lesions. J Neurol Neurosur Ps 20 (1):11-21. doi:DOI 10.1136/jnnp.20.1.11

Semendeferi K, Lu A, Schenker N, Damasio H (2002) Humans and great apes share a large frontal cortex. Nature Neuroscience 5 (3):272-276. doi:10.1038/nn814

Shatz CJ (1992) The developing brain. Sci Am 267 (3):60-67. doi:10.1038/scientificamerican0992-60

Stent GS (1973) A physiological mechanism for Hebb's postulate of learning. Proc Natl Acad Sci U S A 70 (4):997-1001. doi:10.1073/pnas.70.4.997

Tambini A, Davachi L (2019) Awake Reactivation of Prior Experiences Consolidates Memories and Biases Cognition. Trends in Cognitive Sciences 23 (10):876–890. doi:10.1016/j.tics.2019.07.008

Tompary A, Davachi L (2017) Consolidation Promotes the Emergence of Representational Overlap in the Hippocampus and Medial Prefrontal Cortex. Neuron 96 (1):228-+. doi:10.1016/j.neuron.2017.09.005

Tracey JB, Tannenbaum SI, Kavanagh MJ (1995) Applying Trained Skills on the Job – the Importance of the Work-Environment. Journal of Applied Psychology 80 (2):239-252. doi:Doi 10.1037/0021-9010.80.2.239

Wheeler ME, Peterson SE, Buckner RL (2004) Memory's echo: Vivid remembering reactivates sensory-specific cortex (vol 97, pg 11125, 2000). Proceedings of the National Academy of Sciences of the United States of America 101 (14):5181–5181. doi:10.1073/pnas.0400883101

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About Active Training Team

Active Training Team (ATT) are innovators in safety leadership. Our unique programmes equip people with the critical skills to become safety leaders and the practical communication tools to make a difference.

Using a blend of film, live action and facilitated discussion, ATT creates realistic active learning environments that bridge the gap between theory and the reality of life in the workplace. ATT's immersive approach heightens emotional and sensory experiences, positively impacting on learning, memory, recall and subsequent behaviour.

ATT designs and delivers award-winning safety leadership centres and mobile programmes at scale across the construction, transport and energy sectors. Clients include Ørsted, Tideway, TRU/Network Rail and Scottish Power. ATT aims to set the benchmark in safety leadership and welcomes the opportunity to work with organisations which share this aspiration.

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