



HAL
open science

Domestic Ubimus

Damián Keller, Ivan Simurra, Marcello Messina, Tânia Neiva, Sebastian Tedesco, Bruno Mesz

► **To cite this version:**

Damián Keller, Ivan Simurra, Marcello Messina, Tânia Neiva, Sebastian Tedesco, et al.. Domestic Ubimus. EAI Endorsed Transactions on Creative Technologies, 2022, 10.4108/eai.22-2-2022.173493 . hprints-03602695

HAL Id: hprints-03602695

<https://hal-hprints.archives-ouvertes.fr/hprints-03602695v1>

Submitted on 9 Mar 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Domestic Ubimus

D. Keller^{1,2,*}, I. Simurra^{1,2}, M. Messina^{1,3,4}, T. M. Neiva^{1,3}, S. Tedesco^{5,6}, B. Mesz^{5,6,7}

¹Amazon Center for Music Research, Brazil

²Federal University of Acre, Brazil

³Federal University of Paraíba, Brazil

⁴Southern Federal University (SFedU), Russia

⁵Universidad Nacional de Tres de Febrero (UNTREF), Argentina

⁶Instituto de Investigación en Arte y Cultura (IIAC), Sáenz Peña, Argentina

⁷Programa de Investigación STSEAS, EUD, UNQ, Argentina

Abstract

INTRODUCTION: In this paper we discuss concepts and practices that point to a new field of ubiquitous music (ubimus) research centered on domestic settings.

OBJECTIVES: The objective of this paper is to document and share a preliminary study of the use of taste as a trigger for creative decisions and a comparative study of creative music making done at home and in transitional settings.

METHODS: Groundwork in this area encompasses the design, implementation and deployment of ubimus systems. Key aspects include sonic resources and metaphors for creative action based on multimodality.

RESULTS: The results indicate that unpredictable sonic environments foster originality but may compromise the subjects' creative performance — reducing their level of engagement and fun and the possibilities for collaboration, while increasing the cognitive demands of the activity. Home seems to furnish a positive context as long as the objective is not to increase the originality of the outcomes.

CONCLUSION: The effectiveness of taste as a scaffold for creative decisions was partially confirmed, demanding further studies. These results have implications for both the artistic aspects of sound making and the everyday usage of sound for distant socializing in domestic settings, posing renewed challenges to the ongoing STEAM initiatives.

Keywords: ubiquitous music, gastrosonics, sound sphere, multimodality creative practices, domestic settings

Received on 26 January 2022, accepted on 10 February 2022, published on 22 February 2022

Copyright © 2022 D. Keller *et al.*, licensed to EAI. This is an open access article distributed under the terms of the [Creative Commons Attribution license](#), which permits unlimited use, distribution and reproduction in any medium so long as the original work is properly cited.

doi: 10.4108/cai.22-2-2022.173493

1. Introduction-Motivation and background

Doing music in the early twenty-first century entails dealing with conditions that were not encountered by musicians during the twentieth century. Access to technology is pervasive in urban contexts, encompassing central and peripheral countries. Information technology not only has become ingrained in everyday life. Some technologies are beginning to change the way people interact during daily activities. This trend is starting to shape new forms of music making that target both local and remote resources.

Concomitantly, physical distancing has become the norm of most social encounters during the covid-19 pandemic, pointing to an unmet demand of alternative forms of interaction and socialization that skew physical presence. This is the socio-technological context in which domestic ubimus emerges.

The expanded notions of music making encouraged by the ubiquitous music (ubimus) conceptual frameworks acquire a special relevance during the current times (Keller et al. 2014). Until 2020, music was predominantly done through face-to-face, synchronous interactions. While it is true that some musical activities — such as studio post-production and karaoke — rely heavily on offline resources, an implicit target of most musical activities is to make sound together, in person

* Corresponding author. Email: musicoyargentino@gmail.com

and at the same time. Nevertheless, the current pandemic has turned the traditional musical practices into high-risk and in some cases potentially deadly activities. According to Keller, Costalonga and Messina (2020), this begs the question: Will music making become an activity for a select elite, secluded from the mundane buzz and divorced from community exchanges, once again? Reduced physical mobility, lack of face-to-face, physical interaction, avoidance of crowds are among the detrimental factors for the usual acoustic-instrumental practices. Will musical robots, musical algorithms or refined methods of data analysis replace the music practices of the twentieth century? The authors believe that this may not necessarily be the case. New areas of ubimus application may highlight the usage of domestic settings, the asynchronous strategies of group support and the incorporation of multiple modalities of knowledge for musical exchanges. We tackle these issues in this paper pointing to the emergent paradigms that provide support for rich artistic experiences at a musical venue whose potential has remained undervalued: the home.

Ubiquitous music (or ubimus) has been defined as the study and the deployment of ecologies of (1) human agents and (2) material resources that (3) afford musical activities through (4) creative support ecosystems (Keller and Lazzarini 2017). This four-component definition encompasses the human factors, the material resources and the properties that emerge during the creative acts, combined with the design strategies that foster creative outcomes — targeting both the processes and the unavoidable and sought-after byproducts. It is interesting to note that the early ubimus initiatives did not necessarily target the creative aspects of music making.² During an initial exploratory phase (2007-2014), ubimus proposals placed a strong emphasis on the technological infrastructure. This issue was highlighted by the adoption of the term *ubiquitous*, hinting at a subset of proposals related to ubiquitous computing (Weiser 1991). When faced with the diversity of social and cognitive factors triggered by the deployment of musical activities in everyday settings, this perspective presents some limitations.

An undue stress on performance is typical of the currently hegemonic approach to musical interaction (see the concept of virtuosic performance³ laid out by Wessel and Wright in 2002). This view is shared by some forms of network-based music practices (more on this below). Let us take as an example the proposal for an Internet of Musical Things (IoMusT). According to Keller, Gomes and Aliel (2019), there is a strong resemblance between the initial definitions of ubiquitous music and the recent conceptualizations of the

IoMusT.⁴ It may also be argued that these two fields are complementary. Despite the fact that IoMusT research remains as a theoretical construct,⁵ when fully deployed it may provide a material basis for home-based ubimus activities. Therefore, we discuss its limitations and potentials within the context of the development of the infrastructure for domestic ubimus.

2. An IoMusT for domestic ubimus?

A question raised by the early ubimus initiatives is whether network-based music practices should follow the extant acoustic-instrumental modalities or whether they require new forms of social engagements. The current limits in the remote participation of multiple stakeholders are intrinsic or do they arise from a temporary lack of technological support? A case in point is the recent adoption of multimodal resources to be featured in the implementation of a tactile internet (Maier, Mahfuzulhoq, Rimal and Pham Van 2016). In theory, tactile-internet technology allows for multimodal forms of interaction that can be engaged synchronously within a maximum radius of 300 kilometers. According to Turchet, Fischione, Essl, Keller and Barthet (2018), the tactile internet should enable ubimus participants to share haptic and visual data, thus enhancing the quality of their engagement during simultaneous musical activities. Furthermore, virtual reality and robotic resources may become accessible through network connectivity, reducing the differences between the affordances of the collocated and the remote resources (Camporez, Silva, Costalonga and Rocha 2020).

The increase in the speed, bandwidth and reliability of internet connectivity may impact positively the music practices that demand synchronized timing, that depend on the immediate feedback from partners and that use data-intensive resources. In particular the activities enabled by video-based scoring (Bhagwati 2008), haptic devices (Chafe 1993) and movement tracking (Rokeby 1986) may be further enhanced by the deployment of a tactile internet. But it is not yet clear if very fast connectivity will ensure support for key aspects of the creative cycle, in tasks such as the selection of massive audio resources or for the ability to predict effective musical outcomes when the actual sonic resources are only partially known. These two issues are related to cognitive and social aspects of musical interaction that require creatively oriented design strategies. These strategies may or may not be related to synchronous interaction.

For instance, the current speed and the bandwidth of the internet — with the exception of the acoustic musical

² This is also the case with isolated projects that addressed partial aspects of music making in alternative settings, music making by novices, design of network technologies, design of mobile technologies and design of embedded platforms, including genres such as the music for “laptop orchestras”. A feature of ubimus is the strategic avoidance of device-centric, musical genre-centric and more recently sensorial modality-centric proposals.

³ This view is found in the works targeting New Instruments for Musical Expression (NIME). Without dropping the emphasis on the implementation of isolated devices, this area has recently changed the word instruments for interfaces. As it will become clear in the discussion below, the undue focus

of NIME on the device, the instrument or the interface does not necessarily help in the advancement of the support of creative practices.

⁴ See Pimenta, Flores, Capasso, Tinajero and Keller (2009) for an early definition of ubimus that focuses mostly on the technological infrastructure for music making.

⁵ There has been a multiplication of derivative proposals during the last few years, including the internet of audio things, the web of musical things, the semantic web of musical things, the internet of musical robots, etc. etc. Despite the multiplicity of related concepts, actual deployments with a careful analysis of their aesthetic and social implications are still scant.

instruments — does not preclude the use of highly diverse musical resources. As documented by Barbosa (2010) among other authors, synchronization is a serious limitation of remote performances that involve acoustic ensembles. Fortunately this caveat only applies to the acoustic-instrumental formats based on 19th-century music practices. If the caveats in speed and reliability are approached as musical opportunities rather than as technological flaws, then the requirements for tight synchronization are relaxed (Messina and Aliel 2019; Stolfi, Milo and Barthelet 2019).

While the development of the IoMusT focuses on the infrastructure needed for musical activities (an important demand of first-wave ubimus research), current ubimus initiatives highlight the creative processes that foster enhanced social sustainability and more flexible forms of participation. Consequently, over the last decade ubimus has moved beyond the issues directly tied to tool development and usage to embrace aspects of cognition and social interaction. For instance, some ubimus endeavours take advantage of the local resources available through opportunistic design strategies⁶ (Flores, Miletto, Pimenta, Miranda and Keller 2010; Keller, Ferreira, Pinheiro da Silva, Lima, Pimenta and Lazzarini 2013). Other ubimus projects call for custom, network-based professional audio technology which may be aligned with the objectives of the IoMusT (Lazzarini and Timoney 2019; Zawacki and Johann 2014). Consequently, Keller, Gomes and Aliel (2019) envision a dynamic of mutual enrichment between ubimus and IoMusT research. Ubimus experiences trigger the development of new IoMusT technology and as the IoMusT resources become available, they open fresh opportunities for applications in ubimus contexts. Given the potentially massive presence of the internet of things in everyday settings, the requirements and the affordances of the IoMusT raise multiple ethical implications that need to be considered before adopting its resources for ubimus practices. Current ubimus practices indicate that flexible approaches to the organization of musical time may be more effective than some solutions based on the adoption of new technologies for old musical genres. The studies presented in this paper are a case in point.

3. From multimodal creative practices to gastrosonics

Braun (2017) views sonic studies as a field within the cultural and social sciences that can be approached as a specific case of the fusion of science with art. This proposal entails an interdisciplinary research agenda with a strong cross-cultural component that aligns well with the theoretical perspectives proposed by ubimus research (Brown, Keller and Lima 2018; Keller, Lazzarini and Pimenta 2014; Lima, Keller, Flores and Ferreira 2017). According to this author, sound making should be handled within the context of and in relation to the

other senses (Braun 2017: 89). Furthermore, we believe that the creative and aesthetic implications of ubimus deployments furnish excellent opportunities to engage with aspects of technology that remain under-represented in laboratory settings. One of the consequences is a renewed need to consider the role of the arts within the context of the STEAM⁷ initiatives (more on this below).

When approaching music making from a multimodal perspective, the resources may come in two flavors: fully multimodal and proto-multimodal. The first group encompasses the material resources that belong to the various sensory modalities. The second group entails the usage of resources that trigger direct associations with other senses beyond their actual material support (see the section on domestic spaces for more details). For instance, sounds may be used to emulate tactile sensations and visual cues that may trigger smells. From a design perspective rather than targeting a specific modality, the approaches that deal simultaneously with several modes of interaction may be described as supramodal (Lakatos, O'Connell, Barczak, Mills, Javitt and Schroeder 2009). Artistic applications of this approach can be heard in the eight-channel pieces ... *soretas de punta* and *touch 'n' go* (Keller 1998; Keller 1999).

As an example of a supramodal perspective on sound making, Braun (2017: 85) discusses Tyler Kinnear's analysis of ... *soretas de punta* (1998). Keller and Truax (1998) implemented a set of techniques employing databases of sonic grains extracted from environmental events, combined through control functions based on real-world sonic behaviors. Braun states that the compositional usage of synthesized water sounds highlights a variety of manipulations and interactions relevant to the usage of environmental sound in creative endeavors. These techniques hint at aesthetic strategies that rely on supramodal aspects. According to Kinnear's analysis, ecologically based granular synthesis provides a consistent toolset to handle the identity of the sonic resources.⁸ In ... *soretas de punta*, these resources are modified through parametric operations that incorporate the water-drop behaviors while interacting with multiple surfaces. Consequently, the sounds derived from this referential identity become available as materials that expand the sonic palette without interfering with their timbral qualities. These qualities result from the relational properties that come into play during the compositional process (Keller, Otero, Lazzarini, Pimenta, Lima, Johann and Costalonga 2015). Despite departing from a limited set of sonic materials, the manipulations of phase-synchronicities and temporal decorrelations among the sonic streams expand the timbral profile of the sonic events and textures (Keller and Rolfe 1998). According to Braun, these processes furnish a wide range of sonic outcomes. Thus, he concludes that as a creative process the use of the water stream functions as a thread between a baseline timbral identity — established through the spectral characteristics of the drop collisions on surfaces —

⁶ Keller, Messina and Oliveira (2020) establish a difference between *adaptive opportunism* and *maladaptive opportunism*. While the latter may have a negative impact on the social and environmental byproducts of the activity, the former will tend to enhance the creative potential with reduced or manageable negative consequences.

⁷ Science, Technology, Engineering, Arts and Math.

⁸ See also Basanta's (2010) and Haworth's (2015) complementary elaborations on the same topic.

and the supramodal transformations provided by the ecologically grounded synthesis techniques. The conceptual framework of ecologically grounded creative practice pushes the limits of the creative processes beyond the realm of sound. As a consequence, this paradigm is a good candidate for practices that involve multisensory experiences (see Capasso, Keller and Tinajero 2020 for multiple artistic examples that apply this perspective).

So how is this relevant to domestic ubimus endeavors? There are at least two aspects to consider. While traditional artistic venues are usually equipped and designed for artistic purposes, this is seldom the case when the musical activities take place in everyday settings such as the home of a non-musician. Therefore, the infrastructure and resources that can be expected do not usually include high-end audio equipment or acoustic instruments. Another factor that may influence how the stakeholders engage in home-based collective music making is the set of activities and behaviors that characterize being at home — either alone or with others. It is different to make music in a private room, in a community hut or in a shared dormitory. Though, somehow, all of these spaces could be considered homes.

The next two sections explore the implications of using resources that characterize home spaces that have not been explored through the acoustic-instrumental way of musical thinking. We also consider a few examples of musical projects that have targeted domestic spaces and analyse how these projects could inform the development of future ubimus deployments in domestic settings. This emerging area of research can be termed *gastrosonics*,⁹ since it engages with gastronomic experiences that involve sonic components or with musical experiences that include food. Domestic ubimus endeavours could provide a rich playing field for future gastrosonic experiences. A key contribution of this paper is the documentation of the challenges and opportunities encountered during the implementation and deployment of a creative-action metaphor for gastrosonics.

4. Gastrosonics: using food as an epimusical resource

All along history, food has been associated with music. However, only recently researchers have started to consider the impact of what we hear on the experience of eating and drinking, be it consumption sounds, instrumental, synthesized or everyday sonic events. Empirical research shows that sweet taste tends to be matched with sounds that are high in pitch, music with slow tempo, legato, soft and with consonant harmonies (Bronner, Frieler, Bruhn, Hirt, and Piper 2012; Mesz, Trevisan and Sigman 2011). By contrast, sour taste tends to be matched with extremely high-pitched sounds, and fast and dissonant events. Bitter taste tends to be matched

with low-register, brassy sounds (Crisinel and Spence 2012; Wang, Woods and Spence 2015). Salty taste is mostly associated with staccato articulations (Mesz et al. 2011; Knöferle and Spence 2012). Interestingly, the same correspondences have been documented in non-western cultures (Knöferle, Woods, Käßler, and Spence 2015). These crossmodal correspondences between taste and sound have been used to modify the experience of several foods and drinks by changing the sounds that people listen to (Wang, Mesz and Spence 2017; Crisinel, Cosser, King, Jones, Petrie and Spence 2012; Reinoso Carvalho, Van Ee, Rychtarikova, Touhafi, Steenhaut, Persoone and Spence 2015a; Reinoso Carvalho, Van Ee, Rychtarikova, Touhafi, Steenhaut, Persoone, Spence, C. and Leman 2015b; Wang, Mesz, Riera, Trevisan, Sigman, Guha and Spence 2019; Hauck and Hecht 2019). As a result, chefs and musicians are becoming increasingly interested in exploiting the expressive potential of combining music and food (Spence and Piqueras-Fizman 2014; Youssef 2015; Houge and Friedrichs 2018).

The emerging evidence of the impact of sound on taste suggests a potential for usage of food and food-related activities as enablers for creative music making. This potential seems to be enhanced by the increased presence of network-based technology (as discussed in the previous sections). Thus, current gastrosonics proposals expand the range of possibilities afforded by the pioneering exploration of food teleportation by Wei and coauthors (2011).

5. Sensory applications for sonic food augmentation

Food augmentation has received renewed attention during the last decade. The so-called “sonic seasoning” approaches can be boosted by the use of specially designed sensory applications (Spence 2019; Velasco, Reinoso Carvalho, Petit and Nijholt 2016; Velasco, Obrist, Petit and Spence 2018). For instance, a device built by Japanese designers called the *Chewing Jockey* can detect the user’s jaws movements and play a pre-recorded sound in synchrony (Spence and Piqueras-Fizman 2014). This can have an effect on food-texture perception and also on the pleasure or surprise of the eating experience — think matching mastication to the sounds of thunder or a breaking glass.

At their lab at Muntref Centro de Arte y Ciencia, Mesz, Tedesco and Amusátegui made a similar device for drinks, the *Augmented Wine Glass*.¹⁰ This appliance consists of a wine glass with sensors that detect user gestures when the cup is grabbed or when the liquid makes contact with the mouth while drinking. The device tracks the changes of position of the glass in three-dimensional space. The sensing is performed through electrodes, capacitive sensors and an accelerometer. The sensor data is sent wirelessly to a

⁹ VanCour and Barnett (2017) use the term *gustasonic* to describe the discourses that engage with food-related aspects of sonic production and consumption. Yang et al. (2018) propose the neologism *gustosonic* for the initiatives related to interacting with devices that produce sounds to be used while eating. These approaches are complementary and, in our humble

opinion, the multiplication of terms does not help to establish music and food as equal standing resources of a potentially unique area of research.

¹⁰ <https://vimeo.com/338451637>. Last access: 01 July 2020.

computer. Thus, the intervention on the object is minimal and its use is similar to that of a normal glass (Mesz, Herzog, Amusátegui, Samaruga and Tedesco 2017).

At a recent neuroscience and wine symposium, these glasses were used with young or aged wine to match the sounds with the age of the wine. Background sounds were triggered when the glass was grabbed, matching lower spectral centroids for aged wines. Air-like or windy sounds were assigned to the act of airing the wine, while high- vs. low-pitched sounds were activated while drinking young vs. aged wines. At the same event, Mesz et al. presented a system for sonification of tagged tweets. Wine experts qualified wines via Twitter, and the system modified jazz music on the basis of the semantics of their tweets, driving the music to a region in musical parameter space associated with the reported taste. For instance, bitter wines produced a transposition of the music to a low register, a slowing down of tempo and a richer (i.e. more dissonant) harmonization (Mesz et al. 2017).

The data obtained through the glass sensors can be used to trigger various kinds of stimuli such as sounds, motors, transducers, etc. Hence, it has the potential to be applied in transmodal drinking experiences for scientific studies, artistic performances, gastronomic experiences and health-oriented settings. Converging with the proposals discussed in the previous sections, it can also be incorporated in domestic deployments of the IoMusT. Other stimuli may be synchronized as well with each sip, linking drinking to the parametric control of lights, videos or smells. Furthermore, the Augmented Wine Glass could be useful in achieving a more precise synchronization between musical elements and the act of drinking, allowing on-the-fly tracking of the various stages of taste and aftertaste.

6. Domestic spaces and ubimus practice

The task of addressing the multiple intersections between sound-making and home involve, among other things, a critical grasp of the potential demarcations that exist within the domestic spaces. Crucially, such demarcations may boil down to what Armstrong describes as the “politics of domestic space” (1995: 4-5), that is, a set of spatial tensions, struggles and everyday negotiations enmeshed with gender and status. These demarcations highlight the potential for “conflicted identities” within and outside the family, for example as a “worker, parent and partner” (Armstrong 1995: 4).¹¹ A strong correlation with gender and class and the role of domestic spaces as a *loci* of intellectual production are also underlined by Opitz (2016), who focuses on the “domestic threshold as a regulator of private and public access to knowledge” (Opitz 2016: 256). In his book *The Practice of Everyday Life*, Michel de Certeau suggests that the “home” is a spatiality “constituted on the basis of the wall”, and that “there is no spatiality that is not organized by the determination of frontiers” (Certeau 1984: 123). In this sense,

a further demarcation may distinguish spaces for food preparation and consumption from music-compatible or incompatible domestic spaces.

The kitchen has been widely explored as a space of music consumption and creation. A well-known creative intervention in kitchen settings is John Cage’s *27 sounds manufactured in a kitchen* (1983), originally contained in a documentary by Peter Greenaway. A more recent example of musical creation deploying kitchen appliances within the concert hall is Bertelli and Rudnicki’s project *Kitchenware* (2009). Projects based on the domestic use of kitchen appliances include Merino and Arena (2012), Vacchi (2012) and Joseph (2013). A corporate example of marketing based on the sounds of domestic (mostly kitchen) appliances is the *Bosch Sensorchestra* (2016).

Different musics in the kitchen might impact taste and perception. In this sense, food properties become part of a general sphere of meaning in that they acquire different nuances depending on their context. The connection between meaning and food serving, presentation and consumption has been explored by Roland Barthes in monographs such as *Elements of Semiology* (1968) and *Empire of Signs* (1982). Food consumption may be associated with racial and gendered representations of normative bodies and behaviours (Calamita 2014; Messina and Di Somma 2020). Giorgioni (2002) also suggests that narratives of food consumption vary dramatically depending on the general socioeconomic situation, while VanCour and Barnett’s (2017) aforementioned formulation of *gastrosonics* explores — again with a critical approach on the market forces and consumer narratives involved — the metaphoric and material connections between the consumption of food and the consumption of music.

Largely, what emerges here in terms of ubimus practices is the radical overcoming of a set of dedicated spaces for musical activities (Keller et al. 2014), through a mediation of language and meaning. In the context of ubimus research, semantics — as a branch of linguistics concerned with meaning — has been abundantly deployed as a facilitator of creative activities (cf. Bessa, Keller, Silva and Costa 2020; Keller, Messina, Silva and Feichas 2020; Stolfi et al. 2019). *Creative Semantic Anchoring*, involving verbal contextualisations for the use of everyday sounds (Keller and Feichas 2018), is closely related to the two case studies presented in this work. In this sense, a complementary study involving semantics, creative metaphors and culinary settings is Freitas, Bessa, Costa, Nazaré and Keller (2019). While many of the cited works provide evidence that listening to various types of sounds may impact the sensation of flavor in specific ways, the second study presented in this paper is the first to tackle the potential impact of taste onto sound making.

7. Gastrosonics in SoundSphere 1.5

coexist and expand their expertise on very demanding tasks — such as home schooling.

¹¹ It is interesting to note that the current pandemic has crushed some of these roles into a shared domestic space, where parents and workers need to

As indicated by Colzato, Lorenza, Haan and Hommel (2015), food intake during creative tasks may impact the cognitive resources available for the target activity. In line with the findings by these authors, the concept of gastroevent (and its representation, the gastroicon) extends the usage of the epimusical resources to the realm of taste. A gastroevent entails the intake of food — either liquid or solid — with the objective of triggering a cascade of associations that lead to

an aesthetic decision. A gastroicon is a symbol that represents a gastroevent. As a concrete example, let us focus on the implementation of gastrosonics in the SoundSphere 1.5 prototype. We expanded the Sound Sphere Ecology of tools (Bessa, Keller, Farias, Ferreira, Silva and Pereira 2015) to support the representation of sipping a drink during sound mixing.



Figure 1. Using a tomato-juice gastroicon in the prototypes leading to the design of SoundSphere 1.5: An event may take place from second 5 to second 14 within the mix. The participant takes a sip of tomato juice within this temporal slot.

This form of food representation does not target a pre-established aesthetic result. Hence, it is expected that various instances of a single gastroicon will lead to different sonic outcomes involving various aesthetic approaches. Furthermore, the gastroevent is defined as an action that may take place within a definite period of time — indicated by an event onset and offset — situated within a specific musical context. But in this implementation accurate timing, synchronization or exact replication according to strict temporal directives are not necessary (see the section *An IoMust for domestic ubimus?* for the motivations behind this design proposal). This relaxed approach to musical-information handling is motivated by several factors: 1. Lay participants readily understand instructions involving qualitative information pertaining to time but may encounter difficulties when trying to achieve tight synchronization (Hennig 2014); 2. Several ubimus-oriented proposals have encouraged flexible approaches to the organization of time by avoiding the adoption of a hierarchical, metric-based paradigm that tends to restrict the outcomes to a small set of musical genres (Messina and Aliel 2019; Stolfi et al. 2019); 3. While there is evidence that listening to various types of

sounds may impact the sensation of flavour in specific ways, we focus on the influence of taste onto sound making. This justifies a parsimonious strategy regarding the manipulation of the taste parameters and the concomitant constraints on the sonic processes. We chose to use a small set of beverages. We carefully selected the sonic classes provided for the activity, including samples and sonic processes that have been linked to specific taste dimensions. We also instructed the subjects to attempt to relate their gustatory sensation to their aesthetic choices.

Having laid out a procedural path for domestic ubimus research, we now report two case studies involving the usage of domestic spaces in creative music making. The first study targets the impact of place on the creative processes. The objective is to identify creative factors that may play a role in everyday musical activities, highlighting the requirements and opportunities for everyday musical creativity (also termed *little-c music* — Keller et al. 2020; Keller and Lima 2016). The second study targets the challenges presented by the gastrosonics experiences in domestic settings.

8. Domestic ubimus study no.1, comparing the impact of transitional and domestic settings¹²

The proposal encompasses five conditions: the type of environment (domestic or commercial); the subject's posture during the activities (sitting or standing); the type of creative activity (exploration, creation or imitation); the number of participants (solo or duo); and the type of sound sample (kitchen sounds or bathroom sounds). Our report highlights and discusses the results related to the type of environment and the subjects' gender.

This study uses the creative-action metaphor time tagging (Keller, Barreiro, Queiroz and Pimenta 2010) as a support strategy for musical activities in everyday settings. Time tagging in mixDroid¹³ (Radanovitsck, Keller, Vargas, Pimenta and Queiroz 2011) involves the use of environmental sonic cues to scaffold the decision-making processes. Participants do their mixes by pressing buttons or stripes on the touchscreen (depending on the implementation) while using local acoustic cues for their aesthetic decisions.

8.1. Methods

A total of 108 creative activities (here indicated as iterations) were carried out covering various combinations of experimental conditions; 54 iterations were made by subjects working in pairs and 54 were individual; 43 corresponded to men and 65 to women. Half of the iterations used bathroom sonic classes and the other half employed sounds produced in the kitchen; 61 mixes were made in domestic settings and the remaining 47 took place in commercial environments. Of the 47 iterations performed in commercial environments, the subjects stood up during 27 activities. During the remaining 20, the subjects were seated.

Table 1. Experimental conditions and activities.

Variable	Condition	Number of iterations
Number of subjects	single	54
	paired	54
Gender	men	43
	women	65
Type of environment	domestic	61
	commercial	47
Audio samples	bathroom sounds	54
	kitchen sounds	54
Body posture	standing	27

¹² This study was previously published in Portuguese (Keller et al. 2013). Nevertheless, it is not available for English speakers and has not been addressed by the Anglo-Saxon publications. Its reproduction and replication

	sitting	20
--	---------	----

Experimental settings: domestic vs. transitional. The first part of the experiment took place in a domestic setting. At home, the subjects chose the most comfortable space for creative activities. To avoid affecting the ecological validity of the proposal, no intentional modifications were made to the existing everyday conditions — intrusive noises and other distractions were maintained. The house is located in Rio Branco, Acre (Conjunto Esperança, close to Ceará Avenue) (figure 3a). It is 7 meters by 11 meters, with four rooms. Part of the activities were carried out at the collection sites of the sounds used in the mixes — the kitchen and the bathroom. The other iterations took place in the bedroom.



Figure 2. A subject performing creative activities with the time tagging metaphor implemented in mixDroid, in a domestic environment (home).

A second session was held at Via Verde Shopping Mall, located in Rio Branco, Acre — in pre-pandemic times, a high-circulation and usually crowded retail space. We use the words mall, store and shopping center interchangeably to refer to this space (figure 3b). The sessions were held at a passage area with seats, at the center of the mall. During the sessions, we identified sound classes that were also present at the domestic soundscape, such as: a refrigerator motor, a blender, opening and closing of drawers, sizzling of frying pans and the sounds of brooms brushing the floors.

may be impossible in the near future. All these factors justify a thorough presentation and discussion.

¹³ Available for non-commercial purposes from the Amazon Center of Music Research. The tool runs on most Android-based devices.

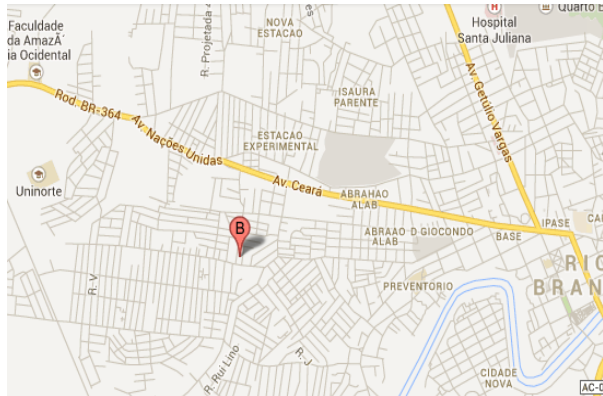


Figure 3a. Location of the domestic environment (home), indicated with the letter B

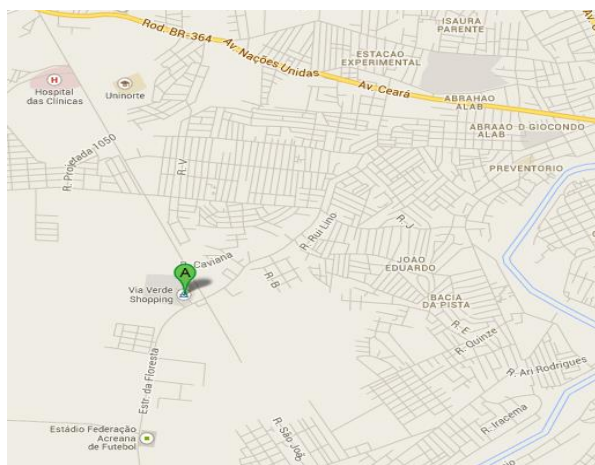


Figure 3b. Location of the transitional environment (store), indicated with the letter A. City map: Rio Branco, Acre, Brazil.

Body posture: sitting vs. standing. The subjects most of the time adopted two body postures while performing the activities, either sitting or standing. While sitting and standing, all subjects held the device with both hands.

Creative activities: exploration, creation and imitation. The sessions included three types of activities. After a brief demonstration by the researchers, each participant was invited to use the mixDroid tool without setting a specific purpose for the activity (the exploration phase). Immediately afterwards, the subjects made a mix in 30 seconds, using up to nine sound samples (the creation phase). The third activity consisted of reproducing a model of a previously done mix, provided by the experimenters (the imitation phase).

Number of participants per activity: individual and in pairs. During the imitation phase, when performing an individual activity, the subject repeated an existing mix model. During the activity in pairs, they had to replicate the mix performed by their partner. Both the creation and the exploration phases were performed simultaneously by the two subjects. Some spaces did not support activities in pairs due to the lack of physical space (e.g., the bathroom in the domestic-settings condition).

Creativity assessments. CSI-NAP version 0.3 was used to assess the level of creativity support during the activities (Keller et al. 2011). The items include a text field for free comments and suggestions by the subjects (table 4). The assessment was aimed at determining the type of support needed to carry out the creative activities. In this version of the CSI-NAP, the measurement scale ranges from -2 to +2 (table 2), with the corresponding semantic descriptors (table 3). For deployment purposes, the questions were printed out. The questionnaire was presented to each subject immediately after completing each activity.

Table 2. CSI-NAP v. 0.3: assessment of creativity support.

Construct (factor)	Evaluation (questionnaire)	Scale
relevance	the result was good	From -2 to +2
originality	the result was original	
cognitive effort (the opposite of ease)	the activity was easy	
engagement	I was focused during the activity	
fun	the activity was fun	
collaboration	It was easy to collaborate	

Table 3. CSI-NAP v. 0.3: Likert scale and semantic descriptors.

Value	Semantic Equivalent
-2	Strongly Disagree
-1	Partially Disagree
0	Do not know
1	Partially Agree
2	Strongly Agree

8.1. Methods

The data highlighted specific tendencies of several combinations of variables. The six factors to assess creativity support were: relevance and originality (of the product), ease, engagement, fun and collaboration (of the activity). Ease is the reverse of cognitive effort, so high values correspond to little effort and low values indicate that the activity requires a significant cognitive effort. We present the results in abbreviated form (Average ± Standard Deviation), encompassing the total iterations performed for each activity.

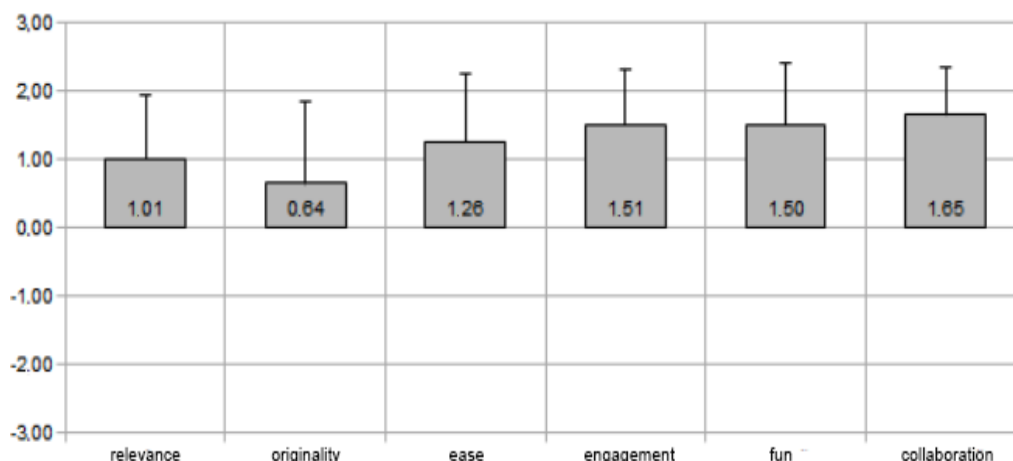


Figure 4. Results with the time tagging metaphor using domestic sounds (for 108 interactions). Bars indicate average and lines represent the standard deviation for each creativity factor.

The overall results show positive assessments on all factors, both for the product and for the activity. In particular, engagement, enjoyment and collaboration got fairly high scores with some variability among subjects (1.51 ± 0.81 ; 1.50 ± 0.91 ; 1.62 ± 0.69). The activity was assessed as being easy but this result was not uniform for all participants

(1.26 ± 0.99). The relevance of the product yielded slightly positive scores (1.01 ± 0.91). When considering all the experimental conditions, it is not possible to determine whether the products were original or not (0.64 ± 1.21). Therefore, it is necessary to analyze the conditions separately to draw conclusions about the creative products.

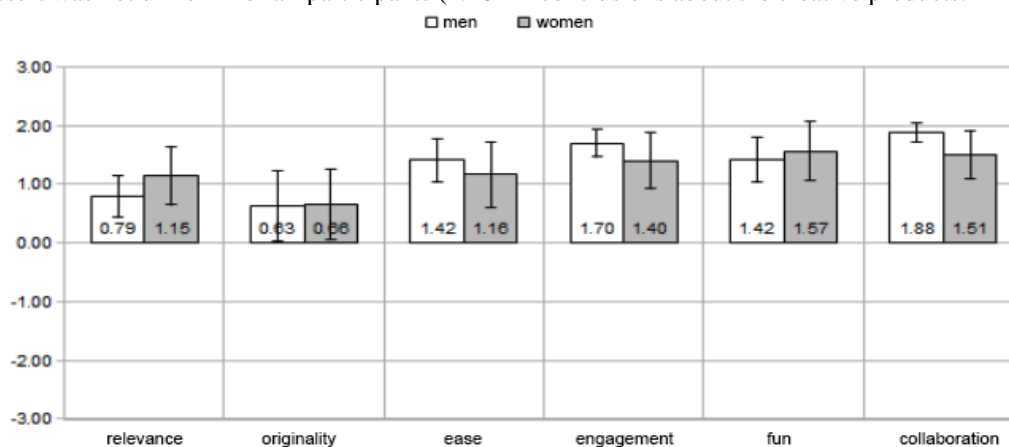


Figure 5. Results with the time tagging metaphor using domestic sounds (for 108 interactions). Bars indicate average and lines represent the standard deviation for each creativity factor.

Given that both sexes participated in equal numbers, we can make tentative comments on the impact of gender on the assessment of support to creativity (keeping in mind the limitations of the subjects' profile). All comparisons correspond to the male vs. female groups. The biggest differences were on engagement, collaboration and relevance. Men scored higher than women in the items collaboration

(1.88 vs. 1.51) and engagement (1.70 vs. 1.40). In contrast, women gave higher assessments to the relevance of their creative products (0.79 vs. 1.16). Differences between male and female assessments of ease (1.42 vs. 1.16) and enjoyment (1.42 vs. 1.57) were smaller, and the originality of the products presented no detectable differences (0.63 vs. 0.66).

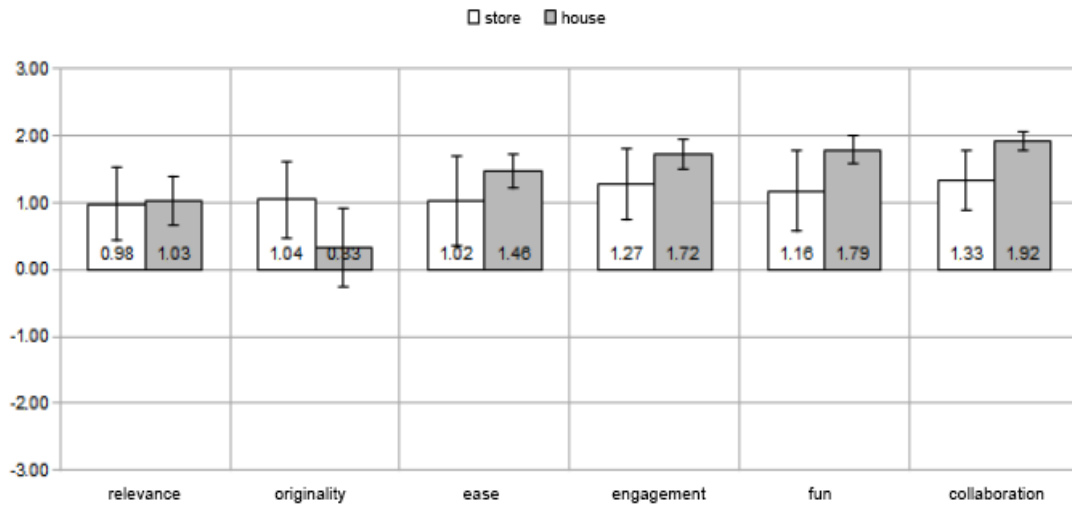


Figure 6. Results: men (grey) and women (white). Bars represent average and lines indicate the standard deviation.

The specific impacts of the retail store and of the domestic settings on the creative activities point to very different profiles. All factors related to the activities performed at home yielded higher scores. Ease, engagement, fun and collaboration were best assessed at home, with small differences among the subjects (standard deviation: 0.25; 0.23; 0.21 and 0.14). The differences between the average of the store condition and the home condition were 0.44; 0.35; 0.63; and 0.59. Here we underscore the fact that the transitional setting was the only context where the subjects gave high scores to originality. The average of the originality scores was higher for the products made in the transitional location (1.04 ± 0.57), when compared to the mean and standard deviation of the creative products made at home (0.33 ± 0.58). The relevance factor was almost the same for both conditions.

8.3. Discussion of results

This study was motivated by the following inquiries: (a) Do the settings impact the assessment of the creativity support? (b) If so, is there any possibility to qualify this impact? (c) When designing support for ubimus systems, what aspects are linked to the environmental factors? Two hypotheses emerge from these issues. The first is backed by environmental psychology: Untidy environments foster creativity (Vohs, Redden and Rahinel 2013). If these findings are extended to the musical realm, an unpredictable soundscape is expected to have a positive impact on the creative activities. An alternative explanation may be grounded on ubimus experimental work (Keller 2018; Pinheiro da Silva, Keller, Ferreira, Pimenta, and Lazzarini 2013). By employing the anchoring mechanisms to aid the creative decision-making process (Keller, Barreiro, Queiroz and Pimenta 2010), sonic resources consistent with the acoustic cues provided by the

settings tend to help decision making (see the section Domestic spaces and ubimus practice).

We defined five variables, each featuring two conditions: the number of subjects per activity, the subject gender, the local characteristics of the soundscape, the class of sonic resources and the body posture. Among these five variables the gender and the local characteristics presented significant differences between the tested conditions, which may be relevant for the design of future ubimus systems. Summing up, unpredictable sound environments foster originality but have a negative impact on the creative performance — reducing the level of engagement, fun and the possibilities for collaboration, while increasing the cognitive demands of the creative activity.

The results related to the gender of the subjects were intriguing. According to the economic perspectives on creativity (Rubenson and Runco 1992; Rubenson and Runco 1995) a greater investment of resources increases the chances to reach creative results. Therefore, greater engagement in the activity should correlate with a positive assessment of the relevance of the product. That was not the case. The scores of the male participants indicate that the activity encouraged their engagement and furnished opportunities for collaboration. They also indicate less effort when compared to the scores of the females. Nevertheless, the product relevance was higher for the female subjects. Other studies suggest that the profile of the subjects could be influencing the type of the creative product assessments (Pinheiro da Silva et al. 2013). Larger studies are needed to determine whether the level of musical training impacts the assessments of the relevance of the creative product. Particularly when the activities employ transitional settings, an aspect that may be influencing the results is the gender of the experimenter. It is possible that four of the variables considered are somehow related: The gender of the experimenter, the gender of the subjects, the level of engagement and the relevance of the products.

The results indicate the following. The use of cognitive clues from the environment has an impact on two aspects of the technological support for creativity: (1) Domestic environments aid the creative performance, reducing the cognitive effort and promoting engagement, fun and collaboration; (2) According to the subjects, public and open environments reinforce the originality of the creative products but have no impact on their relevance.

The practical implications from these findings are manifold. Cluttered or unpredictable environments can be adopted to foster originality. Nevertheless, when the objective is to assist and to expand the participation of lay people in creative activities, familiar or predictable environments may help their creative performance. By linking complex cognitive cues to activities that require original results and familiar cognitive cues to activities that require high levels of cognitive effort, the design of ubiquitous musical systems may satisfy the demands of novices and musicians interested in increasing their artistic creative potential.

Complementing the results obtained by comparing the domestic and transitional settings, we now turn to strategies applicable to asynchronous creative activities tailored for domestic contexts. Despite the differences in target, the following study presents interesting parallels with the time-tagging study. It uses resources readily available for most participants, even if they do not have musical training. It engages subjects in collaborative endeavours. And it handles music making as an activity that does not demand domain-specific expertise.

9. Domestic ubimus study no. 2, deploying gastrosonics

Our proposal for this study entails using drinks for creative purposes. We asked the participants to produce sound mixtures congruent with the flavor of six different drinks (coffee, apple juice, orange juice, lemon juice, tomato juice and water)¹⁴, using sonic materials provided by us, most of which were designed on the basis of crossmodal taste-sound correspondences (60%), while the rest was not specifically aimed to evoke taste associations (40%) and featured everyday events as a common characteristic.

This section provides a description of the procedures plus a preliminary analysis of the results. Our data-gathering protocol targets not only the assessment of the experience but also provides information on the creative processes. The methodological complexities of the multimodal procedures were compounded by the difficulties in securing resources during the pandemic. With these caveats in mind, we decided to relax part of the requirements of the activities.¹⁵ Let us state these issues at the outset.

¹⁴ The intention was to use tomato juice to include the umami flavour. But several subjects had difficulty in obtaining the beverage, so we ended using five drinks in total.

¹⁵ Had the study taken place in laboratory settings, more stringent conditions would have been enforced. But this would imply a reduction of

Limitations. The number of participants was small. A reliable internet connection, reasonable headphones and access to the ingredients for the drinks were prerequisites. These requirements sharply narrowed the pool of potential participants. Other than a superficial familiarity with technology and a reasonable grasp of either Portuguese or Spanish, no screening was applied.

9.1. Tools

The Sound Sphere Ecology (SFS) is a set of web-based tools, loosely organized around audio mixing and processing tasks (Bessa et al. 2015). The series 1.4 of SoundSphere prototypes features a selection panel and a mixing panel. Stereo, PCM audio files are imported at the start of the session and are displayed in alphanumeric order, each item featuring a distinctive colour. After clicking on the icon, the user can insert several instances of the selected audio simply by touching (clicking on) the mixing panel. Each action creates an event, its width being proportional to its duration. For prototype-testing purposes tracks are limited to 80, and the total duration of the mix cannot exceed an hour.¹⁶

The sound sphere metaphor gives priority to the information based on the user's actions. Consequently, the interface elements furnish a picture of the current choices which the participants can use as hints for collective decision-making. These include the sonic content – identified by the colour of the events (user-driven or automatically assigned based on the sources' alphanumeric order); the event's onset timing and duration (corresponding to the event position on the mixing panel's horizontal axis and to its length, respectively); the type of audio processing (identified by a label and represented by a grey gradient); and the timbre-operator in use (indicated by an airport-style abbreviation of previously user-assigned descriptors) (see Bessa et al. 2020 for a detailed description of features and usage). A new SoundSphere prototype (version 1.5) was implemented to support information sharing targeting the create-while-drinking procedures.

9.2. Materials

We provided the participants the sonic materials as stereo, uncompressed PCM files (wave format) coded with 3 digits. They received a total of 110 files with durations of 5, 10, 15 and 30 seconds. The sounds were generated on the basis of crossmodal correspondences between basic tastes and sonic parameters.

We selected two kinds of materials: a) “Tasty” sounds with parameters associated with the basic tastes (60% of the sounds). 18 of these files were validated as corresponding to the basic tastes sour, sweet and bitter in a pre-test online,

ecological validity rendering the results less relevant for future ubimus deployments.

¹⁶ These limitations are not hardwired and will be available for user configuration in future prototypes.

where more than 70% of the participants (N=19) associated the “correct” taste to the sounds. The rest of the files were rendered through granular synthesis as small variations of the validated ones. b) “Neutral” sounds not specifically designed to be associated with tastes (40% of the sounds). These were either synthetic sounds or recordings of everyday events.

Five drinks (200 ml each) were prepared at home by the participants. To obtain a uniform temperature, all drinks were refrigerated for at least 3 hours before the start of each session. They were served in transparent glasses. The beverages were selected to induce four the five basic tastes: coffee without sugar — bitter (1 spoonful of instant coffee Nescafé in 200 ml water); lemon juice — sour (20 ml of Minerva or Campo Largo lemon juice in 180 ml water); apple juice — sweet (Campo largo Valle); orange juice - sweet and sour (Del Valle or Campo Largo); mineral water without sodium — mostly insipid.

9.3. Participants profile

One group of participants completed the experiment. Both were male, 25 and 30 years old, with some musical experience (3 and 4 years respectively), and no reported auditory, gustatory or olfactory disorders. Both subjects were musicians, long-time users of technology and had ample experience with multimedia tools. Hence neither of them were the typical target of SoundSphere deployments.

9.4. Procedures

The participants were sent a protocol via e-mail. They had to fill in personal data, including questions hearing, taste and smell disorders, either transitory or permanent. They were instructed to work in pairs, using headphones in a room with a low noise level. All subjects used desktop or portable systems equipped with a mouse, a QWERTY keyboard and an operational system that supported Google Chrome.

A session order was given in the protocol, each session devoted to one specific drink. The order of the drinks was randomized, but remained the same for both participants within a single group. They were instructed to produce sonic mixtures congruent with the flavor of the drink. Drinking was to be done in sips. For each sip they selected a sound sample and placed the corresponding gastroicon on the graphic representation of the event (see figure 1). At the first session, one participant made a sonic mix while using the first drink on the list. He then sent the file produced by SoundSphere to the other participant. The second participant worked on the file (either adding or suppressing sounds) while drinking the same beverage. Subsequently, he sent back the file to the first participant, who worked on the same mix while drinking the second beverage. The process went on until both participants finished the sequence of beverages.¹⁷

¹⁷ The protocol indicated that if a participant missed a specific drink, that part of the procedure was skipped without affecting the rest of the process.

¹⁸ Digital Audio Workstation.

After concluding each session, the participants filled a questionnaire about the taste of the drink. The reporting followed a 5-point Likert scale, anchored at *not at all* (-2) and *very much* (+2), with 0 corresponding to *do not know*. The dimensions included: bitterness, sweetness, sourness, saltiness, umami taste, pleasantness, intensity, arousal, complexity and familiarity.

9.5. Preliminary results and discussion

At present, we have results from a single group that completed the experiment. Overall, the evaluation of the activity was positive with a particular emphasis on the attractiveness of collaborating on a shared musical project. Given their profile of musical training and advanced expertise in multimedia tools, it is not surprising that several comments on tool usage were not very positive. Some issues may be easily solved with better demonstrations of the mixing methods. For instance, a subject complained that “moving sounds” was difficult. SoundSphere does not enforce the traditional DAW¹⁸ mechanism of drag and drop (we have ample experimental evidence that this mechanism is awkward for casual usage). With straightforward and potentially fast sequences of two clicks, the events can be inserted and removed from the mixing panel. Casual users doing one-minute activities have assessed this process as more intuitive and fast to execute than dragging events across the screen (Bessa et al. 2015). Likely, the adjective “slow” expressed by one of the subjects to describe SFS, does not hold for time-pressing creative activities by casual users.

Our hypothesis regarding the sound-taste associations states that for a given drink, mostly the sound materials that match the taste of the drink will tend to be selected. Because the collaboration procedure entails keeping the previous files while producing the mixes, we looked at the ratio between “tasty” and “neutral” sounds added by both participants at the sessions they dedicated to a single drink (only in the case of the first drink, coffee, we counted all the files). Figure 8 provides a summary of the results.

Considering just the “tasty” sounds,¹⁹ for coffee (ie., bitter) there was a strong tendency to use the bitter files. For orange juice (a combination of acid and sweet), mostly the sweet and sour sound files were added. For apple juice (sweet), mostly the sweet audio files were inserted. Water was served after the sweet drink in this group. So for water new bitter sounds were incorporated in an equal proportion to the neutral sounds. Finally, while drinking the lemon juice, the subjects added predominantly sour audio files.

These preliminary results are aligned with the hypothesis that crossmodal taste-sound correspondences may serve as a basis for sonic selections associated with a drink. The results for water are less clear but are also consistent with this hypothesis. Looking at the total amount of files for water (not featured in the figure), mostly bitter and neutral sounds were

¹⁹ We freely attach the taste adjectives to the sounds. It is understood that sounds are not bitter or sweet.

used, together with a small number of sweet and sour sounds. Note that the drinks were ingested cold. Cold water may evoke primarily sour or salty taste (Cruz and Green 2000), but also note that only sodium-free water was used. As expected, water was not linked to any specific taste by the participants. So the fact that the insipid water was not aligned with any particular class of flavoured sound also supports the connection between drink taste and sonic taste.

10. Implications for domestic ubimus deployments and the intersection of art and science

This paper proposes a new field of research within the context of the initiatives fostered by ubiquitous music practices. Its focus is music making done in domestic settings, but the issues involved may reach beyond music at home. We documented two cases of deployments targeting home and transitional settings, doing synchronous and asynchronous musical activities, both in place and remotely. The two examples were not meant to be exhaustive or definitive regarding the possibilities for development of domestic ubimus practices. On the contrary, they highlighted the new challenges presented by this field. Three issues demand grounding for future empirical proposals: The potentially pervasive deployment of technologies in everyday settings and at home entails ethical and social consequences that need to be understood before embarking on a massive quest for sound making at any cost; epimusical resources readily available in domestic contexts may furnish a rich palette to support creative music making, especially if socializing activities such as eating or drinking are considered; music making at home may be approached as an ecology of material resources and symbolic meanings grounded on dynamic relational properties that shape and are shaped by social

identities. The latter aspect sheds new light on the vision proposed by Armstrong (1995). It also sets new challenges for the recent proposal of a second-wave of ubimus practices.

Domestic ubimus challenges are enmeshed with the political implications of space, sharing and materiality — a preoccupation that has been central to the ubimus agenda since its emergence (cf. Keller et al. 2010; Keller et al. 2014), while being expanded by the second wave of ubimus initiatives (cf. Keller, Messina and Oliveira 2020). Prime examples are provided by the notions of physical presence and synchronous creative interaction. Although formerly considered the ideal formats for music making, these modalities have become progressively fragmented and unrealistic for sustainable, non-specialized venues. Domestic ubimus gains weight as a theoretical and programmatic rubric in the current times of pandemics. The need to remain physically distant while socializing has dislocated the threshold between the public and private spheres, turning home settings into spaces for work, creative leisure and scientific endeavours. This transformation may point to permanent societal changes that entail new perspectives on scientific and technological practices allied with aesthetics targets. This body of initiatives have been gathered under the label of STEAM.

By placing the artistic perspectives as key elements of a research agenda grounded on scientific methods, ubimus enriches the existing palette of approaches to the epistemology of interdisciplinary research. Gastrosonics is a new area that draws from the existing knowledge on taste and smell for creative music purposes. An ideal setting for the gastrosonic deployments is the domestic realm. Home — a multifarious space for diverse activities — while acting as an emergent venue for distant socializing, provides an unmet challenge for the implementation of technologies for creativity. Domestic ubimus crystallizes a range of social and aesthetic demands unique to the 21st-century cross-fertilization between scientific and artistic practices.

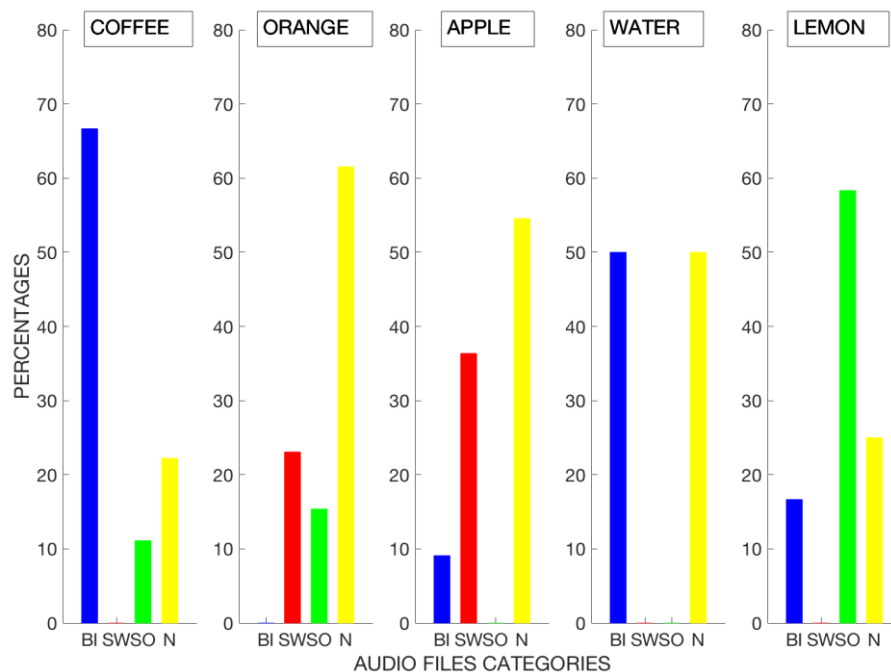


Figure 7. Percentages of audio files added to the sonic mix by both participants for each of the five drinks. **BI:** bitter files (blue). **SW:** sweet files (red). **SO:** sour files (green). **N:** neutral files (yellow).

Acknowledgements.

The first author acknowledges the support of the Brazilian Research Council for Scientific and Technological Development through Research Productivity Grant [CNPq 300996/2018-7].

References

Journal articles:

- Armstrong, N.. 'Eating and Earning Your Crust Under the Same Roof': Teleworking and the Politics of Domestic Space. *New Zealand Geographer*, 1995, 51(1), 4-5.
- Barbosa, Á. Performance musical em rede (Network music performance). In Damián Keller & Rogério Budasz (eds.), *Criação Musical e Tecnologias: Teoria e Prática Interdisciplinar (Musical creation and technologies: Interdisciplinary theory and practice)*. Goiania, GO: ANPPOM, 2010, pp.180-200.
- Bessa, W. R. B., Keller, D., Farias, F. M., Ferreira, E., Pinheiro da Silva, F. & Pereira, V. S. SoundSphere v.1.0: Documentação e análise dos primeiros testes. In F. Z. Oliveira, D. Keller, J. T. de Souza Mendes da Silva & G. F. Benetti (eds.), *Anais do Simpósio Internacional de Música na Amazônia (SIMA 2015)*. Porto Velho, RO: UNIR., 2015. <https://soundsphere.com.br/beta>
- Bessa, W. R. B., Keller, D., Freitas, B. & Costa, D. F.. A Metáfora da Esfera Sonora desde a Perspectiva WYDIWYHE. *Journal of Digital Media & Interaction*, 2020 3(5), 60-88.
- Bhagwati, S.. Towards interactive onscreen notations for improvisation in large ensembles. In Lasker, G. E., Luz, M. A., and Dack, J. (eds.) *Systems Research in the Arts and Humanities*. Windsor, ON: International Institute for Advanced Studies in Systems Research, 2008.
- Braun, H. J.. An Acoustic Turn? Recent Developments and Future Perspectives of Sound Studies. *AVANT. Pismo Awangardy Filozoficzno-Naukowej*, 2017, (1), 75-91.
- Calamita, F. Voracious Dolls and Competent Chefs: Negotiating Femininities and Masculinities in Italian Food. *gender/sexuality/italy*, 2014., 1, 1-14
- Colzato, L. S., Haan, A. M. and Hommel, B. Food for creativity: tyrosine promotes deep thinking. *Psychological Research*, 2015. 79(5), 709-714.
- Crisinel, A. S., Cosser, S., King, S., Jones, R., Petrie, J., & Spence, C. A bittersweet symphony: systematically modulating the taste of food by changing the sonic properties of the soundtrack playing in the background. *Food Quality and Preference*, 2012, 24(1), 201-204.
- Crisinel, A. S., & Spence, C. The impact of pleasantness ratings on crossmodal associations between food samples and musical notes. *Food Quality and Preference*, 2012, 24(1), 136-140.
- Cruz, A., & Green, B. G. Thermal stimulation of taste. *Nature*, 2000, 403(6772), 889-892.

- Freitas, B., Bessa, W. R. B., Costa, D. F., Nazaré, P. W. M. M. and Keller, D. A ecologia SoundSphere desde um viés culinário: Atividades criativas em um restaurante universitário. *Anais do Simpósio Internacional de Música na Amazônia 2019*, 7(7).
- Freitas, J. B. S., Keller, D., Bessa, W. R. B., Costa, D. F., & Farias, F. M. Interação Timbrística em Música Ubíqua. *Journal of Digital Media & Interaction*; 2020, 3(5), 38-59.
- Hauck, P. and Hecht, H. Having a drink with Tchaikovsky: the crossmodal influence of background music on the taste of beverages. *Multisensory research*, 2019, 32(1), 1-24.
- Hennig, H. Synchronization in human musical rhythms and mutually interacting complex systems. *Proceedings of the National Academy of Sciences*, 2014, 111(36), 12974-12979.
- Keller, D., Messina, M., & Oliveira, F. Z. Second Wave Ubiquitous Music. *Journal of Digital Media & Interaction*, 2020, 3(5), 5-20.
- Keller, D., Ferreira da Silva, E., Pinheiro da Silva, F., Lima, M. H., Pimenta, M. S. and Lazzarini, V. Criatividade Musical Cotidiana: Um Estudo Exploratório Com Sons Vocais Percussivos. In *Anais do Congresso da Associação Nacional de Pesquisa e Pós-Graduação em Música - ANPPOM*. Natal, RN: ANPPOM, 2013.
- Keller, D. and Lazzarini, V. Ecologically grounded creative practices in ubiquitous music. *Organised Sound*, 2017, 22 (1), 61-72. (Doi: 10.1017/S1355771816000340.)
- Keller, D., Lazzarini, V. and Pimenta, M. S. Ubimus through the lens of creativity theories. In *Ubiquitous Music*. Berlin and Heidelberg: Springer, 2014, pp. 3-23.
- Keller, D., Lima, M. H., Pimenta, M. S. and Queiroz, M. Assessing musical creativity: material, procedural and contextual dimensions. In *Proceedings of the National Association of Music Research and Post-Graduation Congress-ANPPOM*, 2011, pp. 708-714.
- Keller, D. and Feichas, L. *Ecocompositional and Performative Strategies for Creative Usage of Everyday Sounds: Creative Semantic Anchoring*. Leonardo, 2018, 51(2), 195-196.
- Keller, D., Gomes, C. and Aliel, L. The Handy Metaphor: Bimanual, touchless interaction for the internet of musical things. *Journal of New Music Research*, 2019, 48(4), 385-396.
- Keller, D. and Lima, M. H. Supporting everyday creativity in ubiquitous music making. In *Trends In Music Information Seeking, Behavior, And Retrieval For Creativity*, Vancouver, BC: IGI Global, 2016, pp. 78-99.
- Keller, D., Messina, M., Silva, C. E. and Feichas, L. V. Embasamento da Ancoragem Semântica Criativa. *Journal of Digital Media & Interaction*; 2020, 3(5), 117-132.
- Chafe, C.. Tactile audio feedback. In *Proceedings of the International Computer Music Conference (ICMC 1993)*. Tokio: ICMA, 1993, pp. 76-79.
- Coelho de Souza, R. C., & Faria, R. R. A. Oito Reflexões sobre a Criatividade na Composição Auxiliada por Computadores. *Proceedings of the 13th Brazilian Symposium on Computer Music (SBCM 2011)*. Vitória, ES: SBC, 2011. 1-12.
- Flores, L., Miletto, E., Pimenta, M., Miranda, E. & Keller, D. Musical interaction patterns: communicating computer music knowledge in a multidisciplinary project. In *Proceedings of the 28th ACM International Conference on Design of Communication*, 2010.,pp. 199-206.
- Keller and Truax. Ecologically based granular synthesis. In *Proceedings of the International Computer Music Conference (ICMC 2010)*. Ann Arbor, MI: MPublishing, University of Michigan Library, 1998, 1-6.
- Keller, D. and Rolfe, C. The corner effect. In *Proceedings of the XII Colloquium on Musical Informatics (CIM 1998)*, 1998, 1-4.
- Keller, D., Costalonga, L. and Messina, M. Editorial: Ubiquitous Music Making in COVID-19 Times. In *Proceedings of the Workshop on Ubiquitous Music (UbiMus 2020)*, Porto Seguro; g-ubimus, 2020.
- Keller, D., Barreiro, D. L., Queiroz, M. and Pimenta, M. S. Anchoring in ubiquitous musical activities. In *Proceedings of the International Computer Music Conference (ICMC 2010)* Ann Arbor, MI: MPublishing, University of Michigan Library, 2010, pp 319-326.
- Knoeferle, K. M., Woods, A., K appler, F., & Spence, C. That sounds sweet: Using cross-modal correspondences to communicate gustatory attributes. *Psychology & Marketing*; 2015. 32(1), 107-120.
- Kn oferle, K. M. and Spence, C. Crossmodal correspondences between sounds and tastes. *Psychonomic Bulletin & Review*; 2012. 19(6), 992-1006.
- Kontukoski, M., Luomala, H., Mesz, B., Sigman, M., Trevisan, M., Rotola-Pukkila, M., & Hopia, A. I. Sweet and sour: music and taste associations. *Nutrition & Food Science*, 2015, 45(3), 357-376. (DOI: 10.1108/NFS-01-2015-0005)
- Lakatos, P., O'Connell, M. N., Barczak, A., Mills, A., Javitt, D. C. and Schroeder, C. E. The leading sense: supramodal control of neurophysiological context by attention. *Neuron*; 2009. 64(3), 419-430.
- Lima, M. H., Keller, D., Flores, L. V., & Ferreira, E. Ubiquitous music research: Everyday musical phenomena and their multidisciplinary implications for creativity and education. *Journal of Music, Technology & Education*, 2017, 10(1), 73-92.
- Literat, I., and Glaveanu, V. P. Distributed creativity on the internet: A theoretical foundation for online creative participation. *International Journal of Communication*, 2018, 12, 16.
- Maier, M., Mahfuzulhoq, C., Rimal, B. and Pham Van, D. The Tactile Internet: Vision, Recent Progress and Open Challenges. *IEEE Communications Magazine* 54, 2016. (DOI: 10.1109/MCOM.2016.7470948).
- Mesz, B., Trevisan, M. A., & Sigman, M. The taste of music. *Perception*; 40(2), 209-219, 2011.

Pimenta, M. S., Flores, L. V., Capasso, A., Tinajero, P. & Keller, D. Ubiquitous music: concept and metaphors. In Farias, R. R. A., Queiroz, M. and Keller, D. (eds.), *Proceedings of the Brazilian Symposium on Computer Music (SBCM 2009)*, Recife, PE: SBC, 2009, 139-150.

Pinheiro da Silva, F., Keller, D., Ferreira, E., Pimenta, M. S. and Lazzarini, V. Everyday musical creativity: Exploratory study of ubiquitous musical activities (Criatividade musical cotidiana: Estudo exploratório de atividades musicais ubíquas). *Música Hódie*, 2013, 13, 64-79.

Reinoso Carvalho, F., Van Ee, R., Rychtarikova, M., Touhafi, A., Steenhaut, K., Persoone, D. and Spence, C. Using sound-taste correspondences to enhance the subjective value of tasting experiences. *Frontiers in Psychology*, 2015a, 6, 1309.

Reinoso Carvalho, F., Van Ee, R., Rychtarikova, M., Touhafi, A., Steenhaut, K., Persoone, D., Spence, C. and Leman, M. Does music influence the multisensory tasting experience? *Journal of Sensory Studies*; 2015b. 30(5), 404-412.

Rubenson, D. L., & Runco, M. A. The psychoeconomic approach to creativity. *New ideas in Psychology*, 1992, 10(2), 131-147.

Rubenson, D. L. and Runco, M. A. The psychoeconomic view of creative work in groups and organizations. *Creativity and Innovation Management*, 1995, 4(4), 232-241.

Spence, C. Multisensory experiential wine marketing. *Food quality and preference*; 2019. 71, 106-116.

Stolfi, A. S., Milo, A., & Barthelet, M. Playsound. space: Improvising in the browser with semantic sound objects. *Journal of New Music Research*, 2019, 48(4), 366-384.

VanCour, S. and Barnett, K. Eat what you hear: Gustasonic discourses and the material culture of commercial sound recording. *Journal of Material Culture*, 2017. 22(1), 93-109.

Velasco, C., Obrist, M., Petit, O. and Spence, C. Multisensory technology for flavor augmentation: a mini review. *Frontiers in psychology*, 2018, 9, 26. (Doi: 10.3389/fpsyg.2018.00026)

Wang, Q., Woods, A. T., and Spence, C. "What's your taste in music?" A comparison of the effectiveness of various soundscapes in evoking specific tastes. *I-Perception*, 2015, 6(6), 2041669515622001.

Weiser, M. The Computer for the 21st Century. *Scientific American*, 1991, 265(3), 94-105.

Wessel, D. and Wright, M. Problems and prospects for intimate musical control of computers. *Computer Music Journal*, 2002., 26 (3), 11-22. (Doi: 10.1162/014892602320582945.)

Yang, W., Makita, K., Nakao, T., Kanayama, N., Machizawa, M. G., Sasaoka, T., Sugata, A., Kobayashi, R., Hiramoto, R., Yamawaki, S. and Iwanaga, M. Affective auditory stimulus database: An expanded version of the International Affective Digitized Sounds (IADS-E). *Behavior Research Methods*, 2018, 50(4), 1415-1429.

Books:

Barthes, R. *Empire of Signs*. New York: Hill and Wang, 1982.

Barthes, R. *Elements of semiology*. London: Macmillan, 1968.

Bertelli, E., & Rudnicki, R. *Kitchenware*. Rymer Auditorium: York, 2009.

Certeau, M. de *The Practice of Everyday Life*. Berkeley: University of California Press, 1984.

Spence, C., & Piqueras-Fiszman, B. *The perfect meal: the multisensory science of food and dining*. London: John Wiley & Sons, 2014.

Chapters:

Brown, A. R., Stewart, D., Hansen, A. and Stewart, A.. Making meaningful musical experiences accessible using the iPad. In *Ubiquitous Music*; Berlin and Heidelberg: Springer, 2014, pp. 65-81.

Brown, A. R.; Keller, D. and Lima, M. H.. How ubiquitous technologies support ubiquitous music. In B.-L. Bartlee; L. Higgins (eds.), *The Oxford Handbook of Community Music*. Oxford: Oxford University Press; 2018. (7) 131-151

Giorgioni, L. *Pane, Amore e Fantasia: Il Cibo nel cinema italiano dal dopoguerra a oggi. La grande abbuffata, Percorsi cinematografici fra trame e ricette*; 2020. 11-34.

Keller, D., Otero, N., Lazzarini, V., Pimenta, M. S., Lima, M. H., Johann, M. and Costalonga, L. Interaction aesthetics and ubiquitous music. In *Creativity in the Digital Age*. London: Springer; 2015, 91-105

Messina, M. and Di Somma, T. The "Greedy Southern Woman" as a National Italian Cliché: A Preliminary Proposal. In Bernardi, C., Calamita, F., & De Feo, D. (eds.) *Eve's sinful bite - food and women in Italian culture, literature and society*. London: Bloomsbury, 2020, (7), 88-100.

Opitz, D. L. Domestic space. In Lightman, B. (Ed.) *A Companion to the History of Science*, Chichester: Wiley Blackwell, 2016, pp. 252-267.

Vohs, K. D., Redden, J. P. & Rahinel, R. Physical Order Produces Healthy Choices, Generosity, and Conventionality, Whereas Disorder Produces Creativity. *Psychological Science*; 2013. 1-8. (Doi: 10.1177/0956797613480186.)

Conferences:

Bronner, K., Frieler, K., Bruhn, H., Hirt, R., and Piper, D.. What is the sound of citrus? Research on the correspondences between the perception of sound and flavour. In E. Cambouropoulos, C. Tsougras, P. Mavromatis, & K. Pasiadis (eds.), *Proceedings of the ICMPC – ESCOM 2012 Joint Conference*, Thessaloniki, Greece, 2012, pp. 42–48.

Camporez, H., Silva, J., Costalonga, L. & Rocha, H.. *RoboMus: Robotic Musicians Synchronization*. Proceedings of the Workshop on Ubiquitous Music (UbiMus 2020), Porto Seguro: g-ubimus, 2020, pp. 72-83.

Messina, M. & Aliel, L. Ubiquitous Music, Gelassenheit and the Metaphysics of Presence: Hijacking the Live Score Piece Ntrallazu 4. In proceedings of the Workshop on Ubiquitous Music (UbiMus 2019). Marseille: g-ubimus.

Mesz, B., Herzog, K., Amusatogui, J. C., Samaruga, L. and Tedesco, S. (2017, November). Let's drink this song together: interactive taste-sound systems. In Proceedings of the 2nd ACM SIGCHI International Workshop on Multisensory Approaches to Human-Food Interaction, 2017, pp. 13-17.

Velasco, C., Reinoso Carvalho, F., Petit, O. and Nijholt, A. (2016, November). A multisensory approach for the design of food and drink enhancing sonic systems. In Proceedings of the 1st Workshop on Multi-sensorial Approaches to Human-Food Interaction, 2016, pp. 1-7.

Wang, Q. J., Mesz, B. and Spence, C. Assessing the impact of music on basic taste perception using time intensity analysis. In Proceedings of the 2nd ACM SIGCHI International Workshop on Multisensory Approaches to Human-Food Interaction, 2017, pp. 18-22.

Wei, J., Peiris, R. L., Koh, J. T. K. V., Wang, X., Choi, Y., Martinez, X. R., Tache, R., Halupka, V. and Cheok, A. D. Food media: exploring interactive entertainment over telepresent dinner. In Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology, 2011, pp. 1-8.

Others:

Cage, J. 27 sounds manufactured in a kitchen. In Greenaway, P. (Dir.) Four American Composers. London: Transatlantic Films, 1993.

Capasso, A., Keller, D. & Tinajero, P. Capasso+Keller+Tinajero artist collective, 2020. <http://capassokellertinajero.squarespace.com/>

Houge, B. and Friedrichs, J. Food Opera; 2018. <http://www.audiogustatory.com/>, last access 2020/02/04.

Joseph, R. Music in the Kitchen. Half Bak'd Productions; 2013. <https://vimeo.com/60658480>

Keller, D. “. . . sores de punta.” [Digital recording]. New Westminster, BC: earsay, 1998.

Keller, D. touch'n'go [Digital recording]. New Westminster, BC: earsay, 1999.

Lazzarini, V. and Timoney, J. The Analogue Computer as a Voltage-Controlled Synthesiser. In Proceedings of the Workshop on Ubiquitous Music (UbiMus 2019). Marseille: g-ubimus, 2019.

Merino, S. and Arena, T. Kitchen Drumming for breakfast: Street drummer at home, 2012. https://youtu.be/zVBOgM_9EtY

Rokeby, D. Very Nervous System [Installation]. Venice: Venice Biennale, 1986. <http://www.davidrokeby.com/vns.html>

The Bosch Sensorchestra, 2016. <https://www.bosch.com/stories/sensorchestra-smart-home/>

Turchet, L., Fischione, C., Essl, G., Keller, D., & Barhet, M. Internet of musical things: Vision and challenges. IEEE Access, 6, 61994-62017, 2018.

Vacchi, L. Kitchen music, 2012. <https://youtu.be/HmKusqRnHBY>

Wang, Q. Assessing the mechanisms behind sound-taste correspondences and their impact on multisensory flavour perception and evaluation. Doctoral dissertation, University of Oxford, 2017.

Youssef, J. Sonic seasoning: how does sound affect what we eat?, 2015. <https://www.greatbritishchefs.com/features/sonic-seasoning-jozef-youssef> last access: 2020/02/08.