Augmented Cognition for Music Play & Interaction

Abstract

The term "augment" in regards to cognition is a loosely defined concept under HCI referring to non-invasive apparatuses and equipment that modify a cognitive experience. In general, music along with many art forms are rapidly digitizing and significant changes are happening in regards to how these forms are created, consumed and learned. Unlike the advent of .jpgs and .mp3s, this form of experience digitization is crossing the boundary of the internet, the physical, and the mind itself. This prompts an augmented cognition framework for creators and learners to harness the latest developments in bridging the mind and computers as the future of music unfolds. Musicians will have to make use of computers more abstractly than they have already delved in terms of music production and electronic instruments, opting for more interconnection with their sound making mediums and more importantly live audiences.

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1 Introduction

Music's extended domain is changing rapidly with the marketization of digital platforms hitting their stride and forcing music makers, especially in live performance hot zones of cities, to adapt rapidly inside an online environment. Consequently the digital domain has taken the initiative in its dominance over musicians livelihoods for which they depend on income and outreach. In the face of restricted shows, closing venues, and mental health cancellations musicians are facing significant immobility (Kao 2021) despite being given access to the far reaches of the internet. Meanwhile streaming services are increasing their market dominance and advertising, although user and consumer oriented services like Bandcamp have provided Friday's where they give 100% of sales to musicians[1]. Large streaming services like Spotify who are broadening their monopolization through their research laboratories are increasingly becoming threatening entities, especially with the sharp tools of their data collection being fed into machine learning.

Music education is also changing, although it may seem not of much interest, the way music is learned is how it is cultivated and propagated. With learning becoming more remote, prospective musicians are learning on screens. Our current interfaces being phone or computer displays are a different learning process taxing cognitive resources (Johnson et al. 2020) taking away from the instrument experience. Consequently instruments that take certain ear and technique training like the violin or in an extreme case the theremin are in need of a better method as the direct response of a teacher with a trained ear is much less likely to be present. This can be made up for with mixed reality experiences that correlate to useful and necessary feedback for a learner. An interesting double edge to this is that these augmented learning experiences might become so good that those who use them will have a clear cut advantage over

[1] https://daily.bandcamp.com/features/bandcamp-covid-19-fundraiser

those who do not. They might as well pick up the technique of the computer assisting them which might be a welcomed or dismissed bias.

Another level of augmentation will be the new live experiences (Zioga et al. 2018) for the music consumer. This is a very experimental area as new interfaces are developed, but as humans begin to reject crude screens for more fluid means of interacting with technology music experiences will be no exception. Augmentation will be the ideal, as VR does not convey the in person worth of attending any musical experience. Concerts might begin to offer ultra sensory experiences, for instance there was a silent disco where people wore headphones instead of speakers. What other interfaces might be offered?

Music production will also be changing. Two parallel paths run: that corporations with access to large data models will begin to experiment using artificial intelligence to develop their main artist investments either partially or scarily fully, and that the regular music studio or independent producer will make use of augmented technology to improve their work as well as the former path mentioned. Those in the music studio are under heavy pressures (Lefford 2018) and would benefit from augmented technology to assist their workflows.

In every art form, augmentation will have a central place as we seek to broaden our media experiences during a time where the internet is flushed with too much content dampening our response to any individual experience. Augmentation will provide the scalable, non-invasive and interactive format for art to be connected with.

2 Traditional Cognitive Augmentation

Augmentation in it's eldest form was conceived by (Englebart 1962) which referred to increasing a person's abilities and intelligence when approaching complex problems through some form of technological interface. Two years later one of the common day results set in motion from the ideas within that project was the computer mouse which has taken over the world. Englebart was a visionary in understanding that within the context of power that computers offer "The entire effect of an individual on the world stems essentially from what he can transmit to the world through his limited motor channels." The opposite of information garnering is also limited. To overcome crude interfaces, augmentation is the favourable field. However, regardless of interface style the goal is to somehow modify the cognitive experience. The field is not well defined yet (Raisamo et al. 2019) but there are enough articles to form a cohesive definition of it's goal.

Within the music domain the augmentation classification might run all the way back to the turn of the century, especially at the dawn of the radio tube. The theremin, originally the thermenvox or etherphone (Glinsky 2000), designed by the well known Leon Theremin sent soon to be propagandized waves over music technology throughout the Soviet Union, even bringing Theremin and his theremin all the way to a small showcase performance with Lenin. Of course the top brass devised all sorts of ways to use electromagnetic waves to strengthen the Bolsheviks grasp on the country while Theremin had grand tours of classical performances all over eastern Europe. Nevertheless, the instrument itself was an accidental result of Theremin designing a device to detect gas densities which has an auditory oscillator component hooked up to headphones for measurements. He noticed that as his hand moved closer to the antenna which was intended to detect gas particles, he could wave out crude renditions from his cellist past. After adding another antenna which controls the volume as slides can be disturbing, originally it was a button but maintaining the illusion of two waving hands is clearly the right way, thus the etherphone was born. After advancements in amplification and other analog music technologies the theremin of today is not far from its inception. This might be the earliest example of what fits augmented music technology, but more on that and the instrument itself in later sections.

Technologies like Augmented Reality(AR) and Virtual Reality(VR) are big advancements both overlapped by what will be categorized as augmented cognition systems. Traditionally brought up is Milgram's virtual reality scale, which can be extended to include AR and VR (Raisamo et al. 2019). What is categorized as augmented has another level of depth because it can include ubiquitous computing systems(cite weiser), and can cross the boundary between all three styles which detaches from the classic reality vs virtual. In augmented technology virtual and reality are seamless domains, whether it obviously separates both distinctively or not in tune with the needs of the user. Ubiquitous computing serves as duct tape considering that these systems will likely need several independent computers all acting together.

Augmented cognition is a blending of embodied cognition developments and virtual reality technology. Embodiment describes the processing structures of human computer interaction in which augmentation is grounded and how augmented systems will need to adapt to their human user's extended consciousness. (van der Schyff et al. 2018) describes 4E cognition being embodied, embedded, enactive and extended. In regard to augmented devices they are a part of "cognition as distributed ... and as continuous with the fundamental adaptive biological processes required for survival and flourishing." Higher order systems have to incorporate these structural ideas to be successful in usability.

Musical performances tend to interact with the audience on a pseudo personal basis, but in the future technological interaction will become more prevalent. The performance experience can be augmented in any number of ways, for example silent discos[2]. Purely VR experiences take away the in person liveliness. Ultimately the focus here is physical interactivity beyond the

[2] https://www.nytimes.com/2015/06/18/style/silent-discos-let-you-dance-to-your-own-beat.html

individual experience, as augmented systems should be designed to include those around the user whether they are too using the systems. As a subset of the broad human computer interaction field, this style of system described here has to break out of the virtual reality spectrum through embodiment considerations.

3 Music Cognition Augmentation

Augmented cognition is a budding style of cognitive framework, generally speculative definitions on the field describe it as enhancing the cognitive capabilities through some medium. On the computational end of that medium (Kaipainen et al. 2011) describes it as an "enactive relationship conceives the underlying technology as continuous, ubiquitous and “intelligent” accompaniment to the human actor", (Cinel et al. 2019) describes it as "embracing a wide definition of human cognitive augmentation that considers augmentation any improvement over the functionality already available in an individual", and (Raisamo et al. 2019) has a definition where "Augmented cognition is achieved by detecting human cognitive state ... , and adapting the computer's response to match the current and predictive needs of the user." Although there is no particular universal acceptance, it is clear the term is gaining traction.

Another idea classically by Hutchins and reiterated by (Raisamo et al. 2019) is that on the cognitive end of augmentation is "how the cognitive processes required to manipulate a tool are not the same as the computations performed by manipulating the tool" (Hollan, Hutchins et al. 2000). Raisomo et al. says that the view of a computer within this system ultimately boils down to a tool. As a tool the computer in as an augmentation device is essential in facilitating the tool process by which "We must complete the information to determine ... what is occurring in the real world that is consistent with the information presented to our senses." (Cook 1999). Distributed cognition (Hutchins et al. 1996) also plays a significant role in the processes of tool manipulation as information may be distributed and accessed across several different systems, and being an extension of the human cognitive apparatus whereas the computational end is a human led execution of intent.

Music directly has a fruitful domain for augmented systems. There is space for using an extensive cognition system to utilize technology intelligence or extend the breadth of a music interaction. By utilizing intelligence it is that any augmented technology might provide some knowledge to the use of how to play their instrument on the fly. For extending the breadth of a music interaction it may be that this system provides an extensive way to interact with instruments that are not so traditional and may have less bounds to the instrument. The importance of this metric is that it expands the possible novelty of music to include a large breadth of possibilities machine and human integration can produce, while traditional record producing and performance methods will be too accessible and a saturated domain.

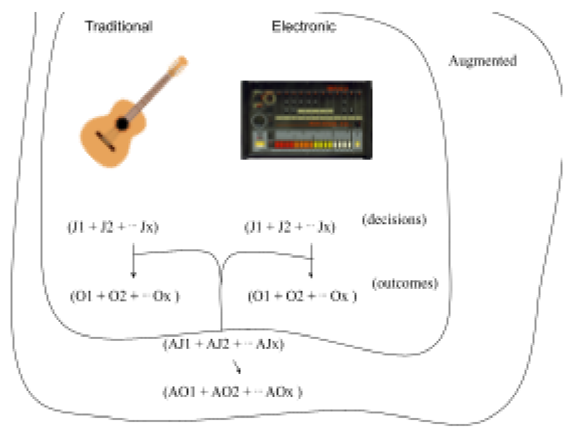

Figure 1

This sets up that musicians will have to innovate on their cognitive abilities utilizing computers. In an augmented context the computer is defined as a tool and for music is a tool to expand the area of possible musical ends (van der Schyff et al. 2018), (Lefford 2018). One of the main driving factors is that music education is rapidly advancing towards more or complete virtual environments. (Johnson et al. 2020) proves that, for at least the theremin which takes a very technical ear, mixed reality settings are as good as a real teacher. As (Johnson et al. 2020) does make a good remark on the detrimental processing needs that a graphic interface uses, "one wonders whether notation is becoming the equivalent of cursive while new graphical user interfaces enable new approaches" (Kao 2021). The detrimental processing is likely a cause of the graphical interfaces being crude, which is what an augmented system attempts to perfect. The justification might be found in (Veloso 2017)'s study where it was found that the children participating will attempt to transform any sign into music fitting prior embodiment literature, thus it is only a matter of facilitating the body's intent through a purer augmented system.

In the wake of these circumstances live music is going to be rapidly changing in the vacuum of the pandemic, especially as the demand for new experiences goes up in the overflowing area of digital music where anyone can publish anything globally. If more brain computer interfaces (BCIs) become commonplace, which (Zioga et al. 2018) proves audience interactivity is possible, then it must be the case that other sensory devices will be developed and the inevitable of live musical or arts performance integration can happen. (Chakraborty et al. 2021) finds that robotic musicianship will also contribute to stranger conditions for live performance experiences. Theremin was sent all over Europe for his invention (Glinsky 2000), so the same will likely be possible with augmented technology performances being an attractive option over internet performances and traditional ones.

The implications of this technology is that it will be in some wearable or embedded form. While it still remains in For augmentation it might be a ubiquitous system throughout the audience, or on the user. Whether or not these technologies will stimulate the cognitive system directly or externally is still up to debate in neuroscience. For every neurosensor there is usually a tradeoff in resolution, quality of data, method of implanting, etc. It is preferable that augmented systems are removable at any time. There is also an ethical concern of how any external influence upon human cognition is shifting their cognitive habits, and that there might be a method (Adams et al. 2015) to track how much damage is done. For the cognition system to be extended some kind of sensory feedback will likely be needed.

The ability of these interactive systems will have profound effects for the music education sector. It may almost seem like cheating in poker with X-ray glasses, but if it is the inevitable then it might be adopted as the norm. It might be necessary for the next generation of rockstars to make use of interactive performances and extensive cognition systems to display their music, while it could become a skill to utilize such extended systems. More on this later.

4 Sensory Extensions

The practical use cases involve extending our senses. Augmented senses are extended or enhanced senses (Raisamo et al. 2019) by parsing available information and feeding it to the human sensory system through an augmentation device. These devices can be ubiquitous in regards to information gathering inside a distributed cognition view, or direct interfaces. (Cinel et al. 2019) reiterates the importance of knowledge represented within "by cognitive enhancement we mean the improvement of the processes of acquiring/generating knowledge and understanding the world around us." Humans cognitive capabilities are limited, and augmented systems are simply experiments in expanding those limits.

BCIs are going to be a part of augmented technology. Interfaces will inevitably be needed to influence the senses brain or nervous system. (Cinel et al. 2019) describes, and provides a table for, the many different versions of neuroscience technology for influencing the brain. There is always some "unique trade-off in terms of spatial resolution, temporal resolution, invasiveness, portability" that is still holding back the public distribution of brain applications. In an augmented framework these types of interfaces will become necessary. Whether they are worn externally or invade to stimulate the nervous system directly is up to design, however this differentiates and overlaps prosthetics that the device is producing some altered state of cognition. Standard prosthetics might respond to surface nervous outputs[3] but augmented cognition implements feedback outside of the typical capability of the nervous system.

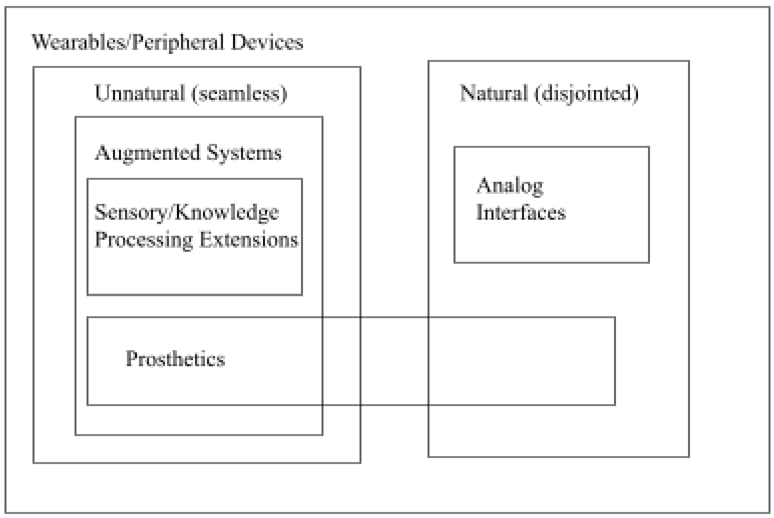

Figure 2

In figure 1 the difference for an augmented system between other types of bodily interfaces is displayed. An analog interface might be an external tool such as a phone or computer, while an augmented system is seamlessly integrated to the body's cognitive system becoming a part of perception-action couplings.

External devices indicating 'biosignals' are also a part of augmented senses. An example would be (Howell et al. 2016)'s t-shirts which display certain lights based on skin conductance values. While the metric is ambiguous it did provide results indicating that it led to open ended questions over why someone's lights might change during a conversation, which are immediately more noticeable than other body language. Through music (Ehrlich et al. 2019) explores emotion mediation and closed loops of self emotion valence changes through influencing music generation based upon EEG signals. These two examples can be seen as augmented methods for

[3] https://www.youtube.com/watch?v=kaFiwC1xh2Y

ambiguous emotional promptings that have some resemblance to the interactions which initiated them.

5 Performance Integration

Augmented systems ultimately will end up in live performances. To contrast fully virtual spaces or fully machine musicians will not be discussed in depth. The goal of augmented technology is to promote the meshing of computers through ubiquitous or centralized systems in the real world to provide experiences that cannot be created otherwise. This is to give more seamless and less crude transfers between technology and non technology interactions, where virtual reality is a novelty space detached from the real world. While that novelty value may be of benefit, as metaverse ads show up around the immediate date of this paper, there are ethical concerns for the purely virtual world. Augmentation is ultimately grounded in the real world and cannot be fully detached from it.

In the previous section the qualities of how augmented technology is interfaced with were explored, for performances interfaces can facilitate an interesting dialogue between performer and audience. This dynamic is characterized by (Zioga et al. 2018) where in their study, using displayed colors during a performance derived from an EEG system, the audience did in fact identify that their thoughts were influencing the visuals of the performance. Ideas of mindless computing (Adams et al. 2015) contrast this by saying that the user should be unaware of their state of mind being influenced by the technology. The tshirt emotional indicators previously discussed is an example walking the line between these mediums, where the users are unaware and aware they are being affected.

This new dialogue is a very interactive way to approach live performances through interconnection. Figure 2 shows the network of how performances can transfer another level of information to their participants. This can change the depth and possible novelty by an extreme amount given the amount of virtual art generated by computers, while these might change certain perceptions or other sensory functions. It will also allow the audience to feedback and interact with the performance in unseen ways as discussed before.

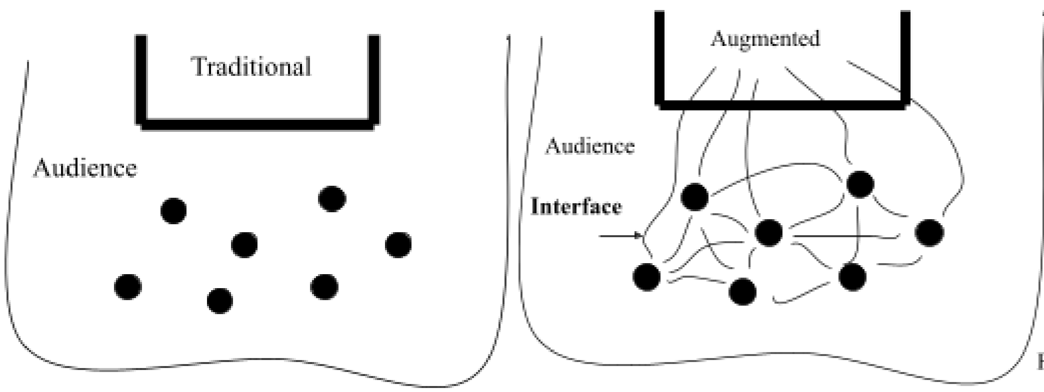

Figure 3

6 Music Education Augmentation

In a wilderness inhabited by musically augmented cognition systems, educators and musicians alike will find themselves at a loss on how to adapt. This area is most ripe for computers to change faster than tradition can cope with. (Raisamo et al. 2019) refers to the change as "In the future, computers will adapt to humans." A cascade of music propagation changes happen within the whole music world when the way music is learned changes. Computer-assisted music instrument tutoring (CAMIT) systems (Johnson et al. 2020) are becoming more prevalent and more advanced by the day. CAMIT systems are beginning to explore utilizing AR and VR technologies and already are promising.

Most importantly music education will change, as many people are being educated through a screen which takes away from the intimate instrument experience and access to quality music teachers centralizes through the internet. At the moment digital music education is becoming more and more prevalent. People who cannot afford in person music teaching are most likely using their devices to access current music knowledge. (Johnson et al. 2020) reminds that using a screen while learning music can be detrimental by taking the cognitive process away from the instrument experience. (Johnson et al. 2020) found in their study of using mixed reality to teach the theremin that real world training and mixed reality training produced equivalent results while beating the group with none. Therefore augmented cognitive systems can provide equivalent results against traditional real world training. While some mixed reality equipment can be a mild cost, it can be used to educate musicians in an intimate manner mirroring real teachers. (Kao 2021) states "As formal education and learning continue to diverge under the influence of disruptive technology, music education institutions are challenged to figure out new strategies."

Consequently especially within pure augmented systems there might be an ethical concern over people who use them to fake, granted fake is the incorrect word to use, their knowledge. Consider that a pianist might overlay their keyboard with some visual augmentation to what they should play, well they could be no better than a synthesizer really. But, what about an AI composing for an improvisation and transferring it's data to the user in real time? Although the human may stutter upon technical complexity, it might be seamless up to a degree. This fundamentally changes the way music education has to be viewed. What may have been a static process can become a fully dynamic on the go time saver. While taken out of context an argument for this is "Anyone can enjoy playing a musical instrument or singing without being a virtuoso." (Oliver 1997), although that intent now can be viewed as a musical instrument being simple enough to enjoy or augmented enough to enjoy. (Kao 2021) makes the amazing observation "Perhaps it is “search and curation” rather than composition that should be seen as the new literacy." Though it is a flawed one, because machines have not truly grasped the nuances of composition in all cases (Brown 2021) yet AI is gaining ground in the creative industries (Benedikter 2021).

Corporations with access to laboratories to develop this enhanced creative technology have the advantage in the market. For the music market this has complicated meaning. On one hand those with less musical skill and access to quality teachers will have much more ability. The drawback is that music can become saturated with decent musicians and too many musicians takes away the status of musicianship which takes a long time to train. Considering that technology assists have the possibility of taking over too much of the cognitive workload as presented here, musicians looking for a living might find themselves in an adapt or die market. While the individual musician can adopt traditional methods for a natural musical learning method, the demand for individual music teachers will probably drop significantly. Another problem is that the music studio market is at risk for creative AI to produce much more unique items than it can, although it is still up to debate at whether AI can generate quality music.

7 Broader Mixed Media & Art Augmentation

In all art forms the constraints and tools which an artifact is developed with influence it's final unique tone (Lefford 2018). Augmented systems is a method of facilitating computers as seamless tools which no doubt will have effects upon the resulting product. As a style it will take on mediating the boundary between digital art and physical art. Music is not the only possible art domain for it's applications.

Augmentation is inherently a mixed media form. No matter what domain augmentation is in, it generally is about compensating or enhancing a cognitive function. It might make up for auditory failures with visuals or vice versa. When compensating there is likely going to be tradeoffs as the brain does when functions fail or are damaged, when enhancing it might make use of a tradeoff or directly contribute to helping a specific cognitive function.

Centralizing the hardware will be an essential task. Likely through some general BCI this will be achieved, but it may be the case that augmented hardware may be developed in a ubiquitous nature, although decentralized equipment makes access and failures problematic. In the augmented cognition sense, phones are successful because it is a one piece access interface over having many peripheral devices. The most ideal scenario is one brain interface which has the ability to augment cognitive functions related to conscious perception while avoiding interfering with the brain's unconscious functions.

8 Conclusion

Augmented cognition will have profound effects for personal computing systems in the future. They provide a framework for how our cognitive systems might be extended through the use of ubiquitous or interface systems. Art is the most fruitful domain as demand for novelty will increase in an AI saturated environment and market. The expansion of possible outcomes of any art process is a valuable aspect when novelty is ultimately prized against a slew of globally connected art output through the internet. The use of augmented reality knowledge will likely influence artists to come. While digital art is here to stay, the concept of reality assisted by computing power is soon to be made.

For the music domain, this has consequences from instruments to live performances. Like the waves electronic instruments and production equipment made in music, so too will computing. While at the moment it is very limited, the idea that concerts can be fully virtual is a negative proof that real life concerts will not begin to make use of personal computing devices as they move away from a small crude screen into a more superimposed and ubiquitous experience. This relies on the distribution of personal augmented devices.

Musicians and other art styles alike will have purists and transhumanists. While direct knowledge and skill transfer may be something of the far future, modifying an experience in real time to provide efficient use of an instrument can be a daunting idea. Although, there will be positives like a musician with a bad ear able to look at a keyboard and see colors which indicate tone rather than having to differentiate pitch. While it may not relate too heavily to these kinds of cognitive systems, the ethical concern lies with any good method of gaining musical knowledge facilitated through technology. What will happen to those who would rather opt out?

In the widely connected internet market the demand for novelty will demand more intimate musical experiences, and augmented cognitive systems will provide these experiences to integrate technology and traditional performance. Over fully virtual experiences, the real world can offer much more through digital means. Practical performances are aging in the era of computation and musicians will have to allow computers to adapt to their playing and performance.

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