VIGOROUS MUSIC-MAKING: THE INHERENT "LIVELINESS" OF A T-STICK INSTRUMENTALIST

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Abstract

I begin by making an argument for evaluating how we think about designing and performing on a digital musical instrument (DMI). Next, I state my four definientia of a digital instrument. This includes, among other things, an explanation of: DMI performance techniques, requisite instrument training and the new possibilities digital instrument technology brings to the compositional project. After that, I look at the technical and design issues of the t-stick and suggest ways in which the instrument conforms to my definition of a DMI. In particular, I address the significance of mapping, t-stick playing techniques and notation. The final section of this paper looks at a case study – one of my own musical compositions – in which two soprano t-stick instrumentalists were integrated into a large acoustic instrument ensemble. I describe some limits and constraints implemented in both the technology (i.e., DMIs) and the compositional project in an effort to create a level of equality among digital and acoustic instrumentalists. In particular, I exemplify how the inherent liveliness of playing the t-stick was not only a counterpart to the activities of the acoustic instrumentalists, but was also an analog to the vigorous music-making within the composition.

1. Introduction

Before one describes a musical performance as active, lively and vigorous, one should make an effort to discern how a performer's 'means' complements any musical expressiveness that occurs during the experience. In my case, the 'means' in examination is the t-stick digital musical instrument. I believe most of us would agree that in a thrilling musical performance, the musician exhibits an inherent link with his or her musical instrument,[1] so much so that we even find it difficult to name the musician without making a reference to the musician's instrument; alternatively, the link between musician and instrument may be implicit (e.g., Miles Davis, Niccolò Paganini). I believe it is our responsibility, especially within the computer music community, to separate the 'means' from the musician occasionally in an effort to design effective digital musical instruments. I am the first to argue for the indispensability of musicians' insights and so, I do not prescribe that we remove the musician from the process of building a DMI. Instead, I propose we draw our attention to what an instrument offers a performer in both its design and musical function irrespective of the inherent link that develops between instrument and instrumentalist. In so doing, we address what I believe is a bone of contention in this field: we lack the underlying principles on which to operate while both conceiving a DMI and using it in the context of a music concert. In my opinion, we need to decide upon certain digital instrument criteria and definientia that reconnect the musician to the 'means' in ways that guarantee an active, lively and vigorous performance.

2. The four constituents of a digital musical instrument

In this section, I discuss my four constituent definientia of a digital musical instrument.

Constituent 1. A digital musical instrument is a gestural controller used by musicians for active on-stage music-making.
Constituent 2. A digital musical instrument is accompanied by an established playing technique and a flexible sound synthesis engine.
Constituent 3. A digital musical instrument requires performance expertise and must be practised.
Constituent 4. A digital musical instrument must form an integral whole with the musical concepts and materials of any composition in which it is employed.

2.1 Active on-stage music making (constituent 1)

Regarding the first constituent of this definition, I subscribe to Axel Mulder's (1) touch, (2) expanded range and (3) immersive gestural controller classifications as an appropriate system for initially defining what mechanical form a DMI might take [2], although some details of Mulder's classifications may be at odds with my own definition of a DMI. For example, electroencephalogram and biosignal sound art may entail the use of 'immersive' controllers. However, if the sound art does not entail bodily movement – which is often the case – then the immersive controller does not meet my definition of a DMI. Another device not matching my definition is the ubiquitous computer keyboard (as used in laptop ensembles, for example), which falls under the classification of 'touch' gestural controllers. Using the computer keyboard does not elicit any particular musically meaningful movements during a performance. Moreover, its function as a focal point during a music concert

[1] Consider Frank DeNunzio, Sr.'s performance on the double bass in *A Study in Brown*, with Reg Keyhoe and the Marimba Queens. <www.youtube.com/watch?v=aeJ5SUQ2qYM> (2010, January 5).

ambiguously intermingles with our cultural understanding of a laptop/personal computer as a tool for interfacing with the infrastructure of our society (e.g., browsing the internet, checking e-mail) – not a particularly artistic endeavour. A DMI should be understood as an extension of the body in the same way as an acoustic wind instrument (including the voice) may be conceived as an extension of human speech, or the reach of a percussion mallet to drum head as an extension of the arm. Moreover, according to my definition, a DMI must be used to maintain the action/response relationship consistently found in music-making, thus centring the performance focal point on the human agent. My definition preserves the dominant performance role of the human musician in live electronics and maintains notions of precision and control through a clear cause/effect co-ordination.

2.2 Playing technique and synthesis engine (constituent 2)

In my second constituent defining a DMI, I advocate developing a fixed set of physical playing gestures *per DMI* while inventing an unlimited sound array for DMI 'voice' on a *per project* basis. Multiple layer mapping and design principles are at the centre of this approach. Mapping the human body movements necessary to execute a particular manipulation of a gestural controller, regardless of the sonic result, is first and foremost. That is, the first layer of mappings connects a performer's natural, intuitive and learned handling of a DMI to functional control data. The next mapping stage entails thoughtfully coupling control data to synthesis algorithm parameters in a way that guarantees a clear action/response or cause/effect relationship for both the performer and the audience. By following this approach, I believe we assure both the longevity of a digital instrument and our ability to transpose the instrument from composition to composition by virtue of the DMI's lack of dependence on a static sound synthesis engine. In my view, this is conducive to composing electronic music, which inherits a great independence of sonic material and sound synthesis techniques. Contrary to this method, composers sometimes build project-specific technology that may or may not have any use after the completion of the project. I consider this approach as failing to exploit fully the malleable nature of technology to its fullest extent. That is, a single flexible technology can be cleverly designed to fulfil as large or as small a technical and creative niche as necessary, on a *per project* basis, while also remaining adaptable to numerous other creative endeavours.

2.3 Performance expertise (constituent 3)

An essential component of my third constituent of defining DMIs concerns the investment of time and effort that is required while practising and developing expertise on a musical instrument. Learning how to play a DMI parallels acoustic instrumental practise, consisting in lengthy training sessions and private practising. Training operates on two levels. Firstly, it results in well-performed music. Mastering a well-defined and established playing technique helps an audience to perceive a piece of music as being well-performed. Secondly, the level of training acts on the musician. By gradually perfecting playing technique, a performer can become engaged with the instrument thanks to an understanding of the idiomatic nature of the DMI. Consequently, he or she feels more at ease and more capable of exploring his or her expressive urges *via* the instrument. That is, mastering technique is intimately tied to any attempt at expressiveness by the musician. In this way, we can measure the skill level of a musician, in addition to evaluating the potential of a DMI to offer new possibilities for expressiveness to the musician.

2.4 Forming an integral whole (constituent 4)

Out of all the facets of my definition of a DMI, my fourth constituent is the most crucial: a DMI must form an integral whole with the musical concepts and materials of the compositional project. With this part of my definition I am emphasising the value and significance of compositional training. Composing for a DMI is less about the digital instrument – less about the technology – and more about the compositional idea behind the music. If a composer includes a DMI in the instrumentation and material of a project, then he or she must dedicate time and effort to fully understanding the digital instrument in order to make the DMI intrinsic to the composition. Furthermore, he or she must consider what new possibilities working with DMI technology can bring to the compositional project. These might include, for example:

- Expanding the sonic palette
- Defining new modes of composing and a new music that position the composer as equal, at the least, to the performer
- Integrating a DMI as an extension of a musician's presence
- Exploring new modes of expressiveness by focussing on a concurrence, or purposeful counteraction, between physical playing gestures and the sonic result, possibly leading to a musico-theatrical composition
- Exchanging expertise among composers, performers and music technologists, leading to both a heightened understanding of science and also the possibility of creating a broader appreciation of music as a whole

3. The t-stick

Joseph Malloch's t-stick is a physical input device that senses where and how much of its surface is touched by the performer, and detects gestures such as tilting, shaking,

Figure 1. The soprano and tenor t-sticks.

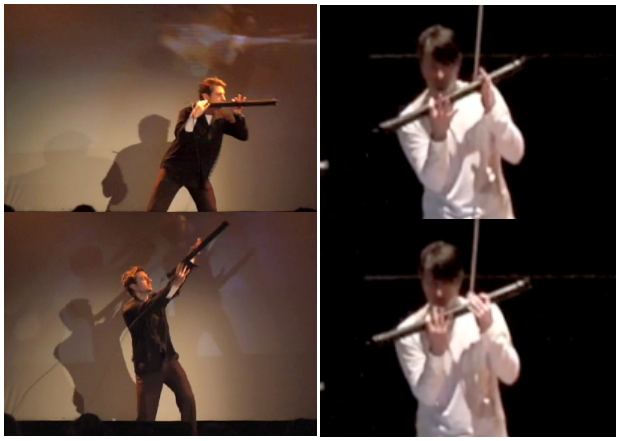

Figure 2. Malleable techniques such as thrust excitation (left) and finger excitation (right).

squeezing or twisting.[2] The manner by which a performer manipulates and manoeuvres the t-stick, therefore, coincides with my first constituent: a DMI is used by musicians for active on-stage music-making. The t-stick is an example of one of the more mature input devices to recently come out of the NIME community. As a result, it has already been well documented by other authors. [1] Nonetheless, the next two paragraphs of this section give a brief summary of t-stick technical and design features. The remainder of this section describes playing techniques and music notation for the t-stick.

3.1 Technical description

The t-stick is built with a structural substrate of ABS or PVC plastic pipe, to which sensors are affixed. The interface features multi-touch capacitive sensing on one side accomplished using discrete strips of copper tape as sense electrodes (Figure 1). It also features 5 independent axes of acceleration sensing (an accelerometer at each end of the DMI), pressure sensing surface (on the side opposite the copper electrodes) and a piezoelectric contact microphone for sensing deformation of the controller as a result of tapping, hitting or twisting. All sensors are sampled using an internal micro-controller fastened within the PVC plastic pipe, and the sensor data are sent to a computer using either wired USB, or Bluetooth or ZigBee wireless protocols. In the current operating mode, sensor data from the t-stick is received by the serial object in Max/MSP. The data is then manipulated within Max/MSP and converted into the Musical Instrument Digital Interface (MIDI) protocol. MIDI messages are subsequently sent to software synthesizers. My usual choice of synthesizers is a physical modelling module from LogicPro called *Sculpture* and a granular synthesizer native to Max/MSP called *Granul8*.[3]

3.2 Design strategy

The design strategy behind the t-stick included developing (1) the outer shape and dimensions of the DMI, (2) the sensor technology allowing a user to interface with the instrument actively and most significantly, (3) the multi-layer mapping techniques that allow for concurrence between a user's manipulation of the DMI and the sonic result. A consistent mapping aim has been to encourage performers to focus simultaneously on both the sound of the DMI and the relation of sound to the entire instrument, rather than having them think about individual sensor mappings. Generally speaking, well-designed mapping layers help a DMI performer in two ways. Firstly, they enable the performer to identify with his or her instrument in a consistent fashion – identifying the control parameters of an instrument is as important as how an instrument sounds and what it looks like. Secondly, as a result of a thoughtful approach to mappings, a playing technique makes itself evident and meaningful for the performer, who is then required to develop his or her competencies with the DMI. In this respect, the t-stick is designed to be played by expert musicians. Emphasis is placed on allowing performers to make expressive decisions based on their musical intelligence, intuition and reading of a musical score. To this end, prominence is given to extending any ceiling on virtuosity rather than on lowering the 'entry-fee'. New users should be able to produce sound from the t-stick, but not necessarily musically pleasing sound.

3.3 Playing techniques

Learning t-stick playing techniques first and foremost entails mastering a repertoire of physical playing gestures irrespective of any sonic result. This approach is, thus,

[2] Designed and built at the Input Devices and Music Interaction Laboratory (IDMIL), McGill University. <www.idmil.org/doku.php?id=projects:the_t-stick>

[3] *Granul8* was designed and built by Stephen Sinclair and Joseph Malloch. <www.idmil.org/software/mappingtools>

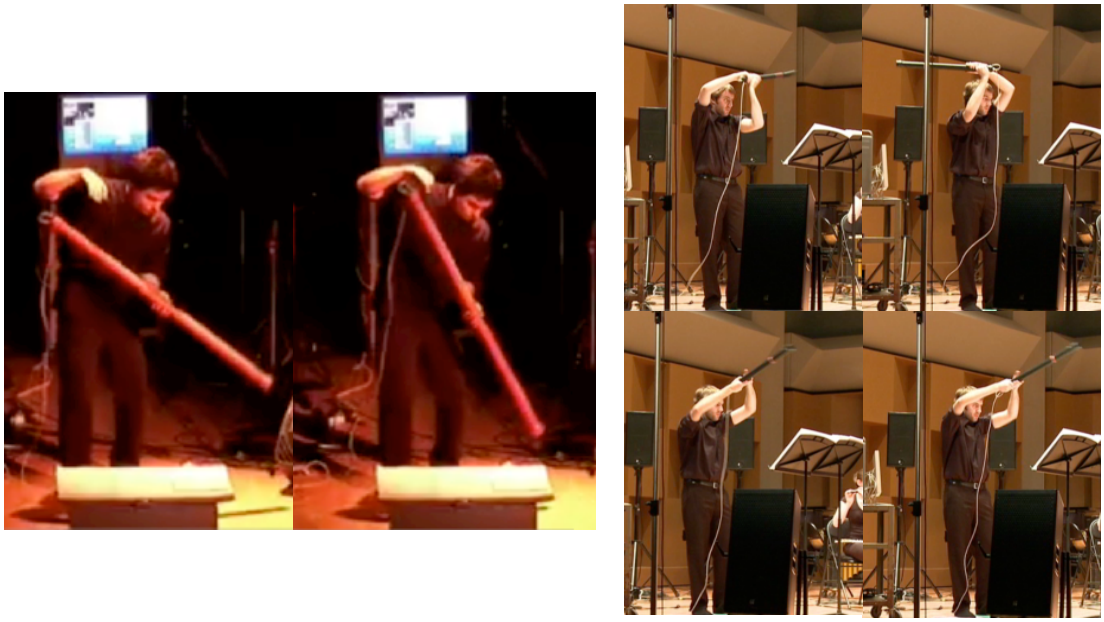

Figure 3. Intractable techniques such as tilting (left) and rotating, or lassoing (right).

synonymous with my second constituent: a DMI is accompanied by an established playing technique and a flexible sound synthesis engine. The reasoning behind this supposition should become more apparent through a reading of the following sections. Performing on the t-stick is solely accomplished through the physical handling of the DMI. No type of computer score following or computer-assisted composition is required. Early in 2005, I began experimenting with t-stick playing techniques, which then evolved through a three-year interdisciplinary project with acoustic instrumentalists, composers and music technologists. [3] I further shaped the techniques into their current form following the completion of the project in March, 2008.

3.3.1 Malleable techniques

I describe the instrument's playing techniques broadly as either 'malleable' or 'intractable'. By 'malleable', I mean techniques (i.e., physical playing gestures) that are easily repeatable and reproduce a consistent sonic result. Malleable techniques are what give performers an immediate 'feedback' recognition of their instrument. For instance, malleable techniques generate sonic gestures such as (1) initiating a sound, (2) articulating a sound (e.g., varying the timbre of an onset) and (3) *crescendi*/ *diminuendi*. These three are fundamental to any digital or acoustic instrument and need to be easily effectuated by performers. Figure 2 illustrates t-stick techniques for initiating a sound.

3.3.2 Intractable techniques

The term 'intractable' refers to playing techniques that afford a great amount of timbral nuance and subtlety. Accordingly, they primarily entail either minute or expanded fluid and shifting physical movements such as tilting and rotating the t-stick (Figure 3). For instance, when notating the music for t-stick, I specifically name intractable performance techniques that visually extend the arms, via the t-stick, and mimic the movement of a large fan ('fan'), the twirling of a lasso ('lasso') or the revolving of an airplane propeller ('airplane'). They are intractable in that maintaining a rigid and static timbre through these techniques is difficult. Mastering the intractable attributes involves learning how to maintain a sense of constant transition among different timbral states and not necessarily how to reproduce repeatedly any timbre at the drop of a hat. Intractable playing techniques rely on performer proficiency, as well as subjectivity, dictated by musical intelligence and intuition. As a result, their successful execution goes a long way toward conveying performer expressiveness.

3.4 Notation

In the previous section, I hinted at the significance of performance expertise, especially when it comes to controlling the intractable attributes of the t-stick in a musically meaningful way. The following discussion on music notation further underlines the importance of instrument proficiency and is, thus, illustrative of my third constituent: a DMI requires performance expertise and must be practised.

3.4.1 Printed musical score

The music for the t-stick is represented in two associated forms: a printed musical score and a software graphical interface of my own design. In the printed score, music for the t-stick is notated on a three-line staff (Figure 4). The top and bottom lines of this staff coincide with the top and bottom of the touch sensing range, respectively. The top of

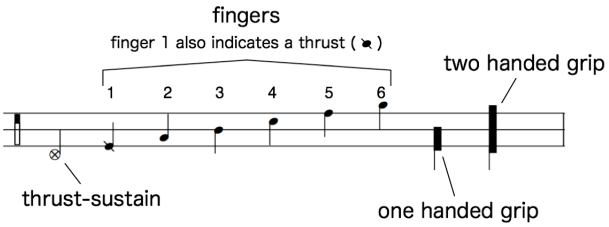

Figure 4. Three-line staff and notational symbols of the t-stick.

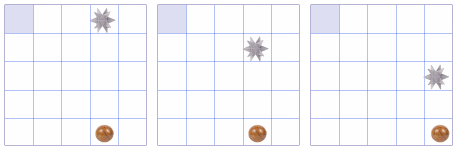

Figure 5. On-screen t-stick tablature grids.

the range denotes the end of the instrument that is furthest away from the USB port; the bottom of the range indicates the end nearest to the port. Musical notes and thin vertical blocks on the staff indicate an approximate placement of single fingers (traditional note-heads) and hand grips (vertical blocks) on the t-stick. The range of sounds is variable and depends upon a musician's control of timbre, which is indicated by t-stick tablature grids located above the staff. I speak more about the t-stick tablature notation in relation to Figures 5 and 6, below. A slash through a note-head specifies a thrusting or jabbing motion with the t-stick and consists in: (1) selecting hand position; (2) tilting and rotating the instrument (and one's own body); and (3) applying a proper degree of force not only in the direction of the jab but also to grip pressure. An encircled 'X' (i.e., ⊗) below the staff specifies a technique known as a 'thrust-sustain', which is an adaptation of the jabbing technique. The thrust-sustain requires a minimum of a 0.75-second preparation time during which the performer must maintain a consistent degree of pressure (on the pressure-sensing side of the DMI) before executing the jabbing movement. The result may be anything from a series of sustained cacophonous bell-like tones to a brittle and woody bubbling, depending on the degree of pressure used. Changes in volume are traditionally notated with standard dynamic symbols: ***p*** , ***f*** , *crescendo*, etc.. In addition, the *lv* symbol, which is a standard mark for percussion music, is found above the staff and specifies that the sound of the t-stick be allowed to resonate.

3.4.2 Graphical software interface

The second component of t-stick notation concerns a graphical software interface for displaying a type of

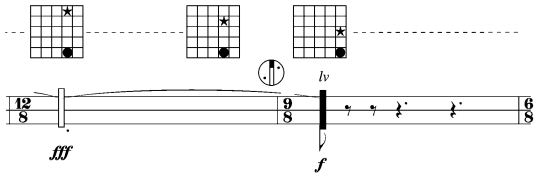

Figure 6. T-stick tablature, above the staff.

Figure 7. T-stick orientation symbols.

dynamically-changing tablature system. I invented both the interface and the tablature system. Generally speaking, the timbre of the t-stick results from both tilt and rotation; however several other factors concomitantly contribute to the resulting sound (e.g., degree and location of surface contact, pressure applied to surface). Symbols (Figure 5) appearing on a computer screen and above the staff (Figure 6) inform the performer about the current tilt and rotation of the instrument, as well as approximate contact positions (i.e., hand positions). In Figure 5, we see three tablature grids. The circle and star contained within each grid correspond to control parameters of two instances of Sculpture (Sculpture is mentioned in **3.1 Technical description**); the circle is related to one instance and the star, the other.[4] During a performance, the grid elements (i.e., circle and star) shift up and down and from side to side corresponding to the physical handling of the t-stick. For instance, tilting the t-stick moves both elements horizontally.[5] The star moves vertically as a result of rotating along the lateral access of the DMI while hand width, combined with hand position along the surface of the DMI, controls the vertical positioning of the circle. During a performance, a musician reads the notated tablature grids in the printed score along with information written on and below the staff. Next, he or she manipulates the t-stick in order to match the on-screen tablature to the notated grids. For instance, the three grids shown in Figure 5 correspond to the notated musical score grids of Figure 6. Furthermore, dotted lines appear between notated grids in Figure 6 and indicate a gradual change from one grid to the next. T-stick playing technique, therefore, requires one to have a swift and accurate grasp of the tablature system so that one can smoothly shift from hand position to hand position while fluidly rotating and tilting the instrument.

3.4.3 A supplementary symbol

One further symbol shown in Figure 6 needs clarification. Throughout the development of the DMI notated

[4] The shaded top left corner of each grid has been used in previous versions of the on-screen interface. The shaded corner can be automated so that it moves from square to square.

[5] I give photographic examples of tilting in Figure 3.

Figure 8. Performance of *Catching Air and the Superman* (2008)
McGill Contemporary Music Ensemble, Denys Bouliane
Kimihiro Yasaka, keyboard
Lindsay Roberts & Eric Derr, soprano t-sticks

indications for t-stick orientation have been found to be useful (Figure 7). I continue to use them even though some similar information is already conveyed by the tablature grids. From my experiences as both composer and performer on the DMI, I have observed that these orientation symbols provide a simple and coherent means of conveying basic tilt and hand position information. For instance, the first symbol of Figure 7 specifies holding the t-stick upright (i.e., the top of the t-stick pointing upward) and vertical with the left hand on the bottom and the right hand on the top.

4. Case Study: *Catching Air and the Superman*

As a final step toward my doctoral degree at McGill University, I created an approximately fifteen-minute, one-movement composition for sixteen musicians, entitled *Catching Air and the Superman*. It features interactive electronics through an integration of input devices and acoustic instruments (Figure 8). In total, three digital instruments are heard in the work: two soprano t-sticks and a MIDI keyboard. The acoustic instruments constitute a chamber orchestra: flute (piccolo), oboe, clarinet, tenor saxophone, baritone saxophone, trumpet, trombone, two percussion, two violins, viola and violoncello. One of my objectives in composing *Catching Air and the Superman* was to illustrate how a DMI can form an integral whole with the musical concepts and materials of a composition (my fourth constituent). In particular, I set out to show how DMI instrumentalists function equally with acoustic instrumentalists in terms of a lively stage presence and musical sound production.

4.1 Introducing limits and constraints

My research into areas of performance technique for the t-stick and sound synthesis for all the digital instruments (i.e., two t-sticks and MIDI keyboard) led to my establishing limits and constraints, which in turn shaped aspects of the compositional project. For instance, the musicians' control over sound production with the t-sticks was limited so that a number of primary musical gestures could be easily communicated to the audience and the rest of the ensemble. These gestures controlled sound excitation or initiation, articulation and volume. In general, audiences find it simple to correlate, say, a physical jabbing motion on the t-stick to a percussive attack, whereas other correspondences remain nebulous (e.g., tilting and rotating the instrument, mapped to uninterrupted timbre modulation). Nonetheless, I limited and constrained the gamut of possible physical playing gestures so that the t-stick would have an equally identifiable stage presence as the acoustic instruments by virtue of its limited range of effective movements.[6] Next, I was able to create a hierarchy of tension based on the t-stick movement vocabulary and consequently, I employed specific playing techniques at critical moments in *Catching Air and the Superman*. The most obvious example occurs at the climax of the work. Both t-stick players use dramatic extended physical gestures that entail fanning, twirling and revolving their instrument. The resulting sound exhibits a cyclic or pericentral motion described by frequency contours. At the same time, a perception of divergence is achieved by a gradual widening of pitch space delineated by the acoustic instruments of the ensemble. In preparation

[6] Acoustic instruments come with their own inherent constraints that allow the audience to identify them. For instance, an instrument roughly held parallel to the floor, laterally across the body and jutting out to one side will most likely be recognised as a flute. Moreover, certain sounds will be anticipated by the audience upon their seeing the instrument move.

for the climax of the piece, the extended gestures of the t-stick instrumentalists decelerate and, thus, the listener is treated to sounds that seemingly diverge simultaneously with, and at the same rate as, the rest of the ensemble. Consequently, musical tension is heightened by the arrival of a synchronised musical gesture among the digital and acoustic instrumentalists.

5. Conclusion

There is no duller musical experience for an audience than observing 'performers' who are seemingly absorbed in a task devoid of any musical meaning. There are too many ambiguities – too much confusion as to the extent of human agency – at play in a performance in which performers rest seated at an ordinary table, in front of an ordinary computer and possibly using an ordinary interface. Even the ordinary can have an enriching artistic significance.[7] However, without 'reframing' the ordinary, mundane or ubiquitous, any sense of evolution or transgression from the norm is side-stepped. On the one hand, the geometry and dimensions of the t-stick call to mind a large array of very ordinary present-day objects. On the other hand, the 'object' has been recast and as a result, has been imbued with unique properties that allow it to be identified as a musical instrument. Performing on the t-stick, therefore, is a means for musicians to engage in active, lively and vigorous music-making.

7. Acknowledgements

I wish to extend my gratitude to those musicians – those performing and scientifically-minded musicians – without whom the outcome of my work would have been much less enriching, and surely meagre in comparison to the advancements we made as an interdisciplinary team while working at the Centre for Interdisciplinary Research in Music Media and Technology (McGill University), as well as the centre's satellite studios and laboratories.

8. References

[1] Malloch, J. and M. M. Wanderley. (2007). The T-Stick: From Musical Interface to Musical Instrument. (in proceedings of the 2007 International Conference on New Interfaces for Musical Expression) New York City, USA, 66-69.

[2] Mulder, A. (2000). Towards a choice of gestural constraints for instrumental performers. Trends in gestural control of music CD-ROM. (M. M. Wanderley & M. Battier, Eds.) Paris: Ircam - Centre Pompidou.

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[7] The pop art movement of the 1960s is evidence of this.