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Algorithms, AI and music composition: When can musical creativity be considered pop?

1. Introduction

One of the most interesting features of humans is that they have managed to survive despite having a biological disadvantage compared to other animals. Although Homo sapiens could not swim like a fish or fly like a bird, nor were they particularly fast or equipped with claws or fangs, they managed to compensate for the biological shortcomings that prevented species-specific specialisation and to overcome their limitations. The explanation for this phenomenon, however, cannot be found in the development of a superior brain that the body obeys: the human mind can be considered "an emergent property of organism-environment interactivity, which involves biological, non-biological, cultural, social, technological, and historical dimensions" (van der Schyff et al. 2018, p.7) according to the 4E cognition approach, it should be considered as Embodied, Embedded, Enactive and Extended. In fact, the brain is inseparable from the body, with which it forms a single entity that forms a network between the nervous system and sensorimotor capacities from which cognition emerges (Embodied) (Gallagher 2011). This does not take place in an empty space, but in an environment that actively participates in and guides emerging cognitive processes (Embedded) (Gallagher 2005); the environment and organisms mutually determine each other by interacting and engaging in meaningful activities (Enactive) (Varela et al. 1991). Furthermore, by using tools and equipping themselves with technologies, humans are able to delegate some of their cognitive processes by externalising them onto material supports: when this happens, higher functions are freed up to rest on the delegated ones. In essence, the ability to make 'things' has allowed sapiens to be "animale sprovvisto ma non sprovveduto" (Parisi 2019, p. 24), *i.e.* an animal whose evolutionary success is due to its lack of specialisation has led it to externalise its capacities and to equip it with artefacts, but which in turn modify it (Malafouris 2013). We are not always aware of this, because when a technology we equip ourselves

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with works, we begin to lose awareness of it while using it, because it becomes semi-transparent (Ihde 2021, 1979), i.e. it no longer requires conscious thought while using it.

With all this in mind, music can be considered as a particular form of cognitive and affective extension, which refers to the possibility of creating a bond that can have different configurations: the musician with the instrument and with the listeners, the composer with the musician and with the potential audience, social groups, cultures and subcultures, etc… In musicology, however, music is not considered in its holistic dimension, but is divided into categories and genres with specific characteristics; the most obvious contrast is probably the dualism between classical music and pop music. Without wishing to deny the usefulness of the historically accepted divisions, the aim of this paper is to propose a new approach that pays attention to the element of continuity between musical genres, identifying it with the ability to extend musical creativity through different kinds of technologies.

The development of Artificial Intelligence (AI) and machine learning algorithms has raised several concerns about the permissibility of their use in the arts (Latikka et al. 2023) to the point that there would seem to engender the fear of artists could somehow be outclassed by generative AI if one admits the possibility of its creativity coupled with increased productivity (Hong and Curran 2019). In recent times, in fact, there is a proliferation of artistic products made with the help of AI or totally formulated through generative algorithms that, in the face of training that starts with an administration of data through which to constitute a dataset to be matched with the specific rules and constraints of the artistic discipline, are able to provide as output images, musical compositions etc… that users easily mistake for human creations (Elgammal et al. 2017). Investigations along these lines have been conducted mainly in the visual arts, but the tendency to co-constitute a new form of creativity by involving "non-human" devices actually concerns all the arts, including music. Also, as will be seen in section *3* and *4*, it is not even possible to temporally limit this practice to the nearest contemporary, as one can discern traces much farther back in time of musical compositions made with the help of particular technologies. Music in particular has some characteristics that cannot be quantified (such as expressiveness, but also timbre) and others that instead lend themselves easily to transposition into mathematical terms (e.g., duration and pitch of sounds, but also more generally the rules of harmonic concatenation). Current programs overcome the limitation of one-way input-output from the use of a new type of generative systems that mimic the circularity of human action through learning. This makes it possible to obtain output from patterns that are taught to the machine so that it returns a new product that nevertheless meets the predefined parameters. This feature is the basis of computational creativity applied to music in order to generate novel compositions ascribable to a particular genre or even to a particular composer: to do so, it is first necessary to determine the parameters to be taught to the machine, so a thorough knowledge is required not only of musical grammar and syntax in general, but of the specific characteristics of what one wants to replicate or – better – emulate.

A long tradition of studies in this regard has characterised this specific property of human beings in various ways, delving into the various forms through which this cognitive extension has always occurred through increasingly complex media, from writing to electricity (Clark and Chalmers 1998; Menary 2010; Noë 2004; Smith and Weintraub 2009), but often this very human capacity is so automated that we stop thinking critically about it. Section *2* briefly introduces the issue of musical creativity by describing the main theories concerning the classical versus pop dualism (*2.1*) and types of creativity (*2.2*). Sections *3* and *4* present examples of how, throughout history, humans have expanded their creative capacity by extending it to analogue media such as pen and paper (*3*) or electronic media such as computers (*4*).

2. From Classical to Pop and beyond: Musical creativity

Considering music as a complex medium through which human beings are able to extend themselves allows us to take a different, and in some ways counterintuitive, point of view: if music is a medium, this means that it is not the end point, but part of a process that does not end with the composition of a piece or its performance. For a long time, there have been – and still there are – debates about the classifications of music genres and sub-genres, sometimes using as parameters the greater or lesser formal complication and consequent greater or lesser commitment to listening, sometimes the mode of diffusion, or even the involvement of electrical, electronic and computer technologies. If we also consider the increasing use of AI at various levels of the musical experience (from composition to listening to diffusion), we arrive at a much more complex scenario, which, emancipating from reductionism and dualism, actually gives us back the real complexity of the phenomenon itself.

2.1. Classifying or (pre)judging?

The classification of musical genres is notoriously an unresolved issue that still continues to be debated by musicologists, starting with the age-old question of the hierarchical (aesthetic, formal, ontological) separation between classical and pop music. To give just a few examples – without claiming to be exhaustive – one thinks of Adorno (Adorno 1976; Horkheimer and Adorno 2002), who drastically contrasted classical music with pop music, considering the latter to be a mere product of the cultural industry, based on predefined and repetitive schemes that produce a standardised product devoid of authenticity. On the other hand, Frith (1996, 1998) pointed to its diversity and complexity, and Middleton (2013) highlighted the multiple meanings and interpretations that can arise among different listeners. Benjamin (1935) observed that the possibility of reproducing music through recording had destroyed its aura as a unique and unrepeatable work of art, turning it into a mass product. Bourdieu (2010) links this distinction to issues of power and social prestige, linking pop music to the social habitus of its users. For Rosen, "the difference between art music and popular music is really largely a matter of how much close attention is required or demanded for appreciation" (Rose 2012, p.166), while for Noë, pop music is something that "looks like music, but it isn't" (Noë 2015, p. 165) and its purpose is reversed in comparison to classical music, as "the artist is not a vehicle for the music; instead, the music is a vehicle for the artist" (*Ibidem* p.171).

What emerges is a rather heterogeneous picture, from which positions emerge that characterise the classical and pop music spheres in different ways, highlighting the peculiarities of their respective manifestations, but hardly (or not at all) dwelling on the creative process from which they emerge. Therefore, taking a step back and analysing the creative process rather than the result of creation may allow us to look at the phenomenon from a different point of view.

2.2. Human creativity and computational creativity

The notion of computational creativity (sometimes superimposed on the concept of metacreation) has arisen in recent times to denote the ability of some artificial systems to generate creative artefacts of various kinds comparable to those generated by humans. Margaret Boden identifies three forms of creativity (Margaret Boden 2010; 2004):

– Combinatorial creativity (C-creativity), which consists of the ability to switch and combine ideas from different domains with each other

– Exploratory creativity (E-creativity), Which consists of metaphorically traversing new paths of an already known conceptual space

– Transformational creativity (T-creativity), which consists of modifying the creative space, subverting its starting rules and structures

A chess master combining well-known moves in an innovative sequence to win a game could be an example of C-creativity, a scientist's discovery of a new species of animal in an extreme environment, such as the depths of the ocean could be an example of E-creativity, an example of T-creativity could be found in the invention of the smartphone.

If we think of musical creativity, it is possible to identify all three types of creativity, separately or in various combinations. The conception of a song is an example of C-creativity, in which elements such as notes, solfege and harmony are combined; however, when this composition arises during a jam session (in which musicians explore the musical space) we can perceive that, in addition to C-creativity, there is also E-creativity. We also notice the presence of E-creativity when the composition goes so far as to create a new musical genre, but also during performances (in the former case the musician explores new musical directions, while in the latter she/he explores the *umwelt* emerging from his interaction with the audience in order to enter into a profound relationship with it). When a new musical genre is conceived, customs and characteristics are created that define its specificity, thus subverting structures with respect to previous genres: this is the case of T-creativity.

Various examples of musical fact could be cited that fit into one or more of the categories outlined by Boden, but it is important to note that musical creativity emerges from the complex interplay of all three types of creativity highlighted. Moreover, all three types of creativity can also be attributed to machines (Boden 2016); this is probably a crucial point that arouses the greatest reluctance, as it is precisely the idea of losing the human primacy of creative specificity in the artistic field that makes one perceive a certain level of risk related to the sense of precariousness and the possibility of being replaceable (Latikka et al. 2023). In light of the aforementioned considerations, it is beneficial to direct attention to a specific contingency that encompasses all the elements previously discussed: the use of algorithms and AI to compose music.

Through the optimisation of mathematical functions, it has been possible to achieve incredible results in the field of AI, emulating human-like behaviour (Russell and Norvig 2016) through various systems and mathematical models used to set the task for the machine in terms of problem solving mixed with a certain amount of more or less controlled randomness. Processes based on Markovian chains are often used, i.e. random processes whereby in a sequence of data, the transition probability is shown that allows one to pass from one state to another: the next state depends only on the previous one. In the case of music, a state may be represented by a note or its duration within a given musical structure, so the machine may be asked to calculate the probability with which one note follows another note. It is also possible to combine several Markovian chains with each other (e.g. value, pitch and duration of notes); an example of the use of Markovian chains can be found in the composition of the Illiac Suite (discussed below, at *4.1.*). Over the years, there has been a shift from rigid algorithms to probabilistic models that allow an element of randomness and variability to be introduced into music generation. Using the manipulation of text strings to represent music and pattern matching to identify and modify specific musical elements, for example, specific programming languages such as SNOBOL (*4.1*) have been created.

A fundamental turning point in the field of computational creativity has been provided by Artificial Neural Networks, a computational model inspired by the biological neural network (or at least a simplified version of it) and organised in layers of neurons called nodes: each node can receive input from outside the network or from other nodes (as happens in biological neural networks) from the processing of which a single output is produced, which can in turn constitute the result or return to the network becoming input for the other nodes. Machine Learning techniques, including Deep Learning, are applied to Neural Networks; the innovation of this approach consists above all in the possibility of constituting systems that are not simply programmed but are trained. The network, therefore, does not receive the rules when writing the software, but processes them by defining them itself, from a training dataset. The weights of the neural network change as the training process proceeds, making it impossible to know what rules the network arrives at and on the basis of which it delivers outputs.

In the wake of these innovations, it has been possible to use artificial neural networks to learn the rules of musical composition (MUSACT), to introduce probabilistic models to generate harmonic progressions (HARMONET) and to make use of Bayesian networks to generate melodies (MELONET) (*4.1*). Another interesting innovation was the constraint programming technique, based on the definition of constraints on variables: instead of specifying step by step how a problem is to be solved, one describes the relationships and restrictions that must be satisfied by the solution. This technique was used, for example, in the realisation of the computer-assisted music composition system CHORAL (*4.2*).

A variant of the described approach is that of the Generative Adversarial Network (GAN), which consists of training two neural networks, one of which has the task of generating a new output, while the other has the task of assessing whether this is real or generated by the network; so the two networks can improve on each other until an output almost indistinguishable from the actual data is achieved (Carnovalini and Rodà 2020). This type of system was used in the third and fourth movements of Beethoven's Symphony X (*4.3*).

3. Diachronic perspective of computational creativity

The ability to equip oneself with tools and technologies capable of externalizing cognitive processes is so inherent in human beings that it also trespasses into the realm of the arts, raising an issue that has been becoming increasingly consistent in recent years, namely the human-machine relationship in the creative process. All forms of art are considered as something that expresses the innermost part of the human soul, the non-manifest and irrational part that is otherwise inexpressible, which makes use of peculiar forms of communication (such as, precisely, visual artefacts, musical compositions etc…) to make accessible to the user precisely that inexpressible humanity that characterizes us; therefore, the meddling of automated processes within a creative process is raising perplexities about the nature of the artistic product generated by the "collaboration" between human and artificial artist. Here we will deal specifically with the relationship between flesh-and-blood artists and AI in the generation of musical language, however, the reflections brought forward in this area may also concern other forms and modes of artistic communication. The purpose of these considerations is not to arrive at an unambiguous solution or *super partes* judgment regarding the use of AI in the arts, but to delineate as clearly as possible the phenomenon, which is not exclusive to the pop music genre; rather, it has a long history in classical music too. Furthermore, it is not a recent phenomenon, having been present in the contemporary era for some time.

In order to be able to better frame the subject of the present investigation, it is useful to take a step back to gain an overall view. One of the most problematic elements has to do with the perception that the denaturalization of creativity due to the employment of elements considered extraneous to human nature has materialized only in recent years, precisely with – and because of – the development of modern algorithms employed in the generation of musical language (discussed below). In fact, upon closer inspection, the employment of elements seemingly external to human cognition is nothing new at all.

3.1. Computational creativity in 20th century

An example of computational creativity predating the use of AI in musical composition can be seen in the early 20th century in the compositions of John Cage, who made use of various compositional strategies and techniques aimed precisely at indeterminism, expunging choice from the creative process (Popoff 2011). His most famous compositional mode was the *aleatory music*, the creation of which was based on the determination of a system of numerical combinations from which to derive the pitch the duration and the type of note. In 1951 Cage made Music of Changes for solo piano, for the elaboration of which the author started by constructing a square of 64x64 cells each containing a value (corresponding to the type of sound, duration and volume) and, relying on random generation operated by a computer, proceeded horizontally to create the melody and vertically to create the polyphony (Akhoundi et al. 2019).

A few years earlier, the artist Marcel Duchamp had also tried his hand at composing two pieces based on causal operations, including Erratum Musical for three voices, which took the concept of random music to the extreme: the three melodic lines were obtained by the extraction from a hat of as many notes as there are syllables contained in four definitions of the word *imprimer*.

In the two proposed cases, the composer's intent was precisely to achieve an artistic product that was not directly dependent on the author's choices, ousting him from his central role; this has obvious references to Eastern philosophies on the one hand, and to the Dadaist avant-garde on the other. The underlying principle is that music is not imitation of nature, but nature itself; therefore, the artist has a subordinate role, in which she/he no longer has the task of functionally organizing sounds with a specific purpose, but only making himself a spokesman for nature itself.

3.2. Computational creativity before 20th century

The examples described so far concern avant-garde art movements; it could therefore be argued that the use of computational creativity in these cases depends precisely on the overly innovative and deliberately provocative character proper to the art movement itself. However, it is possible to go even further back in time to trace the same metacreative approach expressed in different ways.

In 1757 Johann Philipp Kirnberger published *Der allezeitfertige Menuetten und Polonoisenkompon*, a manual in which a method was described through which minuets could be composed without the need to make conscious choices, leaving ample room for chance. The method, referred to as *Musikalisches Würfelspiel*, was based on the use of two tables in which numbers from 1 to 96 were randomly distributed, corresponding to as many previously worked out but separate bars of music (*Table 1*); each table presented the bar number in the abscissa and the result of the dice roll in the ordinate, so that at the intersection of the abscissa and ordinate is the number of the beat to be used. Throwing the dice would determine the order in which the beats were to succeed each other, thus generating a musical sequence that could result in a polonaise, a minuet or a trio; in the first case it was a composition that consisted of a 6-bars period followed by another 8-bars period, while the other two consisted of 8-bars periods. The possible combinations resulted in 11^{14} polonaises and 11^{32} minuets or trios that followed a predetermined harmonic pattern, but could manifest melodies so different from each other that “the entire population of eighteenth-century Europe could have spent a lifetime playing Kirnberger’s dice game without exhausting all the possibilities” (Ratner 1970, p. 344). The combination possibilities arising from the game of musical dice had been investigated by the mathematician Gumpertz at the express request of Kirnberger himself, who delighted in the many compositional possibilities of his invention (Hedges 1978).

	1	2	3	4	5	6
I	23	63	79	13	43	32
II	77	54	75	57	7	47
III	62	2	42	64	86	84
IV	70	53	5	74	31	20
V	29	41	50	11	18	22
VI	83	37	69	3	89	49
VII	59	71	52	67	87	56
VIII	36	90	8	73	58	48

	1	2	3	4	5	6
I	33	55	4	95	38	44
II	60	46	12	78	93	76
III	21	88	94	80	15	34
IV	14	39	9	30	92	19
V	45	65	25	1	28	17
VI	68	6	35	51	61	10
VII	26	91	66	82	72	27
VIII	40	81	24	16	85	96

Table 1: Transcription of Kimberger’s tables. The Roman numerals correspond to the bars, the Arabic numerals indicate the pitch value. From their intersection we derive the number corresponding to the bar (listed with the others on a separate sheet) to be copied into the score.

This compositional approach remained in vogue for a long time, and Kirnberger’s method was followed by various formulations that, although they differed in content and modality, remained somewhat similar in terms of the basic intention, namely the use of the so-called *Ars combinatoria* to generate pleasing music. The mathematical concept of *Ars combinatoria* is based on the combination of a given number of elements that are re-arranged (permuted) and re-combined in various ways through the addition or substitution of selected elements, which is what happens in the application of the musical dice method, in which notes are matched to numbers. A similar approach can also be seen in other contributions by treatise writers and composers, among which one can mention, by way of example, Carl Philippe Emanuel Bach’s *Einfall einen doppelten Contrapunkt in der Octave von sechs Tacten zu machen, ohne die Regeln davon zu wissen*, in which a method similar to that pioneered by Kirnberger is described, but this time the focus is on the combination of individual notes within the measure rather than the combination of whole measures already formed.

A further example can be attributed to Wolfgang Amadeus Mozart, whose autograph sheet on the *recto* and *verso* of which describes a system for creating a short melody by assimilating the letters of the alphabet (24 letters, excluding *j* and *x*) to as many beats: the game thus consisted in applying a compositional method similar to those described above, replacing the dice with a specific word or person's name. The manuscript also gives us the opportunity to observe how Mozart corrected his aim, foreseeing, after an initial attempt in which he had experienced the problem of double letters within the name, a double option of beats to avoid repetitions (Zaslaw 2005). Another attempt today attributed to Mozart in which he devised a compositional method based on a system of combinatorial calculation is the manuscript K561f., containing an accurate *Musikalisches Würfelspiel* based on two tables containing 176 bars intended for the composition of a minuet and a trio: here too, the choice of the bar was determined by the throw of dice indicating the point of intersection between abscissas and ordinates (*Table 2*). Rolling the dice 16 times results in the 16 bars that form the minuet. The table for the minuet, in fact, has 11 rows (the dice range from 2 to 12) by 16 columns. The probabilities with the use of the two dice are different for the 11 possible outcomes: unlike the roll of a single die, with 2 dice, 7 has the highest probability because it is obtained with 6 different combinations. Followed by 6 and 8 with 5, 5 and 9 with 4, 4 and 10 with 3, 3 and 11 with 2, while 2 and 12 are obtained with only one.

	I	II	III	IV	V	VI	VII	VIII
2	96	22	141	41	105	122	11	30
3	32	6	128	63	146	46	134	81
4	69	95	158	13	153	55	110	24
5	40	17	113	85	161	2	159	100
6	148	74	163	45	80	97	36	107
7	104	157	27	167	154	68	118	91
8	152	60	171	53	99	133	21	127
9	119	84	114	50	140	86	169	94
10	98	142	42	156	75	129	62	123
11	3	87	165	61	135	47	147	33
12	54	130	10	103	28	37	106	5

	I	II	III	IV	V	VI	VII	VIII
2	70	121	26	9	112	49	109	14
3	117	39	126	56	174	18	116	83
4	66	139	15	132	73	58	145	79
5	90	176	7	34	67	160	52	170
6	25	143	64	125	76	136	1	93
7	138	71	150	29	101	162	23	151
8	16	155	57	175	43	168	89	172
9	120	88	48	166	51	115	72	111
10	65	77	19	82	137	38	149	8
11	10	4	31	164	144	59	173	78
12	35	20	108	92	12	124	44	131

Table 2: Transcription of the tables of the Musikalisches Würfelspiel. The Roman numerals correspond to the bars (written on separate sheets), the Arabic numerals indicate the result of the pitch, from their intersection we derive the number corresponding to the beat to be copied into the score.

What has been outlined so far poses a question that will also recur in the next section: can we still consider the outcomes of these musical games as classical music? The answer will probably be yes: we would hardly consider a Mozart composition pop.

Attempts to devise new methods of composing using various forms of computation (of which those mentioned above are only two examples, but the musical literature and treatises provide us with many more) are particularly significant here, as it is possible to detect in such an approach to musical creativity a use of structures comparable to the algorithms used by AI. What can be deduced, then, is that the curiosity towards a different way of composing and the tendency to make use of methods that seem to delegate part of the compositional process to something apparently external to human cognition were not born with generative AI at all, but constitute a possible attitude that exists and has always existed regardless of the type of support used to delegate part of the mental processes.

4. New kinds of musical games

As highlighted so far, the idea of composing by making use of elements outside the composer's mind has prompted the search for increasingly disparate tools to which to delegate parts of the creative process (dice, elements extracted from a hat etc…) among which it is possible to include one that is much more complex than the others: AI. Attempts to include AI in the compositional process are numerous (For a review: Civit et al. 2022, Wang et al. 2023) and have very different characteristics depending on the mathematical models used (Monte Carlo algorithm, Markov chains, heuristic approaches etc…), the type of data used (rules of classical harmony, counterpoint, harmonic qualities, recursive patterns of a given compositional style etc…).

The following is a possible analysis of other kinds of musical games with related examples, dividing the various cases according to the level of use of elements commonly associated with human creativity. What is special about these new musical games, however, is that they externalise certain cognitive processes onto technological media. Although such an involvement of technologies would automatically lead one to think of a fully pop outcome, the proposed examples show that this is not necessarily true.

4.1. Composing on the basis of musical rules and harmonic qualities

In 1958 Lejaren Hiller and Lorenz Isaacson produced the first musical composition with an AI-written score, entitled Illiac Suite. The Suite was the result of four experiments performed using the ILLIAC computer, which resulted in a score for string quartet (Hiller and Isaacson 1959). The mathematical model used was the Monte Carlo Algorithm (a randomized algorithm using random number generation) to which was coupled the Information Theory developed by Claude Shannon (1948): through the Monte Carlo algorithm, the information content was generated, while the application of Information theory enabled its selection and subsequent density reduction. Next, the algorithm was programmed for the purpose of generating data to be correlated with musical parameters, through the steps of initialization, generation and verification. During the first phase, the computer had to be instructed on how to make valid choices based on rules provided by the experimenters and tracing the dictates of classical harmony theories (drawing mainly from Joseph Fux's treatise *Gradus ad Parnassum*). Once the rules were defined, they proceeded with the generation of data placed in relation to the previously provided musical parameters and finally with the verification (and thus validation or not) of the generated output. At the end of the three stages, a score in alphanumeric code was obtained, which was then decoded and transposed into traditional notation, resulting in a Suite in four movements for string quartet.

Other important contributions have been made by a type of neural network-based programs that can learn compositional rules based on the constraints of harmony and harmonic functions. Rothgeb (1968) made a program called SNOBOL, which, through learning the rules of harmony, was able to compose from an unfigured bass[1]. In this case, the goal was not to generate a composition, but simply to test the computational soundness of the main theories of eighteenth-century bass harmonization. Applying the rules of harmony to neural networks, Bharucha (1993) devised MUSACT, which is able to infer the expectations of musical users in relation to harmonic qualities by generating graded harmonic successions. HARMONET and MELONET (Hörnel 1997) also functioned similarly, but in addition these add the possibility of making compositions that adhere to specific stylistic canons, thus finding themselves projected into the category described below.

4.2. Composing on the basis of stylistic patterns

With a slightly different conceptual approach, Ebcioglu (1993) elaborated the CHORAL system, which incorporated previous studies on

[1] These are typical exercises at Italian Conservatories, in which there is the construction of three melodic lines (constituting the harmonic triad) from a bass, following precise rules that allow or disallow certain movements of the voices considering their relationship to each other.

solving harmonic problems, but finalized them to the realization of compositions that not only satisfied the compositional rules of traditional harmony, but were able to trace specific compositional patterns befitting the canons of a specific period of music history, the structures of a specific form, and the stylistic features of a specific composer. In the case of CHORAL, the compositional patterns are those attributable to the Chorales of Johan Sebastian Bach. Following this new approach, David Cope (1987; 1992) devised EMI, which was able to devise compositions that replicated the style of Mozart, Palestrina, Albinoni, Brahms, Debussy, Bach, Rachmaninoff, Chopin, Stravinsky, and Bartok. The particularity of these new compositional methods is precisely the introduction of an emulative attitude, which calls into question no longer just universally shared rules, but patterns derived from the choices and sensibilities of flesh-and-blood (though no longer living) humans. Patterns, in fact, are derived by comparing at least two pieces by the composer to be emulated in order to derive recursive elements and highlight the various kinds of constraints that the composer is wont to put in place. Another recent successful attempt to generate music with characteristics specifically assimilable to an author's compositional style was made by Luo et al, who used WaveNet to create high-quality imitated Bach music. WaveNet is a deeply generative autoregressive model that generates one audio sample at a time, conditioned on the previous samples; it uses an architecture based on dilated convolutional neural networks. This novelty problematizes the question of creativity, as it shifts the compositional process to a plane that seems to involve more of a human dimension that is embodied precisely in the use of patterns modulated on specific individuals.

4.3. Composing matching original manuscripts and AI

The third typology of compositional approach using AI involves the use of AI to create compositions that not only exhibit characteristics compatible with the compositional style of a specific author, but actually constitute the continuation of a work that was suddenly interrupted before it was completed. With the pioneering work started by Berry Cooper (Cooper 1985, 2003) and continued by the heterogeneous team consisting of Gotham et al. (Gotham et al. 2022), AI was used to realize Ludwig van Beethoven's Tenth Symphony. Cooper's work had started from the analysis of fragmentary sketches attributed to Beethoven, containing about 250 bars that the scholar thought it possible to interpret as the primitive core of the Symphony. In his correspondence with Moscheles, in a letter dated March 18, 1827 (eight days before his death), Beethoven wrote that he had already prepared the first sketches of the new Symphony (Albrecht 1996); furthermore, Cooper analysed the testimonies of Anton Schindler and the amateur violinist Karl Holz, who claimed to have heard this new Symphony performed on the piano by Beethoven and gave a vague description of it, on the basis of which the scholar compared the sketches with these statements and found them to be compatible with the very first movement of the Symphony. Once he had identified the core of starting bars, Cooper interacted with the machine and was able to work out an Andante in E♭ major and an Allegro in C minor, providing as patterns to follow the characteristic elements of Beethoven's compositional style. The outcome of this work was the creation of a score (published by Universal Edition) that had characteristics resembling Beethoven's compositional style, and which in 1988 was performed by the Royal Philharmonic Society, London, to whom Beethoven himself had offered the new symphony in 1827.

In 2019, Matthias Röder, director of the Karajan Institute in Salzburg, contacted Ahmed Elgammal, professor and director of the Art and AI Lab at Rutgers University, to propose that he resume the work begun by Cooper by extending the collaboration to Mark Gotham, an expert in computational music, and Robert Levin, a musicologist at Harvard University and an excellent pianist, who had previously finished a series of incomplete works by Mozart and Bach. The synergistic cooperation of this heterogeneous research team operated under more hostile conditions than Cooper, because unlike him they did not have as much material written directly by the composer (they had only 40 bars available), so they had to set patterns for learning according to compositional style, predicting the choices the composer might make and teaching the machine to create from a simple motivic core (Gotham et al. 2022). At the end of the 18 months of work, the last two movements (Scherzo, Allegro-Trio and Rondo) were made, which, after a first performance in piano reduction and a second for string quartet that passed a kind of Turing test (proving impossible for listeners to distinguish between man-made and machine-made parts), were performed by the Bonn Orchestra on the occasion of the 250th anniversary of Beethoven's death. In this case, in addition to having a peculiar characterization of human-computer interaction in the present, it is possible to say that we cross the boundaries of time and space, trying to put in place a correlation that looks back in time and simultaneously into the future.

5. Stepping back to get a clearer vision

The strict separation of pop and classical music is somewhat reminiscent of reductionist approach; the increasing use of AI and communicative media has "democratised" the creation and enjoyment of music at all levels. The analysis carried out so far has shown that the tendency to delegate to external media, equipped with more or less sophisticated technologies, is a diachronically common feature of all kinds of musical composition. Following the advent of AI in music composition, there was a perception that the humanisation of artistic creation was at risk of being eroded. This led to the identification of a kind of bionic creativity, which could be characterised as a synthesis of human and artificial elements at varying degrees. This kind of creativity would suggest a field of application properly definable as pop, moving away from the notion of the ideal composer, who is assumed to create a work of art using only their innate creative genius. However, upon examining various stages of musical history, it becomes evident that a compositional approach that makes use of algorithms has consistently been present in classical music as well.

This suggests that this tendency is neither pop nor classical, but rather indicative of a creative capacity that can be found in any musical field. While algorithms are not the only compositional method, this particular mode can be understood as an indication that there is a common thread within what has been separated into distinct categories. Upon closer examination, it becomes evident that no creativity is possible without the use of technology, regardless of its level of complexity (Zylinska 2023): The act of creating art is inherently a form of mediation, whereby a process of exchange occurs within a specific context and is subsequently represented through a medium. In the case of a musical composition, the art is not solely confined to the mind of the composer or the ears of the listener. Rather, it exists within an extended space that connects the entities that co-constitute the very meaning of the artefact. As a consequence of the capacity of humans to extend themselves through the technologies they produce, art, and in this case music, can have an embodied and visceral outcome precisely because it facilitates communication between minds that extend and meet in an environment that puts them in communication. Therefore, the composer's mind does not remain confined to the limits of the skull and does not cease to exist with the cessation of life. Instead, it extends beyond the boundaries of time and space, becoming reified in the sensations evoked by his music in the listener, regardless of their physical location and temporal context.

A final consideration must be made regarding the ability to discern intentionality and creativity in a technology. If we succumb to the fallacy of anthropomorphization, we risk overlooking the human element at the core. If AI succeeds in replicating ostensibly pseudo-human behaviours, it may be that we are merely observing an image reflected in a mirror. The inclination to anthropomorphise AI results in the perception of a threat to human creativity. This is due to the assumption that AI is an equal entity, intentionally competing with human creativity. Conversely, another tendency may be to ascribe to it a level of creativity comparable to that of humans. Consequently, if on the one hand there is a tendency to anthropomorphise AI by characterising it as a sentient entity and contrasting it with an alleged natural intelligence, then on the other hand there is also a tendency to consider such creativity as superior or inferior to that ascribable to natural intelligence.

6. Conclusion

The present work aimed to highlight a common substrate to all genres of music in the human tendency to make use of technologies (commensurate with different historical contexts) to delegate some of the cognitive processes related to creativity, without compromising either the processes or the creativity itself. Following the encroachment of the AI into musical composition, there has been a perception that there is a potential loss of the humanisation of artistic creation, and thus the identification of a kind of bionic creativity with varying levels of human and artificial. Although this type of creativity would make one think of a field of application properly definable as pop, however, tracing back some phases in the history of music, it becomes evident that a compositional attitude that makes use of more or less technological tools (from pen and paper to algorithms) has always been present even in the properly classical music scenario. The utilisation of musical games and algorithms enables the exploration of the potentialities of C-Creativity (the combination of disparate musical elements in accordance with compositional and harmonic principles) as defined by Boden. Additionally, it facilitates the investigation of E-Creativity and T-Creativity (the generation of novel compositions that transcend conventional stylistic boundaries, eschewing mere imitation). Algorithms are certainly not the only way to compose, but this particular mode can be understood as a sign that there is a common thread within what has been separated into distinct categories.

If musical games and algorithms imply a common substratum of musical creativity, and this is true for both classical and pop music, it follows that both belong to the same creative foundation, rather than to two distinct creative processes. This is not to deny *tout court* the distinction between pop and classical music, which appears advantageous for analytical studies in the respective fields. Rather, the intention is to highlight the inconsistency of a hierarchisation, suggesting a 4E conception of music away from dualisms. Through music, human beings extend themselves cognitively and emotionally, interacting and communicating with each other regardless of temporal and spatial boundaries. This faculty may manifest itself in different ways, which we classify as classical or pop, but the underlying attitude and the creative act remain identical in all cases.

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Algorithms, AI and music composition: When can musical creativity be considered pop?

Traditional musicology has long considered pop music and classical music as two distinct entities, or even as two ontologically opposed categories, each with specific aesthetic, structural and compositional characteristics. The recent development of Artificial Intelligence (AI), in parallel with the use of learning algorithms, has prompted some reflection on the type of creativity associated with their use. In particular, the use of AI in the compositional phase is generally associated with popular music rather than classical music. However, if a convergence could be observed in this very compositional approach, it would mean that both musical domains, albeit with different results, originate from the same creative act: this could lead to a less rigid boundary between them. In fact, if one considers that musical creativity (both classical and pop) is the result of human beings' ability to extend themselves beyond the boundaries of the skin through the technologies they produce, the presumed hierarchical superiority or inferiority of one of the two musical domains over the other becomes insubstantial. The aim, therefore, is to question the hierarchical dichotomy between popular and classical music, starting with a critical examination of compositional approaches and proceeding to the analysis of illustrative cases identified on a diachronic level. These cases show that the human tendency to delegate certain cognitive processes to more or less complex technologies is not a recent phenomenon, even in the field of music. A reassessment of the phenomenon is therefore proposed that goes beyond its external outcomes.

Keywords: Music composition; Creativity; Artificial Intelligence; Computational creativity; 4E Music cognition.

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La musicologia tradizionale ha a lungo considerato la musica pop e la musica classica come due entità distinte, o addirittura come due categorie ontologicamente opposte, ciascuna con specifiche caratteristiche estetiche, strutturali e compositive. Il recente sviluppo dell'Intelligenza Artificiale (IA), parallelamente all'utilizzo di algoritmi di apprendimento, ha suscitato una riflessione sul tipo di creatività associata al loro utilizzo. In particolare, l'uso dell'IA in fase compositiva è generalmente associato alla musica popolare piuttosto che alla musica classica. Tuttavia, se si potesse osservare una convergenza proprio in questo approccio compositivo, significherebbe che entrambi i domini musicali, seppur con risultati diversi, hanno origine dallo stesso atto creativo: ciò potrebbe portare a un confine meno rigido tra di essi. Infatti, se si considera che la creatività musicale (sia classica che pop) è il risultato della capacità dell'uomo di estendersi oltre i confini della pelle attraverso le tecnologie che produce, la presunta superiorità o inferiorità gerarchica di uno dei due domini musicali rispetto all'altro diventa inconsistente. L'obiettivo è quindi quello di mettere in discussione la dicotomia gerarchica tra musica popolare e classica, partendo da un esame critico degli approcci compositivi e procedendo all'analisi di casi esemplificativi individuati a livello diacronico. Questi casi mostrano che la tendenza umana a delegare determinati processi cognitivi a tecnologie più o meno complesse non è un fenomeno recente, anche in campo musicale. Si propone quindi una rivalutazione del fenomeno che vada oltre i suoi esiti esterni.

Parole chiave: Composizione musicale; Creatività; Intelligenza artificiale; Creatività computazionale; Cognizione musicale 4E.