Human-centered algorithmic composition for well-being music

Clenio B. Gonçalves Junior[1,2], Vânia Paula de Almeida Neris[1]

[1]Department of Computing – Federal University of São Carlos (UFSCar)
São Carlos – SP – Brazil

[2]Federal Institute of Education, Science and Technology of São Paulo (IFSP)
São Roque – SP - Brazil

clenio@ifsp.edu.br, vania@dc.ufscar.br

Abstract. *The use of music to bring about health benefits is a well-established practice the outcomes of which have been confirmed by research in recent years. By leveraging this capability, the algorithmic composition aimed at producing specific effects on the listener has become a growing field for the automatic creation of well-being music. This work makes a contribution to this field, through a documentary investigative study that puts forward a comprehensive set of human-centered features that should be included in the algorithmic composition of music for well-being. The results are based on a systematic review of 60 papers published in the last few years. The set is divided into categories as a means of assisting their use by the teams involved.*

1. Introduction

There has been significant growth in the notion that musical experience forms a part of a therapeutic process. Advances have been made with regard to employing psycho-physiological devices and understanding the sensory system of patients, through the use of a musical language [Gorelov 2017]. This language is used as a form of interaction in established environments that aims at stimulating natural biological components from sound structures. This is carried out by relying on previously obtained compositions to lead to particular emotional states [Brandes 2013]. Studies in this direction have brought about benefits in treating patients suffering from brain injury, depression, and strokes, among other illnesses [Bradt 2010]. Moreover, there is a large volume of literature that addresses the health benefits of music through a wide range of applications involving therapy, exercises, emotions, cognition, and well-being, among other areas [Sena 2016]. This has led to the creative exploration of key factors in current health indicators by involving innovative, non-invasive, and cost-effective measures [Hallam et al. 2011]. In this sense, compositional originality is a fundamental aspect when there is an intention of drawing the listener's attention. The ability to make innovative constructions in the various musical dimensions is an essential quality in any compositional process designed for therapeutic music, since there is a direct relationship between the sensations induced by a given action and the effects produced on the patient [Nye 2011]. Algorithmic Composition (AC) is a field of research devoted to the development of specialized algorithms in the creation of automatic music [Francis 2015]. By means of AC an increasing number of studies have explored its potential in the area of health research [Sinha 2008]. In the last few years, there have been numerous scientific investigations aimed at understanding how musical structures can be handled [Ariza 2009]. It has been found that using previously selected acoustic elements can be employed as a stimulant for sensations of well-being at a subconscious level [Ellis et al. 2010].

In line with these developments, human-centered (HC) features are a concept defined in this paper as attributes that help designers (humans or machines as in AC) to understand people, their concerns, and activities that should be taken into account while developing interactive technologies. These go beyond the immediate needs of the users, by providing a humanistic view of their interactive situation [Baumer 2017]. In musical composition, these attributes can be used both to have a special influence on the listener and to assess the effects of audition [Otchere 2014]. For example, Hargreaves (2006) examines components such as style and complexity in a composition suitable for the level of musical training of the user. Olsson (2007) highlights the demographic features of the listener, such as age and gender. Gunther (2001) is concerned with physical features such as body position, vibration, movement, and intensity. Landreth (1974) evaluates the physiological response to the musical effects produced, which are based on features such as heart rate, auricular discrimination, and galvanic skin resistance. Abeles (1994) describes the cultural background, in addition to social and situational features, which include the occasion of the performance. Thoma (2013) investigates psychological features to assess the effects of music on the human response to stress. He assessed the value of understanding musical preferences for anxiety control, reducing depression, and regulating emotions.

Although there has been a good deal of research into health-applied AC and this has led to an interest in systems development, there is a lack of a comprehensive summary or analysis of the body of related studies. To fill this gap, a documentary study was carried out, which involved a systematic review of works that were analyzed together with a selection of reference articles. The objective was to investigate works that are concerned with how the algorithmic musical composition can be applied to health, and include studies related to therapeutic activities, exercise, and well-being. The purpose of this was to determine which HC features have been used and could be included in other projects. The resulting set is divided into categories so that they can assist the teams involved. Information about the listeners' backgrounds was considered, such as their particular preferences, needs, and musical interests. Methodological components and programming techniques were investigated, and the relationship between musical structures and their effects on the listener was listed. A broad assessment of the development of this area in recent years was made by selecting studies published with peer review information in the last decade. In this way, we were able to provide an overview of the progress made in the field, and obtain a holistic view of AC for well-being music.

2. Methods

This work was conducted along the lines established by Abdalla (2015), through a systematic review, we have explored studies related to the algorithmic music composition applied to health. The work is based on 60 papers and involves carrying out an investigation aimed at understanding state-of-the-art of research. We sought to identify academic papers, such as articles in scientific journals, workshops, and conference proceedings. Initially, a search for secondary studies that addressed the same theme was conducted; no similar work was found that was similar to the one put forward here.

The main purpose of the work focuses on the investigation of human-centered attributes that are taken into account in the AC of health-oriented music. In accordance with the PICO strategy, we sought to understand, in relation to the population/patients, which characteristics linked to the listener have guided the compositional process. Given the direct influence that components such as style, rhythm and intensity can be applied to produce suggestions to the listener, we sought to investigate, with regard to intervention, computational methods used in the development of systems. Therefore, the present review was carried out according to the stages described as follows. First of all, the review raised 2 research questions. Considering PICO for motivation, our first question relies on People - **RQ1:** How have features linked to the listener and health guided the production of new technologies? And our second question relies on Intervention - **RQ2:** What approaches, techniques, and architectures are employed by the works of AC for wellbeing?

2.1 Identification of potentially relevant publications

The research has a transdisciplinary character, which makes it suitable for obtaining knowledge in areas such as health, music therapy, AC, knowledge representation, and HCI, so that elements that address these disciplines are combined to form an integrated approach. The investigation was carried out with the aid of digital databases while being supplemented with additional material from authors in the area, research groups, and annals of event planning, and finally, the Snowballing method was employed.

The databases of the publishers were used as research tools and included the following: ACM Digital Library, IEEE Xplorer, Springer Link, Cambridge Journals Online, and Computers and Applied Sciences. The indexing mechanisms used were Scopus, Google Scholar, Science Direct, Web of Science, and Academic Search Premier. An interactive search was carried out from a boolean string consisting of AND/OR terms cross-checked with the algorithmic composition, music, and health categories. Instantiations of the general string have been created to match the specific features of some of the search engines. Owing to the limitations of some of the search systems, the basic instantiation of terms has been separated into search form fields.

2.2 Definition of the scope of the study

We included original peer-reviewed papers addressed in publications over the last decade. As an exclusion criterion, we removed publications that (1) did not consist of full papers, (2) could be characterized as secondary or tertiary studies, (3) consisted of duplicate works from previous publications. The initial selection process comprised the following stages: identifying relevant studies, filtering to determine the concentration area, filtering by period, deletion of duplicate studies, and exclusion based on titles.

When searching the databases, additional studies were conducted that involved authors, research groups, and proceedings of specific events. These studies were incorporated into the initial set. The titles of the works were used as a form of subsequent screening. As shown in Figure 1, the titles regarded as relevant, led to the reading of the abstracts and keywords and after this, the screening was based on the full texts.

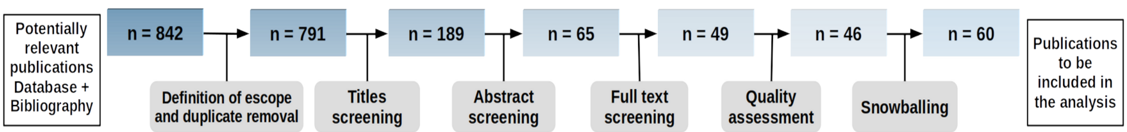

Figure 1. Applied procedure for the selection of articles (n = number of papers)

2.3 Quality Assessment

The quality assessment was carried out by following the guidelines, as these provided an understanding of the state-of-the-art research related to AC and took account of sound production-oriented healthcare. There was an evaluation, based on 3 reference articles [Pasquier et al. 2016, Anders 2017, Poulsen 2017], which was aimed at finding out to what extent the studies could assist the investigation with regard to beneficial approaches, limitations, understanding the scope of the study and methods used, as well as determining the effects of their application. The selection criteria were established by common agreement between the authors of this work and then applied by one of them.

The process of identifying potentially relevant publications, (as previously described) both through databases and institutional repositories of bibliographical references, resulted in a set of 46 studies.

2.4 Snowballing

Aiming to improve the body of knowledge for analysis, the snowballing approach was followed by the selection of keywords, as recommended by Wohlin (2014). The process consisted of 4 stages. Initially, 5 previously selected articles were used to form the database set. The forward and backward search processes were performed to produce a set of 13 articles. Two subsequent stages were carried out to produce a set of 6 articles. Finally, in the last stage, no article was found that met the technical specifications for inclusion, and the process was completed. Of the 19 articles included in the quality assessment, 5 articles were excluded. As a result, 14 articles were included for review. This led to a total of 60 studies.

3 Results

The 60 studies were analyzed with a view to ensuring that AC was focused on the health area. This was carried out in light of the fact that listeners derive health benefits from musical enjoyment. These benefits result from the links established between the created composition and this person. The analysis was conducted to determine how features associated with the listener influenced technological production. Additionally, we attempted to find out if there were any issues with regard to the architecture and implementation of the works.

3.1 Health-oriented music production

The articles were thoroughly reviewed and read in their entirety, after which the features were extracted. Subsequently, they were analyzed by two researchers and some precise categories emerged from this analysis. By providing an overview of the health targets of the works, Figure 2 shows that the total number of studies examined 15 targets for the use of music in health during the years evaluated. The X-axis indicates the years and the Y-axis indicates the health targets – in both cases, they correspond to the center of the bubbles. The coloring of the bubbles has no particular meaning and is only used to distinguish between the targets. The size of the bubbles indicates the number of studies for a specific target carried out in a particular year. For example, in 2012 the studies about both Sleep Disorder and Psycho/Emotion, had the same number of occurrences. As can be seen, studies devoted to the psychological area were classified into subtypes (Cognition, Pain perception, Emotion, Affect, and Mood). This is because they are distinguished in the reviewed studies and the way this is carried out will be made clear in the following sections. A number of features highlight the psychological direction. For example, Target 14 (Emotion) includes a large number of papers, while Target 3 (Affect) shows a constant pattern with regard to publications. These applications, music has been applied in the research field called Affective Algorithmic Composition (AAC). The results were obtained from medical applications such as attention deficit disorder, locked-in syndrome, autism,, and Asperger syndrome [Williams et al. 2015].

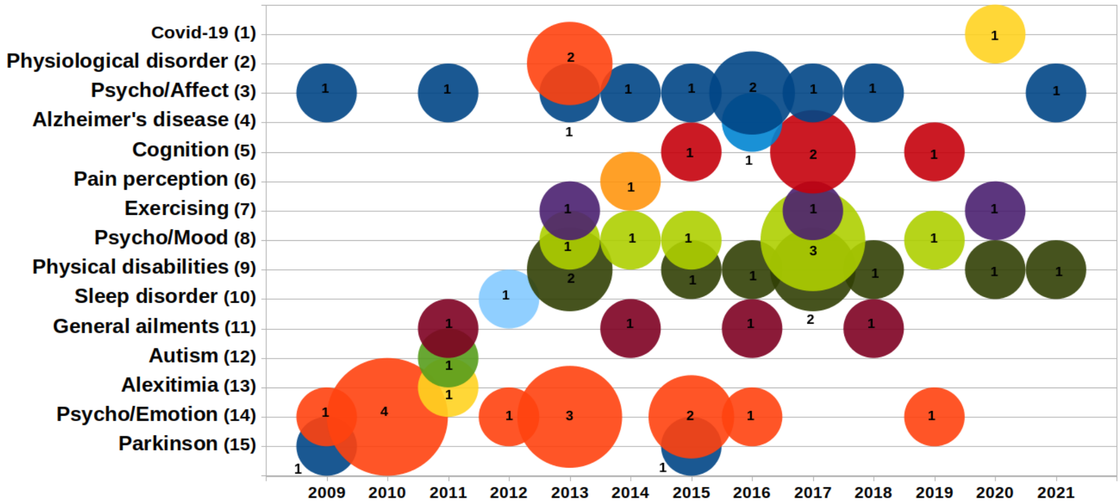

Figure 2. Use of music in health by the reviewed papers

3.2 Human-centered features

During the review process, 6 categories of features associated with humans were identified. These characteristics emerged from the survey made from the works analyzed and are composed of: Musical, Interactional, Psychological, Physiological, Physical, and Situational. These are employed in works aimed at exploring the compositional process from the creation of music to the evaluation of the effects produced. Table 1 presents these categories along with the associated features and the studies in which they were used. The numbering refers to the reviewed works, which are listed in Appendix A. These components are described in the following sections.

3.2.1 Musical category - This category refers to the musicological foundations of a composition, and includes general features such as genre, structure, and style. According to a study based on the listeners' familiarity with the music, 5.77% (3) of the studies included evaluations made by musicians and 69.23% (36) by non-musicians. 13.46% (7) of the studies were evaluated by both and 11.54% (6) did not have any evaluations made by users. When seeking to establish a link between some of the musical components and their emotional effects, it was found that 65.38% of the studies conduct a performance modeling based on valence and arousal (either individually or jointly). The adoption of this approach establishes a direct relationship between the musical components and emotional dimensions. This scheme forges a link between musical components and their evaluation for the valence and arousal dimensions [Core et al. 2017]. For example, a direct relationship is also formed between volume (musical intensity) and arousal, which means that music with a higher degree of intensity has the potential to enhance arousal. The musical context of a song refers to the community or region in which it is based. 78.85% (41) of the reviewed works refer to Western music, 3.85% (2) to Indian music, and a similar number to studies on Oriental music, while 9.62% (5) produce generic music. In two studies, there was no evidence of the existence of a musical context.

3.2.2 Interactional category - Interactional features concern the communication carried out between the listener, the composition, and the computer system at different times of the musical experience. When conducting the analysis on the user context, the data collected showed that few studies address this characteristic. Only 3.85% (2) of the studies collected information about the user's context, and 1.92% (1) make use of the context in the compositional process. In 30.77% (16) of the studies, some kind of interaction occurs during the composition, but only when making musical or emotional selections. In 26.92% (14) of the studies, interaction occurred during a musical performance, and in 73.08% (38) of the studies, the interaction was guided by music. It was also found that 30.77% (16) of the studies provided data and excerpts of compositions that were stored in a repository. In the design and application of experiments, when handling the user's context and interactive features, it was found that 73.08% (38) of the studies carried out some kind of experiment involving human listeners. All of them stated that their experiments had been submitted to, and approved by, their respective ethics committees. Out of the total number of studies reviewed, 63.46% (33) described the experiments in detail, 11.54% (6) of the studies described the experiments with little detail, and 25.00% (13) of the studies did not carry out the experiment. With regard to the assessment protocol, 25.00% (13) of the studies made a statistical evaluation, 1.92% (1) used Self-Assessment Manikin (SAM), 32.69% (17) used simplified statistics. It is worth noting that 42.31% (22) did not rely on any type of evaluation protocol.

3.2.3 Psychological category - Most of the psychological features addressed in the studies concern the emotional component, 51.92% (27) of all the studies. As for the other psychological features, 7.69% (4) are related to cognition and 1.92% (1) to pain perception. The emotional component required employing a multi-purpose model based on several reviewed studies. This is the Circumplex Dimensional Model, which represents a four-quadrant graph of semantic space based on Russell's orthogonal dimensions of valence and arousal [Russell 1980]. An application of this model to music was carried out by Thayer [Thayer 1990] by means of which affective values could be mapped by combining musical elements. It should be noted that owing to the wide range of musical elements that have to be combined, several studies only model a single item between valence and arousal. 15.38% (8) of the reviewed studies model valence values, 30.77% (16) model arousal, 19.23% (10) model both, and 23.08% (12) do not use an emotional model. In 11.54% (6) of the studies, it was not possible to determine if there was emotional modeling. Among the studies that adopted an emotional approach, 38.46% (20) use the Circumplex Model. Other identified models are Affective Linear Estimator, 2DES, Ekman, Mehrabian, Juslin and Laukka, each with only one reference. In these studies, a distinction is made between 3 types of emotional components: Emotion, Affection and Humor. a) Emotion: 23.08% (12) of the studies - this consists of a short-lived event with a detectable stimulus; upon receiving the musical stimulus, the listener can express varied emotions in an individual or mixed way. b) Affection: 15.38% (8) of the studies - Subjective feelings consisting of the emotional experience or sensation that music causes in the listener. c) Mood: 13.46% (7) of studies - an affective state that is characterized by being a more widespread phenomenon, and which lasts longer than the previous components.

3.2.4 Physiological category - While physiological features can be regarded as the biological parameters that are indicative of the state of the listener's organism, physical features related to movement, breathing, and the restricted physical activities of the user when listening to music. The studies were evaluated in terms of the user's state during and after listening to music. It was found that 40.38% (21) of the studies made an assessment of their general condition, which involved collecting data on the general state of the participants after listening to a musical experience. The physiological data that was collected, included information about the following, along with the amount of work carried out: electroencephalogram (EEG) 15.38% (8), heart rate 9.62% (5), skin temperature 1.92% (1), pain perception 1.92% (1), galvanic skin response (GSR) 9.62% (5), electrocardiogram (ECG) 5.77% (3), blood oxygenation level 1.92% (1) and surface electromyography (sEMG) 1.92% (1).

Table 1. Categories of features presented in the reviewed studies

MUSICAL	
QUALITY	23, 29, 11, 15, 53, 51, 26, 42, 21, 40, 10, 3, 45, 20
GENRE	26, 10, 38
STYLE	15, 39, 38
STRUCTURING	20, 2, 22, 53, 50, 51, 26, 40, 3, 24
EXPRESSION	20, 2, 22, 53, 36, 41, 46, 35, 24
MUSICAL CONTEXT	20, 13, 23, 2, 22, 29, 11, 15, 53, 60, 50, 9, 12, 36, 31, 51, 41, 27, 56, 39, 26, 32, 46, 7, 42, 34, 4, 44, 49, 21, 40, 35, 10, 3, 45, 5, 48, 52, 43, 24, 8, 14, 25, 58, 38, 47, 37
INTERACTIONAL	
COMPOSITION-TIME INTERACTION	2, 22, 11, 53, 50, 9, 51, 41, 46, 21, 3, 52, 43, 25, 58
PERFORMANCE-TIME INTERACTION	2, 60, 51, 1, 56, 32, 46, 55, 21, 35, 3, 24, 25,
DEVICE	20, 13, 23, 2, 22, 29, 19, 11, 53, 60, 50, 9, 31, 51, 27, 1, 56, 39, 26, 32, 46, 34, 4, 21, 10, 30, 3, 57, 5, 48, 14, 25, 58, 17

PHYSIOLOGICAL	
CARDIAC ACTIVITY	53, 60, 31, 26, 32, 10, 58, 17, 59
BRAIN ACTIVITY	22, 19, 50, 56, 46, 34, 4, 28, 37
SKIN RESISTANCE	31, 32, 48, 8, 37
PHYSICAL	
MOVEMENT	2, 53, 51, 27, 1, 32, 55, 4, 21, 35, 3, 43, 25, 17
BREATHING	53, 60, 31, 32, 4, 48, 59
PSYCHOLOGICAL	
AROUSAL	20, 2, 22, 29, 15, 60, 31, 7, 42, 55, 44, 49, 10, 30, 3, 57, 45, 54, 52, 43, 28, 24, 8, 14, 58, 37, 59
VALENCE	20, 2, 22, 29, 15, 36, 51, 7, 42, 34, 4, 21, 5, 48, 28, 24, 8, 14, 58, 37
SITUATIONAL	
DAILY ACTIVITIES	11, 60, 1, 39, 10, 3, 45, 47, 17, 59
THERAPY	22, 19, 53, 50, 27, 26, 46, 55, 4, 49, 35, 57, 48, 52, 43, 25, 38

3.2.5 Physical category - With regard to physical data, information about the following items was collected by the studies: hand movements 1.92% (1), general body movements 23.08% (12), vocal utterances 1.92% (1), head movements 3.85% (2), facial expressions 1.92% (1), sleep movements 1.92% (1), the average speed of movements 1.92% (1), extension movement 1.92% (1),and breathing rate 9.62% (5). In most of the studies, 57.69% (30), undertook the compositional task on the basis of pre-established conventions, without seeking any further understanding concerning the user. It was also found that 34.62% (18) of the studies involved collecting physiological data, while 63.46% (33) did not, and in 1.92% (1) of cases there is no description of this item.

3.2.6 Situational category - Situational features refer to two items: i) the environment with regard to the listener at the time of the musical experience, including its general state (occupation, environment, influences); ii) the purpose of the musical experience (work, leisure, health, etc.) [Otchere 2014]. The reviewed works concentrated on the second item, and the focal point of its concern was in the health area. Work related to daily activities (physical exercises, breathing, concentration, and relaxation) represented 13.46% (7) of the total. Studies focused on the treatment of particular diseases, such as musculoskeletal dysfunction, limited motor capacity, and Parkinson's disease, which accounted for 30.77% (16). It was calculated that 55.77% (29)of the studies were devoted to the psychological area.

4 Discussion

As shown by previous data, some studies use elements related to the user, such as genre and style preferences, cultural features and needs, combined with some form of health treatment. Table 1 presents the basic set of features addressed by the reviewed papers. These elements were obtained by automated information gathering, as well as being manually selected by the user himself. Most of the studies use musical components such as harmonic progressions, melodic lines and counterpoint as guidelines in the generative process. It should be noted that few of them rely on advanced musical resources such as dynamics, tension, or any kind of musical structuring, and also fail to adopt the standards based on harmonic functions. Similarly, only one study employs a method to represent musical knowledge.

In almost all the studies, the flow of data from the user - which involves making interventions through some kind of interface - is used as a form of interaction. This is also true with respect to the diversity of rhythms, which are basically designed from predefined patterns. In two studies, there is an automated acquisition of user characteristics, although none of them conducts any type of analysis of these characteristics to enhance the musical experience. In six works a framework is established for sound production. It is worth noting that no work refers to the user context (e.g. cultural aspects, personal characteristics such as age, stylistic preferences, and treatment needs) to support the applied method. In the case of an affectively-driven composition, the aim is to evoke specific emotions in the user and to stimulate feelings and impact in valence and arousal. However, this procedure takes place in a generic and non-flexible way, and no resource is used to adapt the composition to a particular listener. On the basis of the previously explored elements, we have compiled the following list of the key issues that could also be addressed:

• A broader range of elements should be sought within the musical capabilities (melody, chords, harmony, rhythm, timbre, etc.). While a reductionist approach can lead to satisfactory results in terms of effectiveness, it is insufficient when confronted with the challenge of making the musical creation more amenable to the human listener.

• The approach adopted in current studies, is centered on programming techniques, this impairs the quality of the compositions, from the perspective of the listener. The evolution of AC systems should take into account the importance of aesthetic values, and incorporate them with the other musical dimensions.

• The question of how features such as expressiveness, timbre, and symbolic music content should interact, needs to be explored through research aimed at designing compositional models. The evolution of the two-dimensional model of emotions, at first based only on arousal and valence, and then moving towards a more complete representation, will allow a greater scope for adopting a psychological approach.

4.1 Complementary features

In light of this, the basic set of features can be expanded to include new components. Initially, owing to the emphasis on health - which includes needs such as therapeutic objectives and personalization - two categories and new features can be added:

Well-being - User state (e.g. pain, mood, physical condition), therapeutic target, general health goals.

Personal - Demographic data, cultural background, musical preferences, human values, and experience.

In the physical category, the addition of Duration, Intensity and Range will provide support for an appropriate composition [Newbold et al. 2016]. In the physiological category, Xerostomia (dry mouth) will provide greater coverage in the evaluation of stimuli [Souza 2019]. It is also suggested to use additional sensors: Functional near-infrared spectroscopy (fNIRS), Impedance cardiography (ICG), Photoplethysmography (PPG), Electrodermal Response (EDR) [Chang et al. 2015]. With regard to the psychological category, in addition to arousal and valence features, Conduciveness and Control must be included, as recommended by Scherer's 4-dimensional modeling [Scherer 2005]. The user context, generally related to the user, the environment, and the device, includes features divided into different categories. This concept mentions features that are related to the individual, the musical situation and the device used. For example, demographic data apply to the individual, whereas therapeutic needs are linked to well-being, while the device used refers to interaction. In the situational category, the addition of Environment will enable greater control of the setting provided for the musical experience, including characteristics such as the time and place of the listening. In this way, a set of HC features can be represented through 8 categories, as shown in Figure 3, each of which are embodied in the algorithmic composition focused on health. The complementary components, added to those mentioned in the literature, are represented by the gray color.

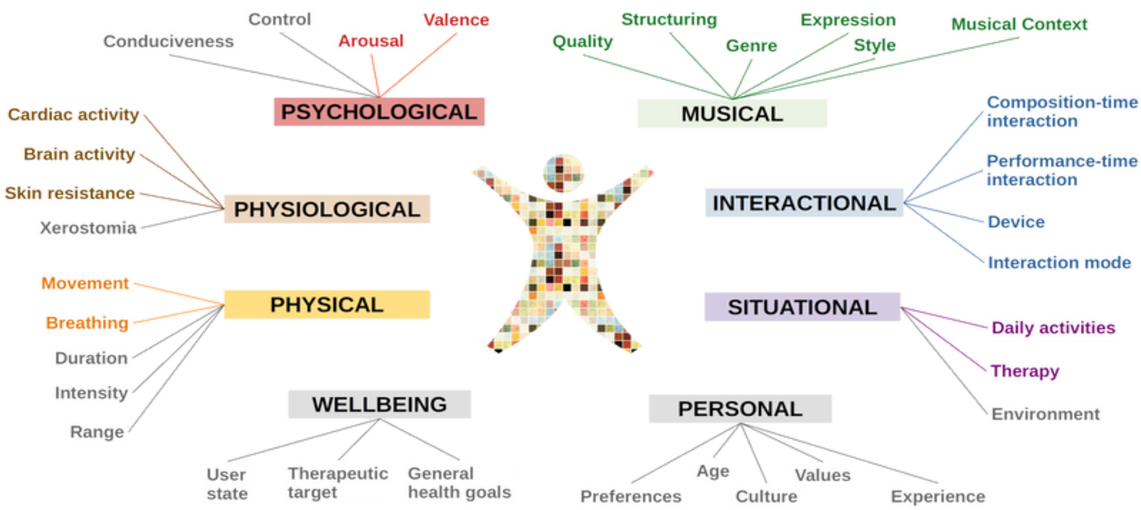

Figure 3. Set of human-centered features for AC focused on well-being

5 Conclusion

It can be concluded from this documentary study that most of the studies in the literature reviewed mainly perform the algorithmic generation of music from the application of automation methods. Even those who view the listener as the central point have limitations on taking into account his background, including cultural context, experience, and preferences. Furthermore, this gap restricts the possibilities of using computer-generated compositions for well-being, as the musical process loses essential elements. In view of this, the study makes a research contribution by introducing a comprehensive set of HC features that may be included in the AC of music for well-being. In future work, creating an HC-AC framework would provide a valuable resource for further development, addressing features used in music composition for health and providing support for the dimensional modeling of systems. As limitations, we can mention the small number of initial seeds and that data extraction was performed by one researcher. Future work includes discussing this initial set of features with specialists to improve it.

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Appendix A – List of studies selected for review

1 A device for persons with (and without) disabilities - Strategies for coherent mapping in movement-to-music interactive systems

2 A musical system for emotional expression

3 A Polyphonic Algorithmic Composer for Interactive Scenarios with Children

4 Affective Brain-Computer Music Interfacing

5 Affective Calibration of Musical Featuresets in an Emotionally Intelligent Music Composition System

6 Affective Evolutionary Music Composition with MetaCompose

7 Affective Expression in Computer Generated Music and its Effect on Player Experience

8 AI and Automatic Music Generation for Mindfulness

9 An emotion-based method to perform algorithmic composition

10 An Experimental Study in Generative Music for Exercising to Ease Perceived Exertion by use of Heart Beat Rate as a Control Parameter

11 Application of Computer-Aided Music Composition in Music Therapy

12 Artificial Affective Listening towards a Machine Learn- ing Tool for Sound-Based Emotion Therapy and Control

13 Automatic Generation of Music for Inducing Emotive Response

14 Automatic manipulation of music to express desired emotions

15 Automatic Melody Generation using Neural Networks and Cellular Automata

16 BCI for Music Making: Then, Now, and Next

17 Biophysiologically synchronous computer generated music improves performance and reduces perceived effort in trail runners

18 Bodily interactions in motion-based music applications

19 Brain Music System: Brain Music Therapy Based on Real-Time Sonified Brain Signals

20 Changing Musical Emotion: A Computational Rule System for Modifying Score and Performance

21 Collaborating with an Autonomous Agent to Generate Affective Music

22 Combining eeg frontal asymmetry studies with affective algorithmic composition and expressive performance models

23 Computational Modeling of Emotional Content in Music

24 Computer Generation and Perception Evaluation of Music-Emotion Associations

25 Constraint-Muse: A Soft-Constraint Based System for Music Therapy

26 Contributions of computer science and biology to receptive music therapy

27 Development of a sonification method to enhance gait rehabilitation

28 Electroencephalography reflects the activity of sub-cortical brain regions during approach-withdrawal behaviour while listening to music

29 Emotional Communication in Computer-Generated Music: Experimenting with Affective Algorithms

30 From Atmosphere to Intervention: The circular dynamic of installations in hospital waiting areas

31 Generation of Music for Inducing Physiological Response

32 Identifying music-induced emotions from EEG for use in brain-computer music interfacing

33 Investigating affect in algorithmic composition systems

34 Investigating Perceived Emotional Correlates of Rhythmic Density in Algorithmic Music Composition

35 Issues and Strategies of Rhythmicality for MotionComposer

36 Learning to make feelings: Expresive performance as a part of a machine learning tool for sound-based emotion therapy and control

37 Listen to your mind' s (He)Art: a system for affective music generation via brain-computer interface

38 Make Your Favorite Music Curative: Music Style Transfer for Anxiety Reduction

39 Melomics music medicine (M3) to lessen pain perception during pediatric prick test procedure

40 MetaCompose: A Compositional Evolutionary Music Composer

41 Mood Dependent Music Generator

42 Moody Music Generator: Characterising Control Parameters Using Crowdsourcing

43 Motioncomposer: a device that turns movement into music

44 Music and Dementia: Two Case-studies

45 Music and Technology: The Curative Algorithm

46 Music neurotechnology: from music of the spheres to music of the hemispheres

47 Nanomechanical sonification of the 2019-nCoV coronavirus spike protein through a materiomusical approach

48 Personalised, Multi-modal, Affective State Detection for Hybrid Brain-Computer Music Interfacing

49 Pulse Project: A sonic investigation across bodies, cultures and technologies

50 Real-time notation using brainwave control

51 Robin: an algorithmic composer for interactive scenarios

52 Simulating Raga Notes with a Markov Chain of Order 1-2

53 Sleep Musicalization: Automatic Music Composition from Sleep Measurements

54 Soundscapes in Hospitals – Music Therapy Perspectives

55 The BeatHealth Project: Application to a Ubiquitous Computing and Music Framework

56 The Space Between Us: A Live Performance with Musical Score Generated via Affective Correlates Measured in EEG of One Performer and an Audience Member

57 Towards a systematic approach to real-time sonification design for surface electromyography

58 Towards an Emotion-Driven Interactive Music System: Bridging the Gaps Between Affect, Physiology and Sound Generation

59 Using Breath-like Cues for Guided Breathing

60 Using music as a signal for biofeedback