1

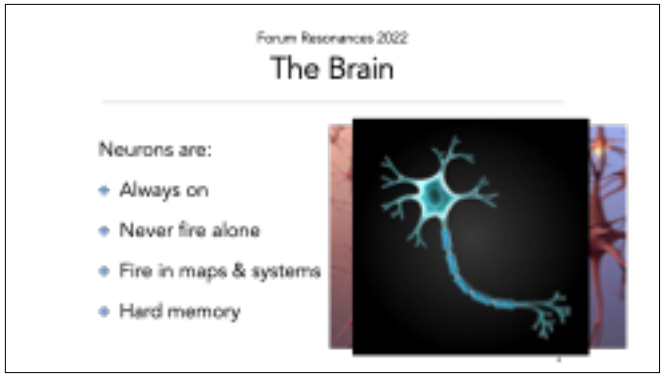
- Neuroscience - inform our understanding about learning, and therefore strengthen our pedagogy.
- This session will focus on the role of movement in learning, embodiment, prediction and the 4 pillars of learning, all based on research in neuroscience. And in all of these, the impact for pedagogy.

2

- Brains are designed for movement; in fact, brains are for movement.
- Neuroscientist Rodolfo Llinas says that brains evolved for movement.
- thinking or cognition “is the internalisation of movement” (Llinas, 2001, p. 5).
- we **intentionally** move on the **prediction** that the outcome for us will be successful, such as hiding from danger, seeking out food, or joining a group of people to be more successful in surviving.
- This picture is of a sea squirt, C. Elergens has a primitive brain called a nerve net.
- allows it to escape danger, find food and reproduce, and to do this, it must MOVE.
- all living things that need to move to survive, have a brain of some sort.

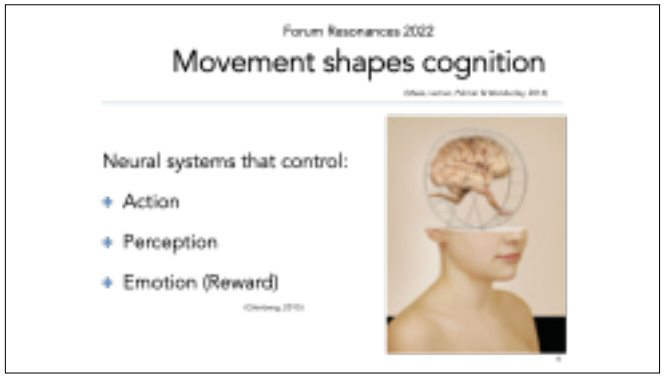
3

- Brain are **complex**
- Noting is ever processed just in one place; processed all over the brain and body, in complex arrays of **softly-assembled**, **interconnected** maps.
- **softly-assembled** - memories are always being reassembling building in all the new experiences.
- **neuroplasticity,** the way the brain changes in response to experience.
- All experience is **mapped** across the body and brain, forming **highly networked** neural systems and processes that **synchronise** to produce successful behaviour and development.



4

- Neurons are responsible for storing and transmitting information across the brain
- neurons are always on, never off, even when asleep
- You never use just one neuron. They always work in systems.
- Neurons always in “ready” mode, and as soon as a message is strong enough, the central system sends an electrical message down the axon and the message is transmitted across a space, the synapse, carried by neurotransmitters
- dendrites grow out from the neuron to receive the message.
- The more times the same system of neurons fire, the harder the memory becomes through a process called myelination.
- memory becomes faster and more efficient, using less neurons
- This efficient system now fires automatically, so that we don’t have to waste cognitive space with always relearning things.
- Implications for teaching:
- New learning = lots of cognitive effort and space.
- An observant teacher watches for this point, and builds upon hard memory, not introducing many new things at once. The best learning builds upon past learning to strengthen, widen and deepen memory and knowledge.

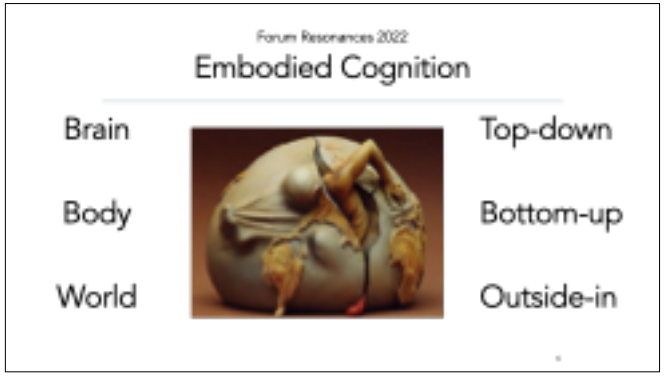


5

- Movement shapes cognition.
- we are designed to move to learn, to be successful, and all learning, thinking, and abstract thought, is grounded in movement.
- brain is designed to create patterns of movement to solve problems that arise in the world.
- carefully synchronised, complex array of interacting components
- That process involves
    - neural systems that control action, firing up all the complex muscles, limbs and body parts to move,
    - neural systems that control perception, the seeing, hearing, tasting, touching, smelling, and inner haptic systems,
    - and neural systems that control emotion or reward, whether the action on whatever is happening results in something that turns out to be good for us, or not.

- But this is only part of the story, because all this would not be possible without a world to interact with

---



6

- Embodied cognition - The brain, the body and the world create a unified, integrated, dynamic system.
- In neuroscience, it is described as top-down (the brain), bottom-up (the body) and outside-in (the world) processing
- Maurice Merleau-Ponty (1908 – 1961) - “embodiment”, what our bodies are like and **how** they experience the world. (Fink-Jensen, 2007; Leitan, Murray, Bergomi, & Michalak, 2014).
- our bodies could never escape the world because our minds were entirely created through it (hence the picture).
- when we learn and develop memory, the strongest memory is that which is embodied, in the body.
- To embody learning, our bodies actively engage with the world we are in, with people and things in it, to create personalised, living memory.
- For teachers, - classrooms where students immersed in rich, lived experiences, with other people, with the tools that increase our capacities and skills.
- lived experiences basis for abstract thought, able to be manipulated and built upon, to combine ideas and explore new creations.
- “lived experience” greatly outweighs any passively received knowledge, because lived memory is created through intricately connected neural networks of perception, action and emotion.

7

Movie showing
1. embodied knowledge - pitch and melody, and dynamics
2. use of elastic - We all joined in a circle, holding onto a circle of elastic. This was used so that my body and theirs could synchronise to develop **joint sensorimotor integration** - the synchronising of senses and bodily action. When done jointly, what the teacher wants the focus to be is experienced by all through the **transference of action** through the elastic, and through the people watching the action of the teacher.
3. cognitive benefits of using elastic as a tool is that it extends my thinking as the teacher, and the thinking of the participants, into the world.

- This is **extended cognition**, the use of things to lighten the cognitive load.
- Moving with the elastic also allows us to externalise our thinking, physicalising the concepts, and making it visible to each other.

- embodied teaching and learning - cognitive benefits, deeply embeds richly networked knowledge into learning.
- key to embodiment is movement, and movement of the body results in movement of the mind.
- effortful action of the moving mind, grounded through embodiment.

8

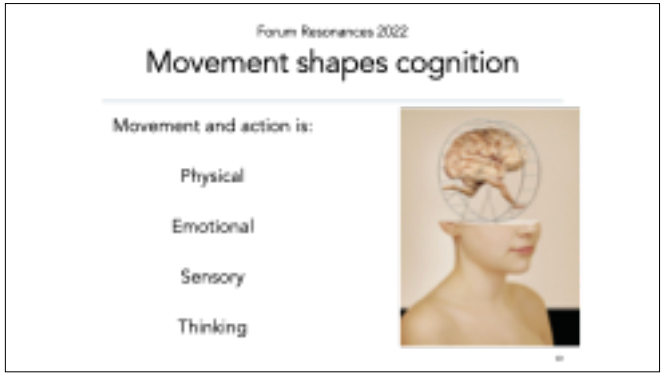
- Mina Johnson-Glenberg -research looking into embodied learning (2016).
- experimented with learning that took place through regular instruction, low embodiment and Mixed reality, and high embodiment and mixed reality.
- embodied learning retained more knowledge and resulted in more knowledge that could be transferred to other contexts.

- integrate sensory and motor areas when moving, learning is quicker and deeper, and the actions create a memory code that strengthens memory, and provides additional memory retrieval cues.
- All learning grounded through the body and action or movement.

9

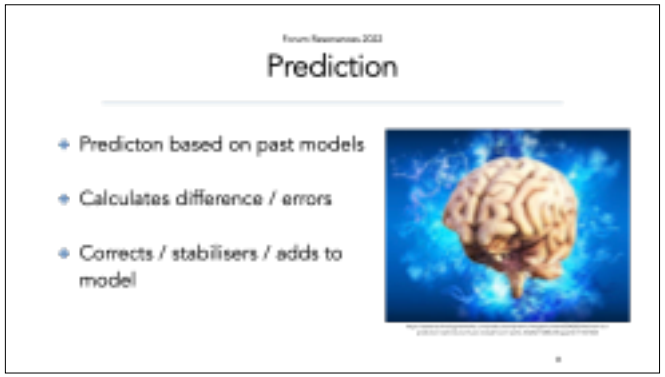
- Esther Thelen - said that babies are always active participants in their own learning.
- skills appeared when opportunities were provided in the environment.
- Learning and development is always a product of multiple components interacting in real-time tasks. Perception, action and cognition are all embodied processes.
- language is also grounded in movement - powerful tool for conveying complex information, is made up of words that map back to how we learned about them.
- processed to a great extent through the parietal lobe, one of the movement centres in the brain.

- Game: Jump in.



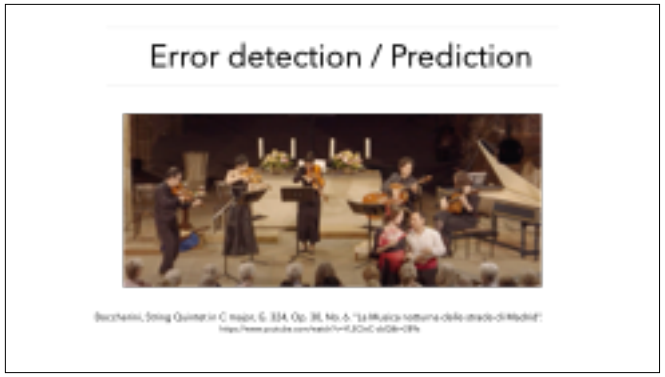
10

- language is always mapped back to the movements.
- When you hear the word, “jump”, already, in the movement parts of your brain where jumping is processed, it is jumping, or YOU are jumping.
- implications for how teachers - For new learners, keeping language simple and sparse, not too many words, is less confusing to process.
- Impact of movement and embodiment for teaching:
- Experience - movement - abstract thought - mentally manipulated, the moving brain, to create unique combinations of ideas - creativity.



11

- Prediction creates meaning based on past experiences; models so that we can predict what is happening and how to act.
- When prediction does not match what is happening in real-time, the brain detects errors.
- change in behaviour to reduce the error, trial by trial, until performance is successful in the context.
- Prediction - the way the brain again saves us cognitive load, because every time we have an experience, we don’t have to learn all about whatever is encountered all over again.

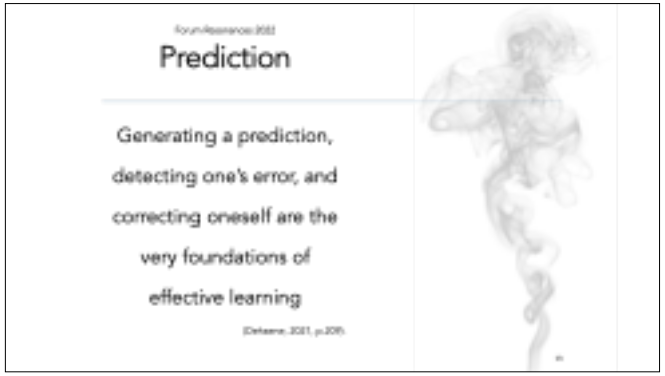


12

Boccherini prediction activity - example of how movement and prediction are the very foundations of what brains were designed for.
So what does this mean for teaching?

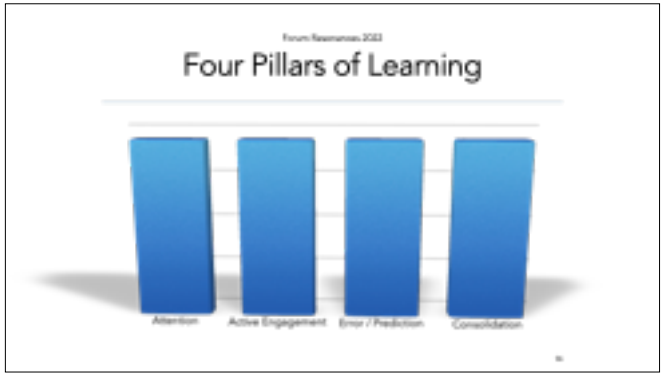
- Challenge predictions.
- provide activities which will attract great attention because when your prediction is not fulfilled, you are impelled to make it right, to stabilise the confusion.
- chance, variety, surprise, change, opposites, comparisons and so on

---



13

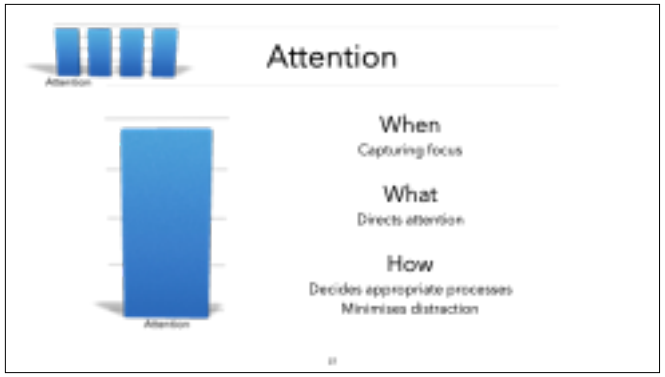
- Generating a prediction, detecting one's error, and correcting oneself are the very foundations of effective learning (Dehaene, 2021, p.209).
- Stanislas Dehaene - conducted much widely respected research on how the brain learns
- ground-breaking research on reading and mathematics, all based on neuroscience.



14

Stanislas Dehaene - model of how the brain learns best; based on neuroscience, watching what happens in the brain when we are learning, and the results of learning events.

1. Attention
2. Active engagement
3. Error prediction
4. Consolidation

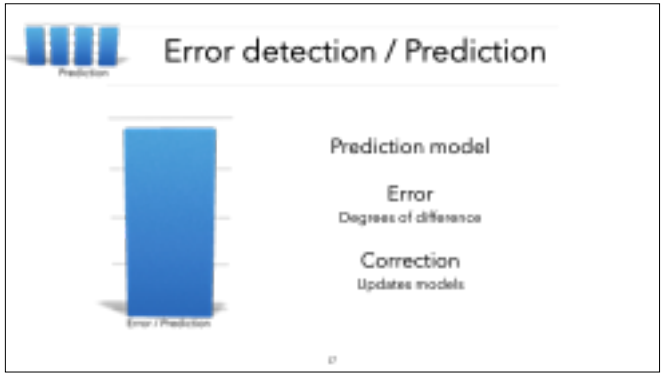


15

- When - capturing focus
- What - directs attention
- How - appropriate processes; no distractions (such as phones and computers).
- Brains cannot multitask, and every distraction means less depth of learning.

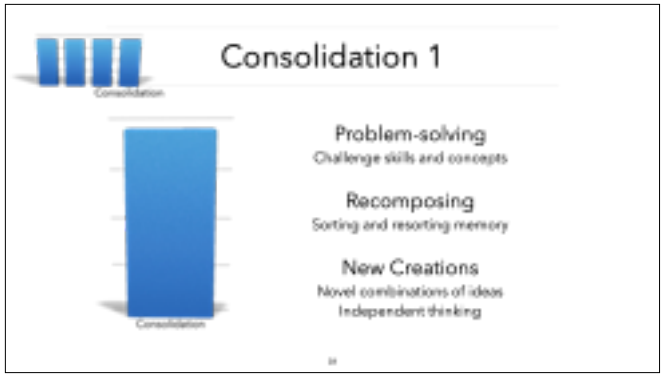
16

- The trick to active engagement involves the body and mind.
- Teachers think about challenge and change.
- The students need to act with effortful thinking.



17

- cognitive effort = stronger learning.
- error detection stronger than telling your students
- The effort is the learning taking place.

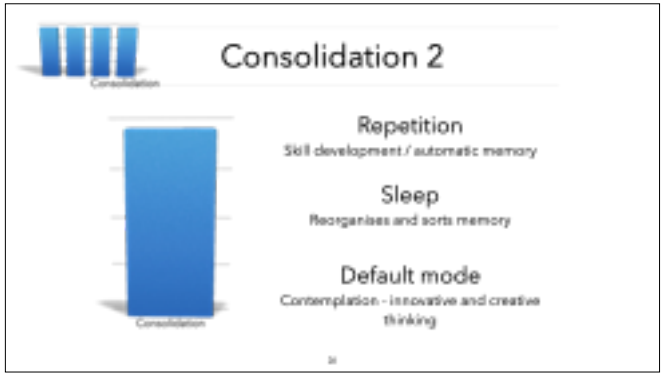


18

- CONSOLIDATION 1 - not in the Deheane model - my observations based on applying the neuroscience in the classroom.
- Problem-solving - strengthens and consolidates old memory and creates new ones.
- Recomposing - my term, explains that using the ideas of others provides mental vocabulary for new creations.
- example - Max Richter's recomposing of The Four Seasons by Antonio Vivaldi.

19

Tertiary students recomposing Miro's painting, "Dancer".

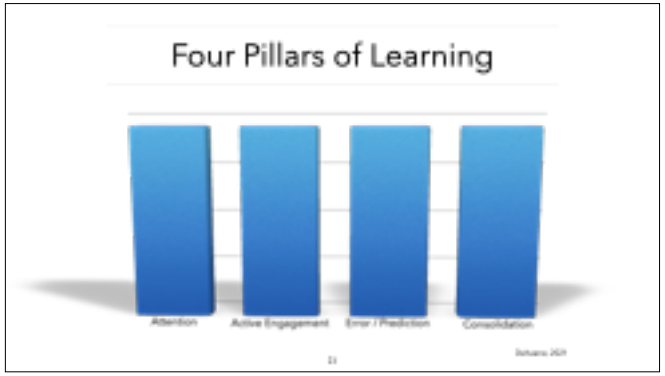


20

Deheane's model for CONSOLIDATION.

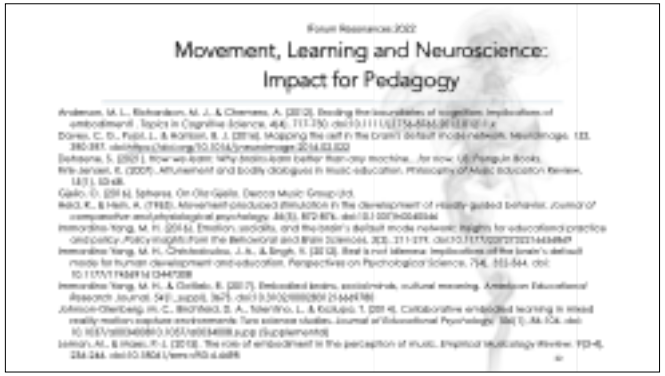
- Repetition - permanent memory
- novelty, surprise, variety, so practise the same thing, but do it differently.
- Sleep – Lack of sleep is related to poor memory and dementia. Good sleep is related to strong memory and deep learning. The brain resorts and reorganises.
- often awaken after a good sleep with much more clarity to your learning. For maximum benefit, sleep should occur within hours of learning (Born & Wilhelm, 2012; Katya Trudeau & Bunney, 2012; Stickgold, 2006; Tononi & Cirelli, 2014)
- Default mode - fairly recent finding in neuroscience.
- not part of Deheane's model,
- the neural mode we go into in contemplation and daydreaming.
- Achieves sense of self, sense of others, sense of future self, insights

- Default mode - active across the parietal and temporal lobes, is highly and densely connected to all areas of the brain and has a high resting metabolic rate which suggests that it is doing important work during rest (Davey, Pujol, & Harrison, 2016; Immordino-Yang, 2016; Immordino-Yang, Christodoulou, & Singh, 2012).



21

All these are ways that neuroscience shows us that deep knowledge and understanding comes from a moving body and mind, in a rich environment where learning is embodied by each individual learner.



22

Reference List

Anderson, M. L., Richardson, M. J., & Chemero, A. (2012). Eroding the boundaries of cognition: Implications of embodiment1. Topics in Cognitive Science, 4(4), 717-730. doi:10.1111/j.
1756-8765.2012.01211.x

Davey, C. G., Pujol, J., & Harrison, B. J. (2016). Mapping the self in the brain's default mode network. NeuroImage, 132, 390-397. doi:https://doi.org/10.1016/j.neuroimage.2016.02.022

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.

Gjeilo, O. (2016). Spheres. On Ola Gjeilo. Decca Music Group Ltd.

Held, R., & Hein, A. (1963). Movement-produced stimulation in the development of visually guided behavior. Journal of comparative and physiological psychology, 56(5), 872-876.
doi:10.1037/h0040546

Immordino-Yang, M. H. (2016). Emotion, sociality, and the brain's default mode network: Insights for educational practice and policy. Policy Insights from the Behavioral and Brain Sciences,
3(2), 211-219. doi:10.1177/2372732216656869

Immordino-Yang, M. H., Christodoulou, J. A., & Singh, V. (2012). Rest is not idleness: Implications of the brain's default mode for human development and education. Perspectives on

Psychological Science, 7(4), 352-364. doi:10.1177/1745691612447308
Immordino-Yang, M. H., & Gotlieb, R. (2017). Embodied brains, social minds, cultural meaning. American Educational Research Journal, 54(1_suppl), 367S. doi:10.3102/0002831216669780
Johnson-Glenberg, M. C., Birchfield, D. A., Tolentino, L., & Koziupa, T. (2014). Collaborative embodied learning in mixed reality motion-capture environments: Two science studies. Journal of
Educational Psychology, 106(1), 86-104. doi:10.1037/a003400810.1037/a0034008.supp (Supplemental)
Leman, M., & Maes, P.-J. (2015). The role of embodiment in the perception of music. Empirical Musicology Review, 9(3-4), 236-246. doi:10.18061/emr.v9i3-4.4498
Llinas, R. (2001). The i of the vortex: From neurons to self. Cambridge, MA: MIT Press.
Maes, P.-J. (2016). Sensorimotor grounding of musical embodiment and the role of prediction: A review. Frontiers in Psychology, 7(308). doi:10.3389/fpsyg.2016.00308
Maes, P.-J., & Leman, M. (2013). The influence of body movements on children's perception of music with an ambiguous expressive character. PLoS ONE, 8(1).
Maes, P.-J., Leman, M., Palmer, C., Wanderley, M. M., Croom, A. M., Lotze, M., & Hove, M. (2014). Action-based effects on music perception. Frontiers in Psychology, 4, 1-14.
doi:10.3389/fpsyg.2013.01008
Maes, P.-J., Lorenzoni, V., Moens, B., Six, J., Bressan, F., Schepers, I., & Leman, M. (2018). Embodied, participatory sense-making in digitally-augmented music practices: Theoretical
principles and the artistic case "soundbikes". Critical Arts, 32(3), 77-94. doi:10.1080/02560046.2018.1447594
Maes, P.-J., Van Dyck, E., Lesaffre, M., Leman, M., & Kroonenberg, P. (2014). The coupling of action and perception in musical meaning formation. Music Perception, 32(1), 67-84.
doi:10.1525/MP.2014.32.1.67
Merzenich, M. M. (2013). Soft-wired: How the new science of brain plasticity can change your life. San Francisco, US: Parnassus.
Schiavio, A. (2014). Commentary on leman and maes, "the role of embodiment in the perception of music" (2014). Empirical Musicology Review, 9(3-4), 1-9.
Schiavio, A., & De Jaegher, H. (2017). Participatory sense-making in joint musical practice. In M. Lesaffre, M. Leman, & P.-J. Maes (Eds.), The routledge companion to embodied music
interaction (pp. 456). New York, NY: Routledge.
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
Tovar-moll, F., & Lent, R. (2016). The various forms of neuroplasticity: Biological bases of learning and teaching. Prospects, 46(2), 199-213. doi:http://dx.doi.org/10.1007/s11125-017-9388-7
Vivaldi, A., & Richter, M. (2014). Spring 0, spring 1. On Recomposed by Max Richter: Vivaldi, the four seasons. Berlin: Deutsch Grammaphon.