Primary

1. Chakraborty, S., Dutta, S., & Timoney, J. (2021). The Cyborg Philharmonic: Synchronizing interactive musical performances between humans and machines. Humanities and Social Sciences Communications, 8(1), 1–9. https://doi.org/10.1057/s41599-021-00751-8
    a. It is here that we seek to investigate how real-time cooperation between machines and humans could be achieved through technologies and models from synchronization and learning, with their exact configuration for the generation of melody alongside each other, to achieve the vision of human–robot symphonic orchestra. (p. 2)
    b. "Robotic Musicianship" has always been a challenging domain and has garnered significant interest among researchers over recent years for the generation of musical pieces. Along with sonic features like beats and chords, time plays a crucial role in terms of the rhythmic aspect of musical performance. (p. 3)
    c. The work of Bishop and Goebl (2018) demonstrated the importance of gestural communication, such as head nods or foot taps, and the leader–follower model as useful features in an ensemble environment. They found that gestural communications helped in establishing early synchronization, sometimes even from the very first chord, and that the identification of the leader had a very high impact on maintaining the beat and timing in-sync with the others. (p. 4)
    d. In such real-time music systems even a small latency could initiate a butterfly effect (Lorenz, 2000), potentially throwing the system out-of-sync. In this regard, MIDI information is beneficial for reducing the time delay over a data transmission (Moog, 1986; Yuan et al., 2010), with the use of 'MidiScore', a score-aligning model based on a bootleg score synthesis, for alignment (Tanprasert et al., 2020). This would help in tracking the portion of the song being played and detect the tempo, as well as provide a global overview of the sonic properties. (p. 5)
    e. Since, human performances are perfected through rigourous training and practice, it might be difficult to find musicians for varied instruments (e.g., for niche traditional instruments, and dependence on musician's skill level or their time schedule) that is associated with ensemble settings. In this scenario, the use of robotic musicianship might reduce such dependences, enabling "musical performance on demand" (p. 7)

2. Kaipainen, M., Ravaja, N., Tikka, P., Vuori, R., Pugliese, R., Rapino, M., & Takala, T. (2011). Enactive Systems and Enactive Media: Embodied Human-Machine Coupling beyond Interfaces. *Leonardo (Oxford)*, *44*(5), 433–438. https://doi.org/10.1162/LEON_a_00244

   a. The core concept, an enactive system, is constituted by dynamically coupled human and technological processes, that is, a dynamic mind-technology embodiment. An enactive system does not assume a standard interface with goal-targeted conscious interaction; rather the function of interfacing is driven by bodily involvement and spatial presence of the human agent without the assumption of conscious control of the system (p. 433)
   b. As a contrast to the standard conceptualization of human computer interaction, the enactive relationship conceives the underlying technology as continuous, ubiquitous and "intelligent" accompaniment to the human actor, or a direct extension of the user's perceptual and cognitive apparatus involved in participation in the system—living and acting with the system instead of just using it. (p. 433)
   c. This discussion also has to do with modeling creativity in general. Creativity can be seen as an enactive process where pattern synthesis and recognition work in tight reciprocal interaction. For example, hand motion and visual perception form an enactive loop in the activity of drawing. (p. 434)
   d. The challenges lie on the side of mapping of the measured psycho-physiological data to meaningful behavioral, semantic or emotional entities that can be applied to control enactive systems. (p. 435)
   e. For a single content element, for example a video clip, the values of the n dimensions constitute the element's ontocoordinates, specifying its position in the ontospace. They may describe subjective judgments, physiological responses that are related to emotional experience, technical properties (color, duration or time-stamps) or any other descriptive characteristics with the potential of meaning-mediation. (p. 436)

3. Zioga, P., Pollick, F., Ma, M., Chapman, P., & Stefanov, K. (2018). "Enheduanna—A Manifesto of Falling" Live Brain-Computer Cinema Performance: Performer and Audience Participation, Cognition and Emotional Engagement Using Multi-Brain BCI Interaction. *Frontiers in Neuroscience*, *12*, 191–191. https://doi.org/10.3389/fnins.2018.00191
   a. It enables for the first time the simultaneous real-time multi-brain interaction of more than two participants, including a performer and members of the audience, using a passive EEG-based BCI system in the context of a mixed-media performance. (s. intro)
   b. The methodology focuses on the oscillatory processes of the brain activity, which occur when large neural populations are not engaged with a specific task and synchronise following an oscillatory pattern. While, with the use of temporal band-pass filters, the 4–40 Hz frequencies are processed and sent to the MAX MSP Jitter software. (s. EEG Data Acquisition)

c. More specifically, the majority of the audience participants and the performer participant across the majority of the events were able to successfully identify whether their brain-activity was interacting with the live visuals or not, and highlighted as main factors the changing colours of the visuals, part 2 “You/We” of the performance, the explanatory vignettes and the dramaturgical use of lights. (s. summary)
d. As in the study by Jola et al. (2011), the currently discussed live brain-computer cinema performance makes a claim about live experiences and experiments outside the laboratory and contributes on new hypotheses about the effects of the length of time, but also the role of the directing strategy, dramaturgy and narrative structure on the audience's perception, cognitive state, and engagement. (s. The Live-Brain computer..)
e. Furthermore, the evidenced relationship between the participants' BCI interaction awareness, the elements of special impression on them and their cognitive state during scene 4 and 5 of part 2 “You/We” can be compared to findings from studies that investigate the effect of films on the spectators' brain activity, searching for similarities in their spatiotemporal responses (Hasson et al., 2008). For example, in a study by Dmochowski et al. (2012), the results revealed peak inter-subject correlation of neural activity during arousing moments of a film, which according to the authors “reflects attention- and emotion-modulated cortical processing.” (s. summary)

4. Cook, P. R. (1999). *Music, cognition, and computerized sound : an introduction to psychoacoustics* . MIT Press. https://mitpress.mit.edu/books/music-cognition-and-computerized-sound
    a. Sound moves through the air as a travelling wave with a velocity of 1128 feet (344 meters) per second. The wavelengths of sinusoidal sound waves of various frequencies and musical notes are shown in table 1.1. Middle C on the piano keyboard (traditionally located closest to the first letter of the brand name above the keyboard) is C4 and has a frequency of 261.6 hertz (Hz; cycles per second). Each doubling or halving of frequency is called an “octave,” and causes the index number to go up or down by 1. Thus the C above middle C is C5, and has a frequency of 523.2 Hz. (p. 2)
    b. What happens when a sound consists of two frequencies that aren’t widely separated, so that some hair cells are excited by both sinusoids? We hear beats. If the two frequencies are a few cycles apart, what we hear is like a single sine wave of rising and falling intensity. As we increase the frequency difference, we hear a vibrating, somewhat harsh sound. If we make the frequency difference large enough, we hear the two sinusoidal sounds clearly and separately. (p. 8)

c. Figure 3.1 demonstrates that internal representation can indeed be quite different from the physical stimulus on the retina. Two tables are depicted as if in different orientations in space, but stating that there are two tables already makes a cognitive interpretation. The figure actually consists only of a pattern of lines (or dots) on a two-dimensional surface. Still, humans tend to interpret the patterns of lines as three-dimensional objects, as two differently oriented tables with one larger than the other. (p. 22)
d. Another fundamental principle of perception is called perceptual completion. Sometimes we have incomplete information coming into our sensory systems. To infer what is going on, we have to do some amount of top-down processing in addition to the normal bottom-up processing. We must complete the information to determine the most probable explanation for what is occurring in the real world that is consistent with the information presented to our senses. (p. 30)
e. It is well accepted that the human motor control system is organized hierarchically. Hierarchic organization is a pervasive theme in cognitive, sensory, and motor biology. There are low-level systems responsible for carrying out lower-level tasks, and high-level systems responsible for supervising. Control loops are closed at both low levels and high levels in the nervous system. (p. 256)

5. Ehrlich, S. K., Agres, K. R., Guan, C., & Cheng, G. (2019). A closed-loop, music-based brain-computer interface for emotion mediation. *PloS One*, *14*(3), e0213516–e0213516. https://doi.org/10.1371/journal.pone.0213516
    a. In addition, the majority of neuroscientific research on affective responses has investigated brain processes involved in mere recognition of emotional content, while the brain processes involved in the induction and mediation of affective states by emotionally-evocative stimuli are not yet well understood, due in part to the difficulty of carefully controlling these types of studies. (s. intro)
    b. Any desired 'trajectory' through the valence-arousal-space is therefore possible, e.g. going continuously from happy over sad towards angry musical expressiveness (see exemplary trajectory in Fig 2B). This principle allows the integration of the algorithm into an online BCI architecture according to our initially proposed concept (Fig 1). (s. Materials and methods)
    c. After the experiment, participants were asked to describe their strategies verbally and in the form of a short written text. All participants reported strategies based on retrieval of emotional mental images or episodes from the past as well as events they look forward to in the future. In addition, for the 'modulation towards sad' task, participant P01 reported in the second session to have successfully used the strategy of self-inducing a "meditative state of mind", rather than retrieving memories. (s. Modulation performance results)

d. The results, however, indicated that ionian mode was rated with higher valence on average than lydian mode, suggesting that swapping these two modes in a future version of the automatic music generation system could result in a better match with perceptual valence ratings. (s. Discussion)
e. The preliminary results of the BCI study show that feedback modulations are possible via this music-based BCI system, and the brain activity analyses (especially the causality analysis) demonstrate how brain processes involved in the interaction can be isolated effectively. These findings are a proof-of-concept for our system, and more generally, provide a promising new approach to studying emotion regulation and related brain processes (s. Future work)

6. Benedikter, R. (2021). Can Machines Create Art?: A "Hot" Topic for the Future of Commodified Art Markets. Challenge (White Plains), 64(1), 75–86. https://doi.org/10.1080/05775132.2020.1842021
   a. However, this paradigm of (explicit or implicit) human-machine hierarchy, with the former as the subject and the latter as the instrument or object, has gradually changed both in essence and acceptance. It has given way to a more accentuated ambiguity. The relation between humans, machines and art is not so clear anymore. More importantly: their constantly evolving intersections have become permeable and fluid, both in theory and in practice. The resulting productive ambiguity is the sign of the age of "posthumanism" as connected with "hyper-digitization." (p. 76)
   b. Machines start to create traditional art. They compose music, paint paintings, write poems. AI is acquiring an always bigger role in the so-called "creative industries" mainly through refining and perfectioning processes of "repetition and difference." The model of the brain sciences still plays a prominent role here. (p. 76)
   c. The trend toward "transhumanism" started in the art sphere in the 1970s and 1980 already, i.e. way before it went mainstream. From artists such as Cyprus-Australian bodytransformation performer Stelarc who pioneered this trend to artists such as Neill Harbisson or Moon Ribas who also employ radical forms by transforming themselves into man-machine beings directly fusing their bodies with technology, "cyborgs art" representatives see this as the ultimate form of contemporary art: as self-transformation in the most literal sense. (p. 77)
   d. Yet, the issue of man-machine-art convergence in the literal bodily sense goes even deeper, as for example with the MIT project "Alter Ego," an AI-based technology application to interface with devices through "silent speech." As the MIT writes: "AlterEgo is a wearable system that allows a user to silently converse with a computing device without any voice or discernible movements—thereby enabling the user to communicate with devices, AI assistants, applications, or

other people in a silent, concealed, and seamless manner. A human user could transmit queries, simply by vocalizing internally (subtle internal movements) and receive aural output through bone conduction without obstructing the user's physical senses and without invading a user's privacy.

e. To some extent, the Pop art and Fluxus representatives should have been more cautious of what they wished for. The merger of the three axes: artist and art realized through advanced machines and thus, as at today, through the ultimate, most evolved form of techn^e is pushing the process to the threshold of intelligence, i.e. the capability of "profound" transformation. (p. 80)

7. Lefford, M. N., & Thompson, P. (2018). Naturalistic artistic decision-making and metacognition in the music studio. *Cognition, Technology & Work*, *20*(4), 543–554. https://doi.org/10.1007/s10111-018-0497-8
    a. As a result, participants can often feel that their unique talents and thus reputations (and thus careers) are determined by the amount of agency they have within the process and by the decisions that are taken during a production. All of these factors contribute to the intense working environment of the recording studio. (s. intro)
    b. The numerous and varying demands of this macrocognitive setting require contributors inside the recording studio to regulate their thinking using metacognitive skills. Metacognition involves evaluating one's own cognition (Flavell 1987) or thinking processes. During a studio production, individuals can use metacognition as a way of managing the multiple cognitive demands placed upon them during collaboration and the multiple forms of information available for decision-making. (s. Macrocognitive work and metacognition)
    c. With all that could go wrong, framing the producer's decision-making is the understanding that ultimately the producer is accountable for the completion and quality of a recording, and ensuring its commercial viability. The producer's problem detection is linked to (personal) risk. (s. The record producer)
    d. The producers' prior experiences are influences on decisions, including knowledge of recorded music history, specific genres and culture and art generally; awareness of existing social pressures at large, outside the production; and formal training (if any). (s. Work goals production decisions)
    e. Additionally, producers sometimes seek solutions that keep an artefact consistent with genre norms and at other times, novelty is valued. The results presented here suggest that metacognitive judgements are an integral part of deciding how, when and why solutions and decisions conform or innovate. (s. Discussion)

8. Johnson, D., Damian, D., & Tzanetakis, G. (2020). Evaluating the effectiveness of mixed reality music instrument learning with the theremin. *Virtual Reality : the Journal of the Virtual Reality Society*, *24*(2), 303–317. https://doi.org/10.1007/s10055-019-00388-8
    a. Current systems, however, typically display real-time visual cues and feedback on standard computer displays. This requires that a student transfer their focus from the music instrument to the computer display to view the information. Furthermore, there is an inherent transfer function that a student must perform to map the visual cues overlaying a graphical representation of the instrument to the physical instrument they are interacting with. These challenges increase demand on the student's cognitive processing abilities. (p. 304)
    b. Furthermore, some instruments that lack signifers of discrete notes, like the violin, require precise ear training for assessment of sound quality. Adding a visual layer to the music learning process makes this already difcult task more complex as students must process multimodal visual and auditory feedback simultaneously (p. 304)
    c. The authors found that real-world training and XR training resulted in equivalent performance on the steadiness test and both outperformed the group that received no training. This work provides strong evidence in support of positive learning transfer with XR training environments but in a contrived scenario. Research in surgical training provides some practical results on the use of XR training for psychomotor skills. (p. 305)
    d. In addition to creating standalone music instruments, XR can be used to augment traditional instruments with new capabilities. In the feld of new interfaces for musical expression (NIME), it is common to augment traditional instruments through the addition of sensors which allows for realtime processing of performance data (Machover and Chung 1989). These hyperinstruments enable the type of control and music generation provided by digital instruments that is typically not available to performers of acoustic instruments. (p. 306)
    e. Most of the participants that preferred Imm said that the visual cues helped guide them to the notes that they had a hard time fnding on their own. This increased their confdence that they were performing the correct notes. Furthermore, a number of these participants found that the Imm was more precise and was able to get them closer to the note than other environments. A few participants also mentioned that they liked the immersion of the VE which helped them to concentrate on the task. (p. 313)

9. Veloso, A. L. (2017). Composing music, developing dialogues: An enactive perspective on children's collaborative creativity. British Journal of Music Education, 34(3), 259–276. https://doi.org/10.1017/S0265051717000055

a. Hence, we may correspondingly state that mind and body form an inseparable continuum, which is simultaneously situated in a particular social context. Thus, the body does not get separated from the mind, and mind/body unity emerges through our experience in the world. Dealing with musical events therefore constitutes an experience that reaches beyond a fragmentary pursuit. Indeed, this amounts to a global experience involving mind, body and context. (p 260 - 261)
b. This lens also resonates with the views of 'situated learning' explored by Lave (1988) and Lave and Wenger (1991), which state that learning occurs in social interactions and is 'distributed – stretched over, not divided among – mind, activity and culturally organized settings' (1988, p. 1). In respect of education, Salomon acknowledges that 'the product of the intellectual partnership that results from the distribution of cognitions across individuals or between individuals and cultural artefacts is a joint one; it cannot be attributed solely to one or another partner' (1997, p. 112). (p 261)
c. In these moments, pupils seemed to embody the musical characteristics represented in the visual score, transforming pictures, signs and words, into music. According to the reviewed literature, this transformation is strongly mediated by children's bodies, by what they were actually experiencing and feeling at the time they were composing. (p 269)

10. van der Schyff, D., Schiavio, A., Walton, A., Velardo, V., & Chemero, A. (2018). Musical creativity and the embodied mind: Exploring the possibilities of 4E cognition and dynamical systems theory. Music & Science, 1, 205920431879231–. https://doi.org/10.1177/2059204318792319
    a. In contrast with information-processing approaches to mind, which tend to discuss cognitive processes in terms of internal computations and representations, the 4E perspective sees cognition as distributed across the entire body of a living system and its surrounding environment, and as continuous with the fundamental adaptive biological processes required for survival and flourishing. (p 2)
    b. Here, creativity tends to be explored in terms of categories such as "big-c"3 and "little-c"—where the former refers to eminent, domain- changing outputs, and the latter to creativity in everyday problem-solving situations and creative expressions, which include the forms of wishful, imaginative, or counterfactual thinking that occur in everyday life (Byrne, 2005). (p 3)
    c. Most centrally, this perspec- tive highlights the active role living creatures play in devel- oping patterns of (sensorimotor, neural, metabolic, interactive) activity that allow them to maintain a viable existence. Such sets of meaningful activities constitute what enactivists refer to as "sense-making," which is ulti- mately equated with "cognition" (see Thompson & Staple- ton, 2009). The enactive approach, therefore, replaces the more traditional input–output model of mind

with a more relational story—where an agent's ongoing history of inter- activity (structural coupling) with the environment becomes central to his or her mental life. (p 6)

d. Here the concept of a strange attractor can help us to understand such phenomena. These attractors are characterized by varying degrees of entropy and thus evolve over time within certain constraints. Under certain circumstances, however, they can also lead to bifurcations whereby new patterns of activity arise—that is, new attractors and attractor layouts. This is crucial for the survival of living systems, which must have the freedom to move, interact, and develop patterns of behavior in relatively stable con- ditions, but also be able to enact new forms of behavior in changing conditions. Because of this, we can think of a living agent's phase portrait as divided into a series of strange attractors that permit divergence in various direc- tions within local basins (Schuldberg, 1999). This affords the bio-cognitive flexibility required to enact new attrac- tor layouts through sustained adaptive–creative behavior (p 8)

11. Hutchins, E., & Klausen, T. (1996). Distributed cognition in an airline cockpit. Cognition and communication at work, 15-34. http://comphacker.org/pdfs/631/cockpit-cog.pdf
    a. It is the performance of that system, not the skills of any individual pilot, that determines whether you live or die. In order to understand the performance of the cockpit as a system we need, of course, to refer to the cognitive properties of the individual pilots, but we also need a new, larger, unit of cognitive analysis. This unit of analysis must permit us to describe and explain the cognitive properties of the cockpit system that is composed of the pilots and their informational environment. We call this unit of analysis a system of distributed cognition. (p 3)
    b. In some kinds of behavioral research, the mappings from observed events to the terms of a theory are taken to be obvious. In others these mappings are justified by "operational" definitions. In our case, however, the theoretical interpretation of some events may depend on the meanings that the participants themselves attach to those events. Because the setting is not familiar to most readers, the mappings from events to theory are unlikely to seem obvious. Because of the complexity of the setting, it cannot readily be made familiar. And since the sort of thing an event is in the theory may depend on meanings that the participants attach to the event, there are no simple operational definitions of many of our terms. Instead, we must rely on an ethnography of the setting to provide the interpretive bridge from the structure of the recordings of activity to the terms of the theory of distributed cognition. (p 4)
    c. The distribution of access to information is an important property of systems of distributed cognition. The properties of the larger system emerge from the interactions among the interpretations formed by the members of the crew and the

contents of those interpretations are determined in part by the access to information. (p 8)

12. Hollan, J., Hutchins, E., & Kirsh, D. (2000). Distributed cognition: toward a new foundation for human-computer interaction research. ACM Transactions on Computer-Human Interaction (TOCHI), 7(2), 174-196. https://doi.org/10.1145/353485.353487
    a. Minds are not passive representational engines, whose primary function is to create internal models of the external world. The relations between internal processes and external ones are far more complex, involving coordination at many different time scales between internal resources—memory, attention, executive function—and external resources—the objects, artifacts, and at-hand materials constantly surrounding us.
    b. The features that the pilot uses in the round-dial instrument have been inadvertently removed from the airspeed tapes of all of the current state-or-the-art cockpits (Airbus, McDonnell Douglas, Boe- ing, Fokker). This is not an inevitable consequence of using digital display technology in the cockpit; it is, rather, a consequence of design that is not based on solid cognitive ethnography. The very newest airline cockpit (that in the Boeing 737-700) contains a replication of the old electromechanical instrument, now rendered in a digital display. This is probably better than the digital airspeed tapes, but one wonders why the designers could not get the appropriate behavior in the tapes, and why, in order to get the right behavior, they had to resort to a literal copy of the old instrument. (p 180)
    c. The very notion of distributed cognition and the need for cognitive ethnog- raphy arose from the observation that the outcomes that mattered to the ship were not determined by the cognitive properties of any single naviga- tor, but instead were the product of the interactions of several navigators with each other and with a complex suite of tools. That work developed distributed cognition theory and extended the methods of cognitive ethnog- raphy. It examined the history of navigation practice in two very different cultural traditions to show how a single computational level of description could cover systems that had radically different representational assump- tions and implementational means. It examined the details of tool use, showing how the cognitive processes required to manipulate a tool are not the same as the computations performed by manipulating the tool. It documented the social organization of work and showed how learning happened both in individuals and at the organizational level. (p 183)

13. Oliver, W. D. (1997). The Singing Tree: a novel interactive musical experience (Doctoral dissertation, Massachusetts Institute of Technology). https://dspace.mit.edu/bitstream/handle/1721.1/43407/37658980-MIT.pdf?sequence=2
    a. The computer acts as a complex musical 'transformer', able to add delay, transposition, repetitions, and even play other solenoid- driven pianos. An interesting concept in Teitelbaum's approach, is that the pianist has full control of the computers functions; there is no ambiguity. The user tells the computer through a switch (not the piano) that he wants a particular transposition, and the computer responds by implementing that transposition [25]. (p 18)
    b. To the author, this work is merely an attempt to develop new and interesting musical experiences. Anyone can enjoy playing a musical instrument or singing without being a virtuoso. Musical prodigy or otherwise, people understand their own musical tastes, the music to which they enjoy listening, and, simply stated, what sounds good to them. If a person can design a musical experience which simply sounds good and is enjoyable to use, then it is the author's belief that the work is a success. (p 21)
14. Adams, A. T., Costa, J., Jung, M. F., & Choudhury, T. (2015). Mindless Computing: Designing Technologies to Subtly Influence Behavior. Proceedings of the ... ACM International Conference on Ubiquitous Computing . UbiComp (Conference), 2015, 719–730. https://doi.org/10.1145/2750858.2805843
    a. Therefore, we define a technology as a Mindless Computing technology if it is a mobile or ubiquitous, persuasive technology designed to subtly influence the behavior of the user without requiring their conscious awareness. (p 1)
    b. In many circumstances it is important to keep the focus on long-term behavior change, since the goal of the person is not something that can be achieved in one single activity. For instance, a user that uses a fitness tracking device with the goal of losing weight will reach his goal only if he starts to practice physical activities regularly. However, there are situations in which a single change of behavior can have major consequences for the individual. For instance, a driver that is persuaded to reduce the car speed could avoid an accident, and a person that adjusts their behavior during a business meeting could create a better first impression. In these situations a technology could provide feedback after the activity, but then it could be too late. These examples show how the timing of the feedback is an important aspect in behavior change technologies. (p 10)
    c. One important consideration to achieve parallel functionality is that the mindless technology should not require any ad-ditional effort while the user is performing an activity. One way of accomplishing that is by providing a cue to the user that is not very different from what the user would normally experience in his daily life. (p 17)

15. Jain, A., Horowitz, A. H., Schoeller, F., Leigh, S. W., Maes, P., & Sra, M. (2020). Designing Interactions Beyond Conscious Control: A New Model for Wearable Interfaces. Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies, 4(3), 1-23. https://dl.acm.org/doi/pdf/10.1145/3411829
    a. Thus, the five pathways of information processing are: (a) completely unaware or subliminal, (b) peripherally aware or preconscious, (c) aware, actively thinking and perceiving or conscious, (d) meta-aware or meta-cognitive, and (e) reflecting and projecting on body sensations or meta-somatic. We argue that while bodily sensations can form aware and conscious thought, many of the sensations remain outside the fovea of attention. We believe these sensations, often considered inaccessible, offer a host of design opportunities for research in influencing user action, thought, judgement, emotional awareness, or behaviour. And since these sensations do not become part of user's conscious experience they do not demand high attentional cost or rely on explicit motivation. (p 2)
    b. We can thus imagine engineering emotional reactions to an environment by creating physiological sensations using wearable electronics and allowing users to label them. For example, we can change user's perception of their heart rate using false heart rate feedback and expect an arousal [15] or fear-related cognitive label through interoception. Since the labelling is part of a reflective process, this phenomenon would be classified as a metaconscious or meta-aware process. (p 6)
    c. Users need to know which mental processes are being targeted and what effects they could expect to feel. Beyond informing users, designers can give the user complete control over their experience by building devices that can be customized, and operated by the user. Another option is to provide a transparent reflection interface for such technologies that, for example, enables users to keep track of changes made to their mind to help them "see" the influence through the non-conscious cognitive processes (p 17)

Secondary

1. Brown, Oliver. (2021). *Beyond the Creative Species: Making Machines That Make Art and Music* . MIT Media Press, https://mitpress.mit.edu/books/beyond-creative-species.

2. Raisamo, R., Rakkolainen, I., Majaranta, P., Salminen, K., Rantala, J., & Farooq, A. (2019). Human augmentation: Past, present and future. International Journal of Human-Computer Studies, 131, 131–143. https://doi.org/10.1016/j.ijhcs.2019.05.008
    a. Today, a user can direct a system, for example, with speech, gestures, eye gaze, or even through human electrophysiological signals. The system can acquire data

through different sensors and provide the user with information through various modalities in real-time, including visual, auditory and haptic presentations. Increasingly, different input and output modalities are being combined within the same task, such as simultaneous auditory and haptic notification of interesting events within the surrounding environment (p. 132)

b. There are a few related terms closely connected to human augmentation. Human enhancement is a broad field covering several disciplines from electrical or mechanical to genetic engineering. Moore (2008), defines it as "any attempt to temporarily or permanently overcome the current limitations of the human body through natural or artificial means. It is the use of technological means to select or alter human characteristics and capacities, whether or not the alteration results in characteristics and capacities that lie beyond the existing human range." (p. 133)
c. Wearable interactive technology is an essential component in enabling human augmentation. It offers a seamless integration with the physical and digital world around us. It can empower the user with non-invasive and easy to use extensions to interact with smart objects and augmented information of the hybrid physical-virtual world of the future. Human augmentation will serve the user by providing essential, timely information for current tasks and filtering out unnecessary information. (p. 133)
d. Augmented senses can also enable sensory substitution or sensory prosthesis, in which information from one sense can be mediated through a different sense (see examples of sensory substitution: Kristjánsson et al., 2016; Wright et al., 2015). This could be done by comparing haptic and audio modalities in order to aid movement and navigation in low-vision environments (Kerdegari et al., 2016). A tactile helmet can be used to mediate information in addition to vision and hearing to improve control (Bertram et al., 2013). More importantly, in extreme environments such as in space, deep in the ocean or buildings that are on fire, the ability of sensors to work in harsh conditions is essential (Alfadhel et al., 2016). (p. 134)
e. When designing augmentation technology for restoring capabilities, user experience and social acceptability should be considered carefully: they affect people's willingness to utilize the technology. The augmentation should genuinely feel like a part of the user's natural abilities and not like technical tools. (p. 137)

3. Kao, J. (2021). Another Perspective: Music Education in the Age of Innovation. *Music Educators Journal*, *107*(3), 63–69. https://doi.org/10.1177/0027432121994079
    a. We live in an era of digital music streaming, online experiences, and intelligent instruments that also shape new patterns of music creation and consumption. And the pandemic of 2020–2021, despite all its challenges, has been a powerful spur to innovation. Virtual performance, new collaborative technologies such as

JackTrip,2 online music instruction, new kinds of software, and novel business models have all made their appearance during this period. In short, we live in a time in which the urgent need and the opportunity to innovate music teaching and to support young musicians have never been greater. (s. Age of innovation)

b. This is an era in which to be employable means to have the improvisational ability to quickly learn new skills—or, better yet, have the skills to create your own job. It is an era that favors the innovator and the entrepreneur. Individuals are empowered as never before with new technology-based capabilities to learn, collaborate, publish, and influence. The implications for careers in music are clear. (s. Age of innovation)

c. Most of us in senior positions grew up in an era of analog media and verbal literacy in which writing essays, penmanship, and manipulating words were considered to be core skills. These days, many students have a new concept of literacy. Some even actively avoid the effort of learning to write in cursive, preferring instead to work on keyboards. This is an era in which new artificial intelligence capabilities can enable a student to write a perfectly composed ten-page paper instantaneously when a topic is typed into a search bar.16 Perhaps it is "search and curation" rather than composition that should be seen as the new literacy. And in the context of music education, one wonders whether notation is becoming the equivalent of cursive while new graphical user interfaces enable new approaches to musical learning and performance. (s. From Symbols to Experiences)

d. Music education today faces an innovator's dilemma. It cannot keep simply improving the existing model in an environment in which economics, talent preferences, and pedagogical methods are shifting dramatically. As formal education and learning continue to diverge under the influence of disruptive technology, music education institutions are challenged to figure out new strategies. (s. So what)

e. One obvious priority is to develop actionable blueprints for transformation, playbooks that are relevant to a broad array of music educators enabling them to embrace effectively the roles of innovator and education change agent. (s. So what)

4. Glinsky, A. (2000). *Theremin: Ether music and espionage*. Urbana: University of Illinois Press. https://www.press.uillinois.edu/books/catalog/98mgt7tm9780252072758.html
5. Engelbart, D. (1962). Augmenting Human Intellect: A Conceptual Framework. Stanford Research Institute. https://web.archive.org/web/20110504035147/http://www.dougengelbart.org/pubs/augment-3906.html

   a. The entire effect of an individual on the world stems essentially from what he can transmit to the world through his limited motor channels This in turn is based on information received from the outside world through limited sensory channels on information drives and needs generated within him and on his processing of that information His processing is of two kinds that which he is generally conscious of recognizing patterns, remembering, visualizing, abstracting, inducing etc and that involving the unconscious processing and mediating of received and selfgenerated information and the uncon scious mediating of conscious processing itself. (p 8)
   b. Increasing the effectiveness of the individuals use of his basic capabilities is problem in redesigning the changeable parts of sys tem The system is actively engaged in the continuous processes among others of developing comprehension within the individual and of solving problems both processes are subject to human motivation purpose and will To redesign the systems capability for performing these processes means redesigning all or part of the repertoire hierarchy (p 15)

6. Bonci, A., Fiori, S., Higashi, H., Tanaka, T., & Verdini, F. (2021). An Introductory Tutorial on Brain–Computer Interfaces and Their Applications. Electronics (Basel), 10(5), 560–. https://doi.org/10.3390/electronics10050560
   a. BCI systems have been challenges for implementing workable real-world systems [9]. Originally, the motivation for developing BCIs was to provide severely disabled individuals with a basic communication system. In recent years, advances in computing and biosensing technologies improved the outlook for BCI applications, making them promising not only as assistive technologies but also for mainstream applications [10]. (p 2)
   b. An early application of BCI was to neural prosthetic implants, which showed sev- eral potential uses for recording neuronal activity and stimulating the central nervous system as well as the peripheral nervous system. The key goal of many neuroprosthetics is operation through closed-loop BCI systems (the loop is from the measurement of brain activity, classification of data, feedback to the subject, and the effect of feedback on brain activity [92]), with a channel for relaying tactile information. To be efficient, such systems must be equipped with neural interfaces that work in a consistent manner for as long as possible. In addition, such neuroprosthetic systems must be able to adapt the recording to changes in neuronal populations and to tolerate physical real-life environmental fac- tors [93]. (p 9)
   c. The frequent use of EEG for BCI applications is due to several factors, namely, it can work in most environments; it is simple and convenient to use in practice because scalp-recorded EEG equipment is lightweight, inexpensive, and easy to apply (it affords the most practical noninvasive access to brain activity); and it is

characterized by a very high temporal resolution (about some milliseconds) that makes it attractive to be used in real time [216,217]. The main disadvantages of EEG, on the other hand, are the poor spatial resolution (few centimeters) and the damping of the signal due to bone and skin tissue that produces a very weak scalp-recorded EEG [218,219]. The reduced amplitude of the signal makes it susceptible to so-called artifacts, caused by other electrical activities (i.e., muscles electromyographic activity or electro-oculographic activity caused by eye movements, external electromagnetic sources such as power lines and electrical equipmen,t or movements of the cables). To reduce the artifacts effects and to improve the signal-to- noise ratio, most EEG electrodes require a conductive solution to be applied before usage. (p 23)