The Appropriation and Utility of Constrained ADMIs

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ABSTRACT

This paper reflects on players' first responses to a constrained Accessible Digital Musical Instrument (ADMI) in open, child-led sessions with seven children at a special school. Each player's gestures with the instrument were sketched, categorised and compared with those of others among the group. Additionally, sensor data from the instruments was recorded and analysed to give a secondary indication of playing style, based on note and silence durations. In accord with previous studies, the high degree of constraints led to a diverse range of playing styles, allowing each player to appropriate and explore the instruments within a short inaugural session. The open, undirected sessions also provided insights which could potentially direct future work based on each person's responses to the instruments. The paper closes with a short discussion of these diverse styles, and the potential role constrained ADMIs could serve as 'ice-breakers' in musical projects that seek to co-produce or co-design with neurodiverse children and young people.

Author Keywords

appropriation, constraint, design principles and concepts, inclusive music, neurodiversity

CCS Concepts

•**Human-centered computing → HCI theory, concepts and models; User centered design;** •**Applied computing → Sound and music computing;**

1. INTRODUCTION

Recent artistic projects such as *Sound to Music* [12], the *Artism Ensemble* [3], and *Jamboree* [6] all reflect an increasing desire among the makers of inclusive art and music to find ways to make work that is either led by, or co-produced with neurodiverse groups of young people. Such projects create an exciting space for new music and new musical experiences, and allow mixed groups of people to learn from one another. However, these are also contexts which are particularly vulnerable to the enculturated habits and assumptions about music and performance held by neurotypical people participating in, or on the periphery of the music;

long-standing biases can often slow or impede collaboration [2, 6]. The design of Accessible Digital Musical Instruments (ADMIs) for such contexts, therefore, presents an interesting requirement: one of needing to remain open to a diverse range of perspectives and preferences, which can all be at play simultaneously within an ensemble [5, 16]. Designing ADMIs with high levels of constraints may be one way to achieve such openness. As well as presenting a lower technical and cognitive entry point for music-making, previous studies with neurotypical groups have found that not only can diverse performance styles occur in spite of a DMI's heavy constraints, they may actually be encouraged by them [7, 18]. Instruments with extreme constraints, modelled after instruments in these previous studies, could be valuable as an open and more immediate alternative to hyper-configurable, commercially available accessible instruments, as the choice offered by the latter can risk disempowering the player by offloading aesthetic decisions to a music/arts facilitator [17]. The work outlined below addresses this very notion, of the potential utility of deliberately constrained instruments as a means to support or develop unique musical practices with young neurodiverse performers.

2. ONE-BUTTON SOUND CUBES

Figure 1: One of three one-button sound cubes.

A single-button ADMI was designed specifically for the small scale study. The instrument's structure was 3D printed, with two colours marking out a single analogue push-button

and speaker grille. These were placed on opposite sides of an 8cm cubic frame, as shown in Figure 1. Inside, the fully embedded instrument houses a Teensy 4.0 microcontroller and I2S amplifier. Sounds were designed using the Teensy Audio Library and FAUST platforms, and were all based around the same clarinet physical model. A bluetooth module was also added to the instrument to allow sensor data to be streamed to a laptop.

Three versions of this instrument were used in the study, with a variety of approaches to sound design taken in order to support a diverse range of sonic preferences. This was based around the idea of *interaction-congruence*, in which sounds are designed based on anticipated relationships between sound, technique and expectations in the performers' use of the instrument [16]. The first instrument, coloured blue, was designed to behave in a highly predictable fashion by mapping the analogue range of the button directly to the volume of a single tone. A second orange instrument also had a predictable mapping of the button to volume, but with added potential to play melodies. Quick successive presses would cycle through a 12-tone row, while a long pause would reset the play position to the start of a row. This was inspired by Skoog Music's 1-button instrument, the *Skwitch* [11]. The tone row was randomly generated each time the instrument is turned on. As a result, the orange instrument was predictable in its behaviour, but with some 'hidden' information that could be discovered and explored. The third, white instrument was designed to provide a more ambiguous relationship with gestures and sounds. The clarinet physical model was placed within a feedback loop, controlled by the button, resulting in non-linear behaviour. Repeated gestures on this instrument would produce broadly similar results, but which were also difficult to predict in detail.

3. METHODS

The instruments were played by a small group of seven nonverbal young people in short solo sessions of up to fifteen minutes, situated in an uncluttered music room at a collaborating special school. These sessions were planned and structured based on prior experiences in inclusive theatre, particularly with the Oily Cart theatre company [10]. This work typically employed social stories to minimise any potential anxiety over changes to routine, made use of clear, minimal performance structures and used little or no verbal language, helping to focus activities around the materials on offer, and on non-verbal interaction between participants. Following a similar model, social stories were sent out in advance of the sessions, and the sessions were largely non-verbal and non-instructive, leaving each player to interact with the instruments as they saw fit. The sessions were clearly structured in five possible sections: a warm up with some recorded music, the introduction of the blue, orange and white instruments one by one, and, if needed, a cool-down section with another recorded track. Adults in the sessions *could* interact in the sessions, but only in ways prompted by the player (an approach similar to Intensive Interaction [8]), or if a lack of direction could cause distress or confusion. Sessions were recorded with a compact HD video recorder, secured discreetly to a wall in the room.

The subsequent analysis of the session recordings was informed by prior studies on constrained instruments by Gurevich et al. [7], and Zappi & McPherson [18]. However, the range of data for this study was restricted to two aspects that could be directly seen and recorded – gesture types and note/silence lengths – as there was little or no possibility for verbal feedback from the group, and a high

risk of interpretive error beyond these categories. Even with these limited modes of analysis, it is important to acknowledge that the data presented below is qualitative, and takes a very simplified view on playing styles within the group, as seen by a neurotypical observer.

Gestures were codified inductively – similar to the approaches taken in [7] and [18] – by recording the first instances of a new gesture in each session, and organising the subsequent list by category and variation. This process loosely defined a 'new gesture' as anything that would feel or sound significantly different for the player in their use of the instrument. In some cases, the process of defining a new gesture involved the use of sketching as a form of non-verbal thinking about the spacial nature of the gestures [9], and/or physically copying sets of gestures from the video footage to gain a first-hand interpretation of what they might feel like. These gestures were then plotted against a list of participants as a means to observe the commonalities and differences in gestures performed by the group.

Sensor data was recorded via bluetooth from the instruments for the active duration of the session. Initially, the use of heat maps (as in [18]) was explored as a way of succinctly representing the use of the sensor's dynamic range across a whole session. This was eventually abandoned, however, as it became difficult to separate intentional dynamic gestures from cases where some dynamic motion is simply a byproduct of a playing technique. Instead, the sensor data was used to give an indication of rhythmic style, taking inspiration from the analysis of note-silence pairs in one button instruments by Gurevich et al. [7]. The same definitions for short, medium and long notes/silences were used: short durations were defined as under 1s, medium durations between 1 and 3s, and long durations as over 3s. As some players used all three instruments at once, it wasn't possible to analyse the sensor data by note-silence pairs as in [7]. Instead, the distribution of note/silence lengths is represented as a percentage of the time from the onset of the first gesture to the end of the last within a session. In cases where multiple instruments were used simultaneously, the percentages for short/medium/long notes was taken as a proportion of the playing percentage for a session. This use of time as an indicator of engagement with musical features is similar to the approach taken on a previous project that aimed to record responses to ADMIs' with differing interaction-congruence [16]. A simple sketch in Processing 3 was used to calculate and render the note/silence lengths and percentages for each session. Regions of sensor data for short, medium and long notes were coloured red yellow and green respectively, and silences with darker versions of those same colours. This allowed the rhythmic fingerprint of each session to be seen once the data was visualised.

Finally, all categorised gestures were again sketched from video stills as part of the documentation process. This was primarily a means by which the creative contributions of the young people at the school could be made visible and acknowledged, without causing ethical and safeguarding issues related to privacy and identity. Identifying features – such as facial features, hair, etc. – were not drawn.

For reasons of space, only some of the data from this study can be shown here, but what *is* included are sketches of all the sounding gestures, visualised sensor data, percentages for note/silence lengths, and a gesture comparison chart [1].

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[1] Supplementary data, as well as larger-size versions of the charts and images, can be found at:
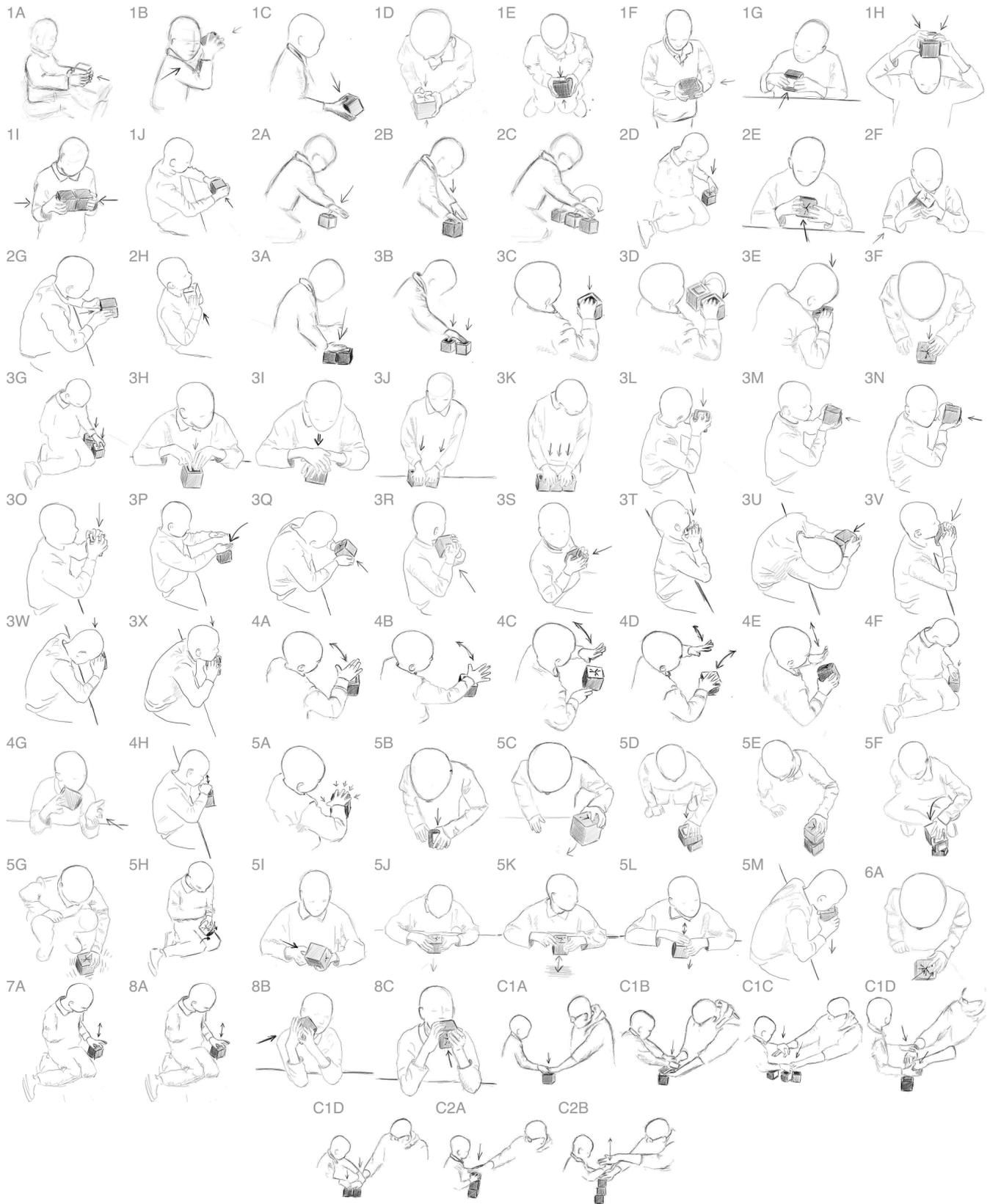http://joewrightmusic.co.uk/NIME20Files.zip

Figure 2: Gestures performed with the Constrained Instruments.

Figure 3: Chart of recorded gestures from the seven players.

Figure 4: Sensor data collected during each player's session.

4. FINDINGS
4.1 Analysis

The responses of the seven players to the constrained instruments were indeed very diverse across all aspects of this data. A total of 83 gestures were recorded comprising 75 sounding gestures (where the instrument is producing sound), and 8 non-sounding gestures (in which a player is engaged with the instrument in a way that does not directly produce sound). Sounding gestures were divided into a further set of categories: Squeezes (10), thumb-presses (8), hand/arm-presses (24), strikes/taps (8), grabs/holds (13), swipes (1), mutes (1), body presses (3), as well as cooperative pressing (5) and cooperative tower stacking gestures (2). Of all the gestures, only 13 (16%) were not unique to one person, and only one of these actions was shared by more than two people. This can be seen in Fig. 3. All except one of the players' gesture-sets were at least 60% unique, and none shared gestures with more than half of the whole group. All of these perspectives on the recorded gestures suggest that the constrained instruments elicited a very diverse range of playing techniques, and that the playing style of each musician was more unique than it was shared with the group (although there were commonalities).

Visualisations of sensor data were similarly varied. Although all players engaged positively with the instruments, the session times varied drastically. This was to be expected, given that the group were trying something new, with a relatively unknown person, and with little in the way of specific instructions. Players 2-5 have clear rhythmic and dynamic fingerprints which can be seen in Figure 4, and where there are similarities in some aspects of the sensor data, differences can be seen elsewhere. For instance, the first four minutes of data for players 6 and 7 are similar, but diverge with the introduction of the white sound-cube. One appears disinterested, while the other begins to explore longer gestures. Sessions from players 1 and 6 have similar rhythmic proportions, but appear very different in the sensor data plots. Player 2, who appeared to share the most in common with other players in the gesture chart, is set apart in this dataset by a strikingly consistent session timeline, which is overwhelmingly dominated by punctuated, medium length notes. The sensor data, then, also suggests a degree of individuality in the playing styles of each player.

As Fig. 3 shows, there are sets of related gestures within each category which emerge from a single player. As the sketches in Fig. 2 appear in the same order, it is possible to see how these sets of gestures flow from one another as part of exploratory musical play. In some cases, this exploration led to the discovery of *hidden affordances* in the constrained instruments. This can be seen in gestures 2H, 5L and 5M, where the cubes' open speaker grille can be obstructed, producing a wah-wah effect; in gestures 5B-5E, where the body of the instrument is slammed onto another surface for an acoustic percussive sound; and in 6A, where a player swept their fingers over the holes in the speaker grille, no-doubt leading to a satisfying tactile experience along with the gentle sweeping sounds.

The data gathered during this small study suggests a similar outcome to previous studies on constrained instruments [7, 18], but in a different context, with a slightly different approach. At the very least, the constrained instruments were capable of supporting the diverse playing styles within this small group of young people. It is also possible that – given the exploratory play and discovery of hidden affordances – the constraints of these instruments encouraged the players to look for satisfying ways to play them.

4.2 Individual Styles

At this point in the paper, I wish to explore the less impersonal aspects of the data gathered for the study. Not only does the information arising from the constrained instruments suggest a degree of individuality for each player relative to rest of the group, it also suggests potential avenues for further collaboration with each of these people. This is especially true when coupled with my first-hand experiences of the sessions.

As discussed in [17], constrained instruments can create more clarity for the user in the exploration of different gestures, and greater clarity for the observer in discerning how and why a player might be responding to an instrument. As a result of this clarity, my first impressions for each player in these sessions with the constrained sound cubes, can be summarised as follows:

Player 1 was most engaged by cooperative press gestures. Future work might explore a musical equivalent of Ahlquist's *Social Sensory Architectures* [1], where the most satisfying sensory results are only accessible through cooperative play.

Player 2 had a highly consistent style, seemingly focused on joining/combining sounds into phrases, rather than varying technique or note length. A more traditional keyboard-like approach, distributed across many devices, may expand this yet further.

Player 3's gestures were exclusively percussive, but were also mediated by a thirst for new sounds. Future work could explore how a large number of sounds could be made accessible through a drum-like interface.

Player 4 used the instruments in a wide variety of ways, being the only player to use an instrument as a drone whilst playing another more percussively. This could lead to explorations of instruments that take contrasting textural roles in sound, and can either be set up to play continuously, or on a momentary basis.

Player 5, by contrast, played drones almost exclusively during their session, and ignored the white sound cube. Next steps might include the design of drone-devices that create a sonic environment that supports an *indwelling* rather than *musicking* stance (see [13]) towards instruments in performance.

Player 6 was very engaged for most of their short session, and it appeared that much of the exploration of the instruments sought to maximise vibrotactile intensity. Further work could explore how the haptic potential of the instrument could be increased and extended to different sounds.

Player 7 also seemed highly motivated by the vibrotactile potential of the instruments. But the performance style changed with the introduction of the more chaotic instrument, becoming more focused on its unpredictability. Future work could therefore explore strongly vibrating or resonant devices with non-linear sound design.

5. DISCUSSION

This study found that, with a small pool of neurodiverse players, the three constrained ADMIs facilitated a very diverse range of playing techniques and styles, providing a valuable first impression for each person's musical tastes. Future research plans stemming from this project will aim to explore how the collaborative ideas listed above can guide the development of bespoke prototype ADMIs for each of the seven players in the study. Like all first impressions, these ideas could be wrong, and where this proves to be the case, constrained ADMIs may again provide a clear tool with which to explore such a misunderstanding. More generally, highly constrained ADMIs may prove useful for in-

clusive arts, music and design when used in this way. As detailed above, they can provide fewer technical/cognitive barriers to participation, and instead emphasise personal style in sonic/musical interaction. As such, they may be able to serve as 'ice-breakers' for contexts that aim for effective collaboration with neurodiverse children and young people, and also serve as a mediating tool through which diverse groups of people (players, makers, designers, music providers etc.), can take part in a longer-term dialogue through musical play, observation and production. In both the fields of inclusive ADMI design and performance, this could be a fruitful area for further research and experimentation.

6. INCIDENTAL OBSERVATIONS

I have seen yet more evidence in this study for the value of fully embedded instruments in inclusive musical settings, building on similar evidence in my prior work [15]. Vibration seeking behaviours in many of the group members reinforces arguments put forward by Frid [4] that vibrotactile feedback is currently under-utilised in ADMIs. The embedded nature of the sound cubes also allowed users to project sounds where they wanted to (i.e. Gestures 1H, 2E, 3T, 8B). This enforces the need to consider an ADMI's sensory coherence (the co/dis-location of sensory feedback an instrument produces), as stressed by Ward et al. [14].

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8. ETHICAL STANDARDS

This research was conducted in accordance with ethical standards and best practices at the Royal Birmingham Conservatoire, Birmingham City University and the participating school. All the data for the study has been gathered with permission from parents and guardians, and every effort has been taken to safeguard the young people involved.

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