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EAI Endorsed Transactions
on Creative Technologies

Research Article EAI.EU

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Abstract

This paper explores the emerging initiatives in ubiquitous music research that employ anticipatory systems. We provide a short introduction to the ubimus field, highlighting the differences with other technologically based approaches to music making. One of the objectives of ubimus research is to expand the range of the stakeholders that participate in creative music making. This is achieved through the development of metaphors for creative action by means of sociotechnical systems that target creativity, including ecologically based creative practices, interaction aesthetics, computational thinking and dialogics applied to music. Another objective entails a push for new forms of music making through the reappropriation of extant technologies or through the design and deployment of new behavioral, material or social resources tailored for ubiquitous music ecologies. Nevertheless, so far, few projects have considered the future creative actions as an object of research. This is the aim of anticipatory ubiquitous music.

Received on 27 April 2020; accepted on 19 May 2020; published on 21 May 2020

Keywords: anticipatory ubimus, semantics, creative surrogates, dialogics

doi:10.4108/eai.13-7-2018.164664

1. Introduction

Anticipatory systems have recently emerged as a target of utilitarian applications in mobile computing [28]. Their potential for creative practice is yet to be explored [6]. The relevance of the anticipatory approach to ubimus-oriented technological developments is justified by the expansion of the context-aware computing and opportunistic design initiatives, highlighting the use of local resources [12]. One avenue of investigation emphasizes the incorporation of data-analysis techniques to adapt the systems' response to the motivations and needs of the users. Another thread focuses on the issues arising from group-based activities.

While tools attuned to the explicit needs of users may be effective in attaining pre-established goals, ubimus research has shown that some design issues are tied to the exploratory aspects of creative practice. Creative endeavors do not always involve a predefined plan or a thorough knowledge of the resources available for the activity. Particularly when the activity targets casual interaction [3] – with limited time for preparation and with no screening of the stakeholders – exclusively relying on the whims of the participants may not suffice to ensure effective outcomes. In these scenarios, fostering fast knowledge transfer – both through readily available resources and through strategies of knowledge-sharing among contributors – may be an alternative to the long training periods and specialized knowledge usually required by the hegemonic approaches to musical interaction[1].

Another thread of anticipatory-systems design involves the development of generative strategies to access cognitive resources that are not directly available to the stakeholders. In this case, rather than to support decision-making, the objective is to expand the range of resources to be used during the creative tasks. Some generative processes may furnish alternative routes when the stakeholders are not satisfied with the existing palette of options. Algorithmic meshworks may trigger new ideas or provide connections among resources that are hard (sometimes impossible) to unveil without computational support [11, 26]. How decisions are negotiated among the stakeholders is a central aspect of

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[1]See [36] for an example of an acoustic-instrumental perspective that targets professional musical virtuosity.

group creativity. A problem arises, for instance, when a target cannot be attained through negotiations. To deal with this issue, ubimus initiatives have employed dialogical strategies involving iterative exchanges during longitudinal studies [19]. These strategies are feasible for educational contexts but it is not clear whether they are applicable to scenarios involving casual participation – with limited time for engagement and very heterogeneous stakeholder profiles. Such scenarios could be approached through algorithmic meshworks to furnish support for consensus-building. Assessing the limitations and opportunities of computer-mediated dialogical approaches through empirical studies is one of the methodological threads explored by anticipatory ubimus.

In this paper, we tackle anticipatory strategies for knowledge transfer in ubiquitous music (ubimus) contexts. Our approach applies creativity-centered design techniques to behavioral ecologies, multimodal ecologies and algorithmic meshworks [11]. The anticipatory-ubimus design strategies are based on the use of semantics, creative surrogates and dialogics. The proposed methods include data-gathering through fast prototyping, deployment and assessment, tailored for two scenarios: *1.* Casual interaction, using anticipatory strategies for aesthetically informed decision-making by musicians and non-musicians in everyday settings. *2.* Dialogical group creativity supported through anticipatory strategies, targeting consensus-building and the preservation of resource diversity in collective, iterative, asynchronous activities.

2. Anticipatory computing and creative practice

According to Lin [20], anticipatory computing can be divided into three categories: *1.* Proposals targeting the development of prediction methodologies and the computational technologies to support them [25, 31]; *2.* The application of anticipatory strategies within computer science (including context prediction and mobile sensing) [7]; and *3.* Anticipatory mobile computing, which relies heavily on mobile platforms [28]. The separation of the predictive technologies and methods from their applications is justified. But it is not clear why mobile computing should be considered a category on its own. More generally, we could say that anticipatory computing relies on existing methods and theories of anticipatory systems and its deployment falls within the realm of design – involving interaction techniques and domain-specific requirements that depend on each field of application. Furthermore, the ability to predict behaviors and outcomes may be inextricably linked to the extant knowledge within each domain [24]. This issue is taken lightly or utterly ignored in some deployments of anticipatory computing. This limited view on the demands of anticipatory systems echoes the long-standing problems of the obtuse application of statistical analysis: garbage in, garbage out[2]. Solid results cannot rely on data analysis without a thorough assessment of the human-activity demands.

The specific requirements of the domain of knowledge are part of the limitations that need to be considered. Pejovic and Musolesi [28] stress the need to define the scope of anticipation. They suggest that anticipatory systems have to work with inherent trade-offs between accuracy and curiosity. To compensate for limited sensory inputs, anticipatory systems may adopt a specific time horizon. This time horizon defines a window into the future that serves to establish the weight and the computational cost of the chosen predictive strategy. For instance, consider the casual engagement of a layperson in a collective musical activity that takes place in transitory settings [8, 14]. This context constrains the time for preparation to a maximum of a few minutes. Furthermore the activity itself cannot be too long, otherwise the incentives may not outweigh the pressures of other demands on the potential participants.

The scenarios involving presencial participation and public settings contrast with the remote and asynchronous modality of the iterative interactions supported by online-based musical systems [23]. In asynchronous ubimus activities, both social and temporal pressures are relaxed. Participants can take their time to evaluate their contributions and may choose the settings to avoid public exposure. Consequently, transitory settings foster fast decision-making and opportunistic strategies while the iterative-activity scenarios involve medium to long periods of engagement that reduce the impact of the local factors on the creative musical outcomes. Support for casual engagements may be addressed through light-weight strategies based on short-term anticipation, with periods of activity that do not exceed a few minutes. In contrast, iterative, asynchronous group interactions may involve persistent resources that do not require tight integration, while fostering long-term engagements. Thus, asynchronous iterative activities demand mechanisms for anticipation that target variable contexts and a potentially large number of participants.

3. Anticipation in creative practice

The approach taken in anticipatory ubimus is rooted on the systemic views on anticipation first laid out by Rosen [31] which later were developed by several other researchers [21, 25]. The definition of anticipatory systems proposed by Rosen and refined by Nadin

[2]According to Stenson, there is no written record of who proposed this concept. https://bit.ly/2XBSm4u. Accessed: 05/2020.

targets 'systems whose current state is determined not only by a past state but also by [the] possible future states' [24]. A key element of this definition is the inclusion of a hypothetical future during decision making. A non-trivial aspect of creative practice is how to conceptualize the future [24]. In utilitarian applications, anticipation basically involves predicting the future behaviors or outcomes from a given sequence of previous events.

In creative practice, while this requirement remains true, there is a further demand to foster relevant and original results[3]. If anticipation precludes originality, it may be useful for rote activities but it will likely be detrimental to creative endeavors. This seems to be an insurmountable barrier. Whether future events contribute or not to creative outcomes can only be known after the results become available [27]. So it may be impossible to assess the impact of the future events on the creative performance. Nevertheless, the assessment of the impact of the predicted outcomes on the creative potential is doable. The creative potential is usually related to the quantity and quality of the resources available for the creative action. Given a predicted context for a creative activity, anticipation involves assessing the quality and quantity of the resources applicable to the creative processes while taking into account their potential contributions to future events.

Having defined the problem of ubimus anticipation as the application of predictive-systemic thinking based on a tradition of epistemological proposals that enabled the emergence of anticipatory computing, we now turn to the ubimus design techniques applicable to the two scenarios chosen for deployment: everyday creative musical activities (*little-c music*) and collective asynchronous musical interaction.

4. Strategies for ubimus anticipation

Ubimus initiatives target the participation of musicians and non-musicians in settings that are not necessarily designed for artistic endeavors. These conditions may be partially reproduced in laboratory contexts and may involve engagements through online platforms. The constraints of little-c music making include: limited time for preparations, short-term activities, wide diversity of stakeholder profiles, unreliable network connectivity and unrestricted public exposure. When considering these factors, collective remote activities provide more relaxed settings. Nevertheless, given that they forfeit colocated face-to-face interactions, they may reduce the social-bonding aspects fostered by co-located music making. When targeting these two scenarios, we believe anticipation techniques may involve three ubimus interaction design strategies: semantics, creative surrogates and dialogics.

4.1. Semantic strategies

The use of anticipation as a strategy to support aesthetic decisions may throw light onto the limitations and advantages of the verbal approaches to knowledge transfer in music making. An aspect to be considered is the widespread adoption of speech as a means for musical knowledge transfer, highlighting the importance of the *memorial transmission* of knowledge [17]. Despite the well-documented usage of oral and mimetic strategies to share musical know-how, creative practice in the academic European and North-American tradition has emphasized the use of written notation as the preferred means to encode musical knowledge [5]. With a few notable exceptions, this approach has also been adopted by music educators including those that praise creativity [34]. It can be argued that the time and pitch precision provided by traditional notation is hard to match when using verbal descriptions. It can also be argued that speech tends to be *prolific* when compared to other forms of encoded musical information. Ultimately, the representation of sound through digital-audio representations seems to furnish the closest match between model and product. Nevertheless, sharing musical information is not the same as providing support for creative music making. A key objective of knowledge-transfer strategies is to furnish the means to share the products of the established musical practices. Contrastingly, the purpose of creative support strategies is to foster opportunities for the generation of new and relevant knowledge, targeting both musical and epimusical[4] resources and processes. Hence, while the use of speech in creative practice may facilitate knowledge transfer, it may also feature specificities that demand tailored support and empirical assessment.

A methodological thread to be investigated targets the use of semantic musical resources for creative purposes, which involves the use of verbal language for parametrization of sonic transformations (with a special emphasis on timbre). This strategy entails the segmentation and identification of verbal tokens which can be obtained either from speech or writing (handwritten or typed). There are several technical aspects to be considered during the encoding of

[3]According to Weisberg's [37] definition of creativity, creative processes and products need to be original and relevant.

[4]The musical literature has usually adopted the prefix *extra* to refer to the aspects of music making that do not yield a sonic result, including social, cognitive and material resources. We propose the adoption of the prefix *epi* to refer to the resources that are not sonic but that have direct impact on the musical processes. By targeting this class of resources, we establish a difference between the ethnographic techniques – which do not usually rely on intensive computational support – and the anticipatory ubimus methods.

semantic information for parametric purposes. *1. Input device*. Depending on the profile of the participants, the hardware resources available and the location of the interaction, speech, handwriting or typing may or may not be feasible. Hence, input mechanisms need to be flexible. *2. Token segmentation*. From a user-centric perspective, a small set of predefined tokens provides the simplest starting point for interaction. This set can be later expanded to fit the needs of the participants. A non-trivial problem is how to deal with colloquial speech when targeting timbre manipulations. This issue entails specific demands for both musical knowledge-transfer and parameterization, including aspects related to discretization, the choice of resolution, the choice of parametric ranges or the use of multidimensional parametric controls. *3. Resource selection*. Furnishing a list of options – as featured in the widespread usage of sonic presets – may prove enough for casual engagements. But a search through a large set of resources involves a temporal investment and the use of domain-specific knowledge that may not be available in casual-interaction scenarios. Furthermore, semantics largely works via non-linear mappings, whose reduction to linear or spatialized lists often proves extremely difficult. Finding a balance between the strategies for representation of the parametric profiles, the mechanisms for accessing the resources and the potential relevance of the timbral results constitutes a key resource-selection target of anticipatory ubimus.

4.2. Creative surrogates

Another technique proposed and investigated by ubimus initiatives entails the usage of surrogates to enable exchanges of musical information [15]. Creative surrogates are digital or material proxies employed for information exchanges during aesthetic decision-making. So far, they have been employed in remote exchanges through re-purposing of previously existing tools. Nevertheless, it is also possible to explore their usage through musical or epimusical tokens incorporated by means of generative strategies. A recent exploratory study within ubimus has involved the deployment of verbal interpretative tokens in order to encourage creative music activities [16]. Promising avenues for exploration include: semantic surrogates, color surrogates, sonic surrogates and time tags. The limitations of each strategy need to be carefully assessed regarding the cognitive costs, the volatility of the resources, their flexibility and the availability of tools to access and modify the data.

Within the context of web deployments, a promising format is Javascript Object Notation (JSON). The three formats or protocols usually employed in music encoding are MIDI[5], MusicXML[6] and OSC[7]. Each of them has positive and negative features for ubimus usage. The advantages of JSON over these three formats are its terseness (when compared to XML) and the availability of web libraries and tools for manipulation (when compared to OSC). MIDI boasts a wide support – especially if the Internet of Things is included as a target – so it seems to be a good option for ubimus ecosystems[8]. JSON has been employed to support exchanges of metadata on sonic qualities. Hence, the choice of formats depends on the type of information and the context of use. Nevertheless, this issue is far from settled[9]. Aligned with previous ubimus approaches, we propose repurposing and opportunistic usage of epimusical resources for decision-making and anticipation.

4.3. Dialogical strategies

Group creativity presents particularly difficult challenges for ubimus deployments. The dialogical approach to ubimus is based on the social construction of knowledge [18, 19]. Pioneered by Helena Lima[10], this perspective is based on Paulo Freire's conceptions [32]. Instead of being a mere conduit of technical information, Freire proposes education as a community-based process of knowledge construction involving the active engagement of students and teachers. Through critical reflections on their choices, the pupils develop an active role in the creative endeavors. From a dialogical ubimus perspective, knowledge is considered the basis for the reflective actions that take place within a community of practice [35]. Expanding on this idea, Lima has adopted ecologically grounded methods to target situated creative actions that make use of local resources. This reliance on the local resources has become a key feature of the ubimus initiatives. For instance, time-tagging employs environmental cues as scaffolds for aesthetic decision-making [10, 30]. Graphic-procedimental tagging uses foraged pictorial elements as referents for aesthetic decisions [1]. Based on cycles of foraging, sharing and selection involving non-hierarchical decision-making, these strategies rest on shared graphical or sonic materials as they relate to collective creative processes.

Two byproducts characterize the dialogical ubimus interactions. On the one hand, group music-making

[5] https://www.w3.org/TR/webmidi/. Accessed: 05/2020
[6] https://w3c.github.io/musicxml/. Accessed in: 05/2020
[7] http://opensoundcontrol.org/spec-1_0. Accessed in 05/2020
[8] MIDI has been largely adopted in recent ubimus experiences, such as in [22]
[9] For a discussion on protocols for ubimus, see [4]
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lets the stakeholders build a shared knowledge pool that serves as a basis for consensual decisions. On the other hand, the participants' usage of their local referents ensures the persistence of diverse components within this shared pool. These two aspects – consensus-building and shared diversity – are key targets of anticipatory ubimus. How to ensure respect for diversity and how to deal with the problems of creative fixation and conflict management in ubimus ecosystems are issues that demand integrated socio-technical approaches. Ubimus research provides the ideal context to deal with these socially and environmentally delicate aspects of creative practice.

Acknowledgement. This project is partially supported by a Productivity Research Grant issued by the Brazilian Council for Scientific and Technological Development (CNPq 300996/2018-7).

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