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Embodiment: Knowledge and Memory-making

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Embodied Cognition

Embodied cognition emphasises the role of the body in learning, becoming skilful and managing the world successfully. The body is part of a dynamic system that includes the brain and the world. Embodiment therefore asserts that cognition arises from the interaction of the brain, the body and the world (Ataria, 2022). Cognitive neuroscience describes this as top-down (brain), bottom-up (body) and outside-in processing (Buzsaki, 2019).

For teachers, embodiment is like the golden key for student learning. No memory is as strong as those made personally, first-hand, by the learner, through the body. Embodied memories then form the basis for imagination, abstract thinking, conceptual development and thinking strategies. Once the learner has accumulated embodied knowledge, the wonderful thing about the human brain is that it has the ability to make connections between previously unrelated ideas and create new, unique combinations. The brain does this through reasoning, inference-making and flexibility; thinking strategies that even the most advanced artificial intelligence cannot, as yet, do as well as humans (Dehaene, 2021). Inference is especially interesting in terms of abstract thinking, or imagining. It is the type of thinking that links ideas of type or category, based on past experience and allows us to imagine and apply understanding from old memories to new contexts.

The ”world” in embodiment

The world, everything outside of the body, provides an environment to interact with, including other people to socialise with, and materials and tools to manipulate and assist with managing the world. The world is the place where we actively engage to learn, to think, and to make relationships. It shapes how we act, think and feel. Merleau-Ponty, a very famous phenomenologist of the 20th century said that our bodies can never escape the world because our minds were entirely created through it (Fink-Jensen, 2007). What he means is that it is the environment that we live in, every one and every thing in that environment, and every experience we have in that environment that creates who we are. We are the sum of all our experiences in the world

When students learn through actively engaging with the world, they do not have to try to imagine the world. Traditional classrooms “tell” students about ideas, they hear the words or see pictures, but without real interaction, this is weak knowledge. ’It turns out to be better to use the world as its own best model’ (Brooks, 1991, p. 140). Rodney Brooks said this in reference to how his research advanced robotics from single-use machines to robots that could act like humans and other animals. He noticed that simple insects could very successfully navigate their environment with very little brain power by adjusting to the world as it was encountered, not creating the world first in their head. This became the basis for not only intelligent machines, but also all the sensory apparatus that is now standard in cars

and other machines. It takes far more cognitive effort to create the world in your head, through imagination, than to just be active in it.

Teachers can greatly reduce cognitive load for their students by not requiring them to imagine the world. Provide the real context. For music and movement teachers, this is a classroom with lots of interaction possibilities with sound sources, other people, tools (objects to enhance or contribute to an experience), stories, rhymes, songs, games, artworks, dances and so on. These opportunities allow the development of embodied skills and knowledge, and the creation of their own ideas through exploration, experimentation and improvisation.

Strong, deeply-connected knowledge is created through embodied interactions with the world. These memories are embedded in all the systems to do with action (movement), perception (the senses) and emotion (reward). This means that students will have multiple ways of accessing, remembering, and retrieving their knowledge because it is “in” their bodies, which means it is in their brains.

Other benefits of embodiment include the sustaining of attention. Distractions make us lose attention and memory. It is easier to maintain attention and remember what you are doing if the body is engaged. The body reminds you what you are doing. The body also shows what the student is thinking, making the learning visible to teachers, and other students.

When the body is manipulating objects, this action makes thinking concrete, a way of externalising thinking so that we do not have to hold so much information in the memory. Offloading or extending thinking into the world (into things outside of the body) is called extended cognition (Clark, 2012; C. C. Moore & Moore, 2021; Ryan & Schiavio, 2019). Manipulating objects also achieves another vital aspect of learning, the grounding of understanding through doing. Art Glenberg, researcher in embodied approaches to language literacy, has found that grounding the meaning of words in actions (simulations), using gesture and objects, enhances understanding of text and underlying meaning, and importantly, a student’s sense of reward (Wall, Foltz, Kupfer, & Glenberg, 2021). He has shown that grounding learning through embodiment, engaging the motor, sensory and emotional systems enhances cognition and retention (Macrine & Fugate, 2022).

Mina Johnson-Glenberg has done much research looking into embodied learning, active learning, and writes that learning that involves physical manipulation results in deeper knowledge structures (Johnson-Glenberg, Megowan-Romanowicz, Birchfield, & Savio-Ramos, 2016). Mina experimented with learning that took place through three different conditions: regular instruction, low-embodiment and mixed-reality, and high-embodiment and mixed-reality. Post testing revealed that the 3 learning platforms gained similar results in learning. However, follow-up testing some time later revealed that the embodied learning groups retained more knowledge and resulted in more understanding that could be transferred to other contexts.

Action through the body has a much larger role to play in cognition than previously thought. In fact, action through the body, the brain acting in the world, makes learning stronger. Everything we learn is foremost grounded through the body and action.

Implications of embodiment for teachers:

1. Strong, deeply connected knowledge and memory;
2. Sustaining of attention;
3. Visible learning;
4. Manipulative learning – to make concrete our thinking so that we can act upon it;
5. Externalised learning so that we can learn from others – socially constructed.

Implications of embodiment for students:

1. Demonstration of knowledge through doing; start thinking by doing (Macrine & Fugate, 2022);
2. Motor skill development;
3. Thinking skills – reasoning, inference, flexibility (through the body);
4. Sensory skill development;
5. Emotional engagement and reward;
6. Social engagement;
7. Feelings of ownership of knowledge and valuing of creativity.

One last word on embodiment: the teacher's body is just as important in the development of embodiment as the learner's body. The teacher's body should be the living model of what they teach, so the student in the music and movement classroom knows what it is to be musical, and what it is to be a mover and dancer, and how artistic behaviour is demonstrated through these embodiments (Staveley, 2020).

The Senses – our entry to the world

The senses are our entry into the world. The senses invite the world in, and we do not just receive sensory information. We have to DO something to perceive it fully. We move to perceive. For example, if there is a bright light, we will turn our heads to see where it is coming from, or turn away to shield our eyes. If there is a strange sound, we will turn to see what made the sound. These are examples of responses to sensations. Often we will move to gain sensation, for example, if we want to "see" how rough or smooth a textile is, we will touch it; but it is not just touching. It is also moving the fingers around to perceive the feeling of rough or smooth. If we want to get a sense of the weight of an object, it requires us to lift it in order to perceive weight.

The senses include:

- **Peripheral** – sight, hearing, touch, taste, smell;

The inner senses are:

- **Haptic** (related to touch) – pressure, weight, temperature, muscles, tendons and joints;
- **Proprioception** – related to body awareness, body position, posture, spatial awareness, movement and force;
- **Vestibular** – balance and motion;

- **Interoception** – inner organ sense – hunger, thirst, heart rate, respiration, inner discomfort, pain, emotions.

With embodied activity, all the senses are engaged in the activity; both inner and peripheral are activated, and so memory and understanding is held in these systems. Together their actions become synchronised, integrated and connected, making a skilful perception of the world. For example, when our students hear recorded music that contains the instruments that they have played, the sensory and motor systems that were involved in the experience of playing the instrument are all activated. They have understanding of how the instrument was played, what action was required to make the sound, what it sounded like, how much effort was required to play loudly, softly, what the instrument felt like, the texture of the material, the weight and temperature of the material, how it sounded with other instruments and so on. All this understanding and knowledge is absent, or much reduced, in those who have not had an embodied experience of playing a musical instrument. 'To perceive something, you must understand it, and to understand it you must, in a way, already know it, you must have already made its acquaintance'. (Noë, 2012, p. 20).

When senses combine to make an integrated picture of the world, it is called multisensory integration, and when activated, this gives us a deep perception and understanding of the world, because we "feel" it.

Multisensory integration

Multisensory integration consolidates information from many senses into a meaningful, coherent, unified whole (Schoenfeld et al., 2003). It helps to guide and manage our actions successfully and skilfully in the world.

We are designed to make sense of a rich, multisensory world, so it makes sense that when we teach music and dance, that teachers immerse students in a richly multisensory experience. This is not to say that aspects should not be isolated to focus intently, but to always bring it back to its place in the unified whole, its authentic place. In this way, we understand how all the parts fit together.

We are designed to make sense of experiences in the world through all our senses. Information in one sensory mode facilitates understanding in another (Anderson, 2016) and results in a cross-referencing mechanism that speeds up processing of ideas, allows us to check for discrepancies, improves our discrimination and perception and allows for the combining of new ideas (Fortuna, 2017).

Multisensory integration improves memory (Okray et al., 2023) and even when only one sensory feature of the memory is activated, the whole multisensory memory is retrieved. For example, at present I am teaching older people. Last week I taught them a Ghanaian greeting song and I told them all about the beautiful Ghanaian lady who taught me the song, and her description of when and how the song would be sung and what the words meant. In other words, I created a story about the song. Stories link memories. I then taught the song, with gestures and movement, and asked them to practise it every time they met someone in the hallways as they passed by, so that they would remember it for the following week. The

next day, one of the class rang me. She said that no-one could remember the lyrics though they remembered the song had come from Ghana and that it was a greeting song. After sending the words, they said they had together remembered the melody, gestures and how it all fitted together. The whole integrated memory was retrieved as the parts were put together.

In the classroom, when students learn a song while gesturing to trace the line of the melody, later on the memory of the song might be elicited just by seeing the gesture of the line of melody. In the same way, when we go to a concert and "see" an instrument being played, we "hear" it more clearly. When we use solfa gestures while singing, the feeling of the gestures elicits the memory of the relative pitch. Combining sensory information helps remember ideas more fully.

Implications of multisensory integration for pedagogy:

1. Immerse students in multisensory, holistic contexts;
2. Use many ways of learning authentically (a song with actions, playing a part in an ensemble, dance movements that match musical periods, creating symbols that represent aspects of music, playing rhythm patterns of chants, and so on);
3. Use real sound sources, so the whole sensory experience of the vibrations of sound, the weight of the instrument, the effort to play softly, loudly, expressively, etc. can be integrated and understood.

Sensorimotor integration - the sensing and moving loop

Esther Thelen, the famous Canadian psychology researcher, devoted her life to understanding how we learn to skilfully manage the world. Her research centred around human development and how it emerged. She was adamant that it was **movement**, through the activity of living, the lived experience, that cognition and skilful behaviour developed. Development and skilful behaviour emerged as a result of multiple components working together in a real environment, such as the opportunity for movement, motivation, a goal and an ability to reach it. She described how babies gained control of their bodies and became "active participants in their own learning," (Spencer et al., 2006, p. 1532) through exploration of their environment, and that perception and action are not bystanders in cognition. They make cognition.

Action and sensorimotor skill development arise out of interaction with the physical space. Thelen described that behaviour and cognition arose simultaneously out of that exploration of the world and was not dependent on the capacity to cognitively plan. It arose out of sensing and acting on the environment in many different ways, over and over again.

For music and movement education, the place where we gather sensorimotor interaction is important to consider for pedagogy. There are special neurons in the hippocampus (a neural structure in the brain) devoted to "place" in the world. The hippocampus is one of the very important places in the brain for memory; for holding short-term memory, and for integration of aspects of memory and navigation (Huijgen & Samson, 2015). The hippocampus is also involved in recalling and integrating the who, what and where of

memories, hence the place cells (O'Keane, 2021). We remember the place and associate who and what happened there.

"Place" must be a very important part of neural processing for us to have evolved to have special "place cells" (J. J. Moore, Cushman, Acharya, Popeney, & Mehta, 2021). In evolutionary terms we can understand that "place" was very important for survival, as it could represent where to find food, shelter, safety, water, others, and so on, so that is probably why we have these special neurons. The hippocampus in other species is devoted to navigation, how we find our way in the world. In the human brain, the hippocampus is involved in spatial navigation as well as navigation to memory, or cognitive mapping. Just one neuron fires to place, but it fires up all the other systems of neurons linked to this place; everything sensed, such as seen, heard, smelled, touched, tasted, felt, held, physically engaged with; every person, activity, idea, and so on becomes linked to this place. This is called a Hebbian process after the researcher, Donald Hebb (1949). He is famous for the idea that "neurons that fire together, wire together" (Shatz, 1992). It means that everything that occurs in the same time and place becomes associated together, gathered into the same memory.

Places engender memory. Most people can think of a place that is special to them, and it will inevitably be related to multiple factors that are involved in the memory of that place. For teachers, this has significance. We try to provide a "world" or place where everything to do with that memory evokes meaning to the memory, so all the people involved, the tools and materials, the language, activities, everything in the room that can be sensed provides associations to the memory, so let's make the place where our students learn fire up special memories.

This research has made me think about what the world of the classroom is, and how I provide the place in the world of students. Sometimes, I set my room up as a "blank slate", something to be created by everyone in the room as we proceed through activities.

Space created from a blank slate

Sometimes, I prepare the room so that every object has something to contribute to whatever we are learning. Always, the space reflects opportunities for action and rich sensory experiences, no matter who the students are.

Prepared space

The memories from each place are stronger if the experience is real, not read or told about, or watched on television.. Embodied memories

are richer and provide much more structure to the experience, and engender those deep, rich, sensorimotor memories.

Implications of sensorimotor integration and place for pedagogy

- Places for learning provide rich opportunities for action and perception – sensorimotor integration;
- Places can be prepared or built by students as the learning takes place;
- Action and sensory opportunities develop cognition.

Memory and embodiment

The wonderful thing about embodiment is that memory is held throughout the body. The body allows us to be constantly reminded of what we are doing and what we are focussing on because we feel it, we move it, we think with our bodies.

Procedural memory, the memory of how to do things, unfolds as we are doing things. We do not have to plan for it first. That is too much cognitive load, too much effort. We do it, let that memory of "how to" occur as we are doing, while this leaves cognitive space for higher order thinking, such as problem-solving, logic, exploration, and so on.

For people to be ready to make memories, you need to get their ATTENTION, and to get their attention, it must appear that whatever is happening is **meaningful, emotional, exciting, or new** (Genova, 2023). Embodiment is a great way to both get and sustain attention. It is easier to maintain attention when the whole body is engaged in the learning.

Once attention is gained, we begin the process of making short-term memory (STM). It used to be thought that STM could hold about 7 items (+ or – 2) (Miller, 1956). It is now thought that we can actually only hold about 4 items at once (Cowan, 2001), and if you get distracted, these disappear. Distractions can take the form of someone talking to you, a sudden loud noise, or more notably now, technology devices, such as smartphones, iPads, computers, etc. When we get distracted, these short-term memories drop away and do not have the opportunity to make links to long-term memory (LTM). LTM is more permanent and is continually updated with conceptual, sensory, motor and emotional networks, especially if it is continually added to or retrieved. It is the connections that short-term and long-term memory make that develop deep, rich, lasting, meaningful learning and knowledge.

Those who can hold STM long enough to link to LTM learn more easily are the FAST thinkers. A dilemma that many teachers find challenging to manage in the classroom is FAST and SLOWER thinkers. There is a place for all types of thinkers. FAST thinkers may be the ones who we rely upon to recall facts and calculate quickly, but SLOW thinkers may be the ones who notice many details or understand how and why things happen. SLOW thinking is also when making sensorimotor memory, as it takes many repetitions to make these memories fluid and seamless, but once they are, they become FAST memory.

Many great thinkers have been what might have been thought of as slow thinkers, such as Santiago Ramon y Cajal (Andres-Barquin, 2002). Cajal is considered the father of modern neuroscience, yet as a child, was considered slow because he had poor short-term memory

and behaved badly at school. However, he always loved art, and wished to become an artist, but his father wanted him to become a doctor. He did become a doctor, eventually, but along the way, his artistic skills were used as he researched, recorded and drew in great detail many different types of neurons, complete with dendrites and axons. These drawings are still considered to be accurate and are referred to in neuroscience topics.

Cajal's great achievements were precisely because of his slow, creative, flexible ways of thinking, that deal with the details, correct and overcome errors and find new solutions. Fast thinkers can find it difficult to recall how they calculated answers and therefore are unable to correct results.

When short-term memory is overloaded, we cannot think clearly, lose focus and forget where we started. We cannot remember the details important for putting the picture together. There are teaching strategies and physical ways to overcome this overloading.

Teaching strategies to overcome low short-term memory include:

- Getting attention;
- Using simple language, and not too much of it, to instruct;
- Giving one instruction or idea at a time, and getting students to say it as well, preferably in their own words, to demonstrate their understanding;
- Accompanying instructions with mnemonics, such as pictures, symbols or gestures;
- Showing how to do something, and getting the student to copy (imitation).

More importantly**,** there are physical ways to strengthen the ability to maintain short-term memory and think. This is called off-loading thinking into the body and world, and increases capacity for skill development and memory.

- Gesture – using fingers to symbolise number, using the body to assist description, using the body to express ideas that words do not capture;
- Objects – using "things" to signify number, place, concepts, knowledge; using things to create knowledge, such as pencils to write words; manipulating and moving objects to perceive more possibilities, e.g. in, out, over, under, patterns, capacity, volume, back, front, big, small, etc;
- Motor patterns – using patterned movement to signify structure, order, category, sequence, procedures;
- Storage units – lists, maps, patterns, diagrams...

Physical manipulation and physicalising knowledge are ways that the body and "things" can become part of cognitive architecture. They can assist problem-solving abilities and reduce overload of short-term memory (Beilock & Goldin-Meadow, 2010; Congdon et al., 2017).

Physical manipulation and gesture lighten cognitive load, and help link short-term memory to long-term memory. Eventually the memory is stored as conceptual memory. By the time it is conceptual memory, many similar, and sometimes distant memories, from other times, places and events that evoke some part of the memory, become part of a multi-layered, intricately connected system, "softly-assembled", richly layered and hard, permanent memory. This type of memory eventually bypasses the hippocampus when it is stimulated to

fire, and you might not remember all the details of where, when, who, how, and so on, but you'll have the conceptual understanding to draw upon. This has become fast memory, memory that is engendered quickly (Oakley, Rogowsky, & Sejnowski, 2021).

To make strong memories

1. **Attention** - get learners' attention (meaningful, emotional, exciting, or new) so that all the neurons are in the "on" position;
2. **Do it together** (whatever is being learnt); the neurons start to join with other neurons linked to the same idea;
3. **Do it on your own**; new memory will start to use long-term memory when you do it on your own, showing your independence, but true independence comes when you can not only do it on your own, but you...
4. **Do it another way**, change it, or recreate it until it is different. You have now learnt how to use that idea independently and it starts to get stored in long-term memory.

(Oakley et al., 2021, p. 4).

An Orff-Schulwerk approach to learning emphasises point 4, "doing it another way". It is only when one can independently create something new, using what has been learned, that they truly and deeply understand the idea. To explore and experiment, improvise and compose demonstrates independent thinking and deep knowledge.

To summarise, "place" is very significant for memory. Fast memory is long-term memory that bypasses the hippocampus. It is a hard stable memory and is not easily changed. It is made up of not only your personal experiences, but really hard, entrenched procedural memory for how to do things, like the way to ride a bike. Sensorimotor memory is very fast memory, which is why we can drive and respond to unexpected distractions without losing the ability to drive. You do not have to think about fast memory.

Slow memory requires a lot of thinking and is assisted by using the body, so much of the thinking can be extended into the body, such as when improvising on an instrument. It is much easier to improvise with the instrument under your fingers, than just imagining it, although experts, who have the instrument in their heads, can also do it there. Slow memory requires you to hold information in STM for long enough to create LTM, so keep it embodied, and the body will keep reminding you what you are thinking.

In embodied learning, the body and all its sensory apparatus is central to all pedagogy. Cognitive processes are based on sensorimotor processes, actively performed in rich contexts. Memory is enriched by embodiment as multiple systems are involved in the memory-making and memory-storing. The body sustains, holds and feels memory and knowledge. Finally, embodied learning leads to creative, flexible cognition and skilful behaviour.

References

Anderson, M. L. (2016) Précis of after phrenology: Neural reuse and the interactive brain. *Behavioral and Brain Sciences, 39*, 1-45.

Andres-Barquin, P. J. (2002) Santiago Ramón y Cajal and the Spanish school of neurology. *The Lancet Neurology, 1*(7), 445-452. doi:https://doi.org/10.1016/S1474-4422(02)00192-8

Ataria, Y. (2022) Phenomenology of the body. In Y. Ataria (Ed.), *Consciousness in flesh: An unapologetic phenomenological study* (pp. 1-37). Cham: Springer International Publishing.

Beilock, S. L., & Goldin-Meadow, S. (2010) Gesture changes thought by grounding it in action. *Psychological Science, 21*(11), 1605-1610. doi:10.1177/0956797610385353

Brooks, R. A. (1991) Intelligence without representation. *Artificial Intelligence, 47*(1), 139-159. doi:10.1016/0004-3702(91)90053-M

Buzsaki, G. (2019) *The brain from the inside out*. New York: Oxford University Press.

Clark, A. (2012) Embodied, embedded, and extended cognition. In K. Frankish & W. Ramsey (Eds.), *The Cambridge Handbook of Cognitive Science* (pp. 275-291). Cambridge: Cambridge University Press.

Congdon, E. L., Novack, M. A., Brooks, N., Hemani-Lopez, N., O'Keefe, L., & Goldin-Meadow, S. (2017) Better together: Simultaneous presentation of speech and gesture in math instruction supports generalization and retention. *Learning and Instruction, 50*, 65-74. doi:https://doi.org/10.1016/j.learninstruc.2017.03.005

Cowan, N. (2001) The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioral and brain sciences, 24*(1), 87-114.

Dehaene, S. (2021) *How we learn: Why brains learn better than any machine…for now.* US: Penguin Books.

Fink-Jensen, K. (2007) Attunement and bodily dialogues in music education. *Philosophy of Music Education Review, 15*(1), 53-68.

Fortuna, S. (2017) Embodiment, sound and visualization: A multimodal perspective in music education. *Zbornik Radova Akademije Umetnosti, 5*, 120-131. doi:10.5937/ZbAkUm1705120F

Genova, L. (2023) *Remember: The science of memory and the art of forgetting*. Australia: Simon & Schuster Australia.

Hebb, D. O. (1949) *The organization of behavior: A neuropsychological theory*. New York: Wiley.

Huijgen, J., & Samson, S. (2015) The hippocampus: A central node in a large-scale brain network for memory. *Revue Neurologique, 171*(3), 204-216. doi:https://doi.org/10.1016/j.neurol.2015.01.557

Johnson-Glenberg, M. C., Megowan-Romanowicz, C., Birchfield, D. A., & Savio-Ramos, C. (2016) Effects of embodied learning and digital platform on the retention of physics content: Centripetal force. *Frontiers in Psychology, 7*, 1819. doi:10.3389/fpsyg.2016.01819

Macrine, S. L., & Fugate, J. M. B. (2022) *Movement matters: How embodied cognition informs teaching and learning*. Cambridge, Massachusetts; London, England: MIT Press.

Miller, G. A. (1956) The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological review, 63*(2), 81.

Moore, C. C., & Moore, D. R. (2021) The extended mind: Physical tools to expand cognition in the collegiate modern dance class. *Journal of dance education, 21*(3), 198-202. doi:10.1080/15290824.2021.1939358

Moore, J. J., Cushman, J. D., Acharya, L., Popeney, B., & Mehta, M. R. (2021) Linking hippocampal multiplexed tuning, hebbian plasticity and navigation. *Nature, 599*(7885), 442-442,448A-448V. doi:https://doi.org/10.1038/s41586-021-03989-z

Noë, A. (2012). *Varieties of presence*. Cambridge, US: Harvard University Press.

O'Keane, V. (2021) *The rag and bone shop: How we make memories and memories make us*. UK: Penguin Random House UK.

Oakley, B. A., Rogowsky, B., & Sejnowski, T. J. (2021) *Uncommon sense teaching : Practical insights in brain science to help students learn*. New York: TarcherPerigee, an imprint of Penguin Random House LLC.

Okray, Z., Jacob, P. F., Stern, C., Desmond, K., Otto, N., Talbot, C. B., . . . Waddell, S. (2023) Multisensory learning binds neurons into a cross-modal memory engram. *Nature*. doi:https://doi.org/10.1038/s41586-023-06013-8

Ryan, K., & Schiavio, A. (2019) Extended musicking, extended mind, extended agency. Notes on the third wave. *New Ideas in Psychology, 55*, 8-17. doi:https://doi.org/10.1016/j.newideapsych.2019.03.001

Schoenfeld, M. A., Tempelmann, C., Martinez, A., Hopf, J. M., Sattler, C., Heinze, H. J., & Hillyard, S. A. (2003) Dynamics of feature binding during object-selective attention. *Proceedings of the National Academy of Sciences, 100*(20), 11806. doi:10.1073/pnas.1932820100

Shatz, C. J. (1992) The developing brain. *Scientific American, 267*(3), 60-67.

Spencer, J. P., Clearfield, M., Corbetta, D., Ulrich, B., Buchanan, P., & Schoner, G. (2006) Moving toward a grand theory of development: In memory of Esther Thelen. *Child Development, 77*(6), 1521-1538. doi:10.1111/j.1467-8624.2006.00955.x

Staveley, R. M. (2020) *Embedding embodied cognition and neuroscience in music pedagogy.* (Doctor of Philosophy PhD), University of Technology Sydney, Sydney, Australia. Retrieved from https://trove.nla.gov.au/work/246931922

Wall, D., Foltz, S., Kupfer, A., & Glenberg, A. M. (2021) Embodied action scaffolds dialogic reading. *Educational psychology review, 34*(1), 401-419. doi:10.1007/s10648-021-09617-6

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