Hands where we can see them! Investigating the impact of gesture size on audience perception

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ABSTRACT

This paper explores the relative effect of gesture size on audience perception of digital musical instrument (DMI) performance. In a study involving a total audience of 28 people (split into 2 groups of 13 and 15), we used a small and large version of a DMI to examine how the size of performers' gestures might differ, and how this affects post-hoc audience ratings of enjoyment, interest and understanding, as well as their indications of 'enjoyment' and 'error' in real time. For each audience we held two 5-minute performances, the first on a custom-designed percussion DMI, and the second on a laptop. The DMI used in each performance was made up of three elements identical in shape, materiality, interaction and sound, but the physical size was different: For one each element was approx 12x10x5cm, and the other was about 3.5 times bigger (approx. 40x30x20cm). Data was collected both during and after the performance via post-hoc and real-time methods. We found that beyond a performance simply involving physical gesture, the size of gesture has an impact on audience ratings. In this paper we detail this study and its results, and present the implications that this finding has for DMI design.

1. INTRODUCTION

The NIME community is intensely interested in gesture. In 2014 Jensenius found that NIME uses the word 'gesture' in an average of 62% of publications per year, far more than other related fields (SMC: 34%; ICMC: 17%). [1].

Gestures are a core component of music, and act as a 'bridge between movement and meaning' [2]. Leman [3] has presented theoretical insights on embodied musical cognition, suggesting that music is both *multimodal* (sensed with a combination of auditory, visual and sensory information) and *embodied* (closely linked to bodily experience). A study by Tsay [4] supports this: By watching only silent video footage of a music competition, amateurs were as good as experts at picking the winners, suggesting that we rely primarily on visual information when judging music.

The sound produced by traiditional instruments is tightly bound to the gestures used to play them: The performer gesture generates the energy to produce the sound, thereby determining the amplitude, pitch and dynamic and timbral qualities of the sound [5]. In the case of digital musical instruments (DMIs), that tight coupling between the action and the sound produced is entirely optional, thanks to the miniaturisation of computers the the labour-saving qualities of electricity [6].

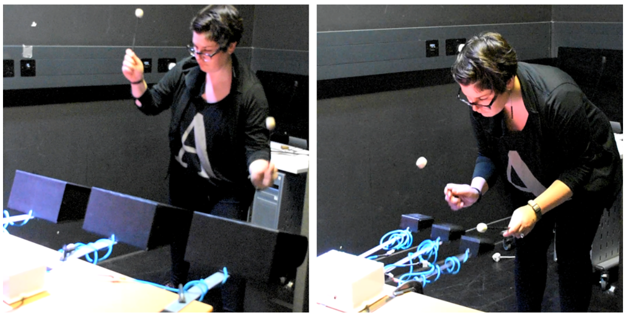

Figure 1. Example of playing gestures for MOAI. Left: Large. Right: Small.

Though there are many well-established frameworks for understanding that nature of gesture in the context of NIME, such as [7, 8, 9, 10]. There are also studies comparing diverse instruments [11] and the diversity of performance on a single instrument [12]. Wessel and Wright mention that there 'should be some sort of correspondence between the size [of the gesture] and the acoustic result' [10], but they do not offer any specifics on gesture size, or how the instrument itself might affect this relationship. In order to address this gap in specific gesture knowledge, this study examines how the size of instrumental gesture changes audience perception by comparing audience feedback on one instrument made in two sizes, and considers how the physical design of a DMI impacts the gestures used to play it.

1.1 Defining 'gesture'

Cadoz and Wanderley, in an early interdisciplinary study, state that gesture does not have one common definition [13]. NIME has borrowed heavily from HCI ideas about gesture, including adopting broad definitions such as 'a motion that contains information' ([14], quoted in [15]), applying Fitts law to musical gestures [16], and developing systems to understand the affective content of gestures [17].

In this paper, we consider the notion of 'gesture' within Miranda and Wanderley's 2006 concept of *instrumental* *gesture*: '[I]t is applied to a concrete (material) object with which there is physical interaction, and specific (physical) phenomena are produced during a physical interaction whose forms and dynamics can be mastered by the subject.' [18] In other words, we consider gesture as a human physical action applied to an object that produces sound.

1.2 Gestural affordances of the DMI

Leman [3] presents a theory of the body building up gesture 'repertoires' as it mediates between the physical world and subjective experience. Though there is a huge range of performer decision, history, and knowledge that will determine their exact method of playing (as established by Jorda [12]), the physical design of the DMI impacts this gesture repertoire by presenting certain *affordances*. 'Affordances' are defined by Gibson [19] as what an environment offers to an animal (or human actor) within it, and in a DMI context can be described as a mapping between environment's properties, and the actor's potential actions. The affordances of an instrument have been used to study the microdiversity of playing styles [20], but there is yet no specific use of affordances to adjust gestural repertoires.

1.3 Gesture and multimodality

Music is a multimodal experience, meaning visual and other sensory factors profoundly influence the way audiences perceive it. There is general consensus that gesture is important: Fyans et al. [21] suggest that audiences must relate gestures to sound to build a mental model of how the instrument and understand the performer's intent. Schloss [22] states that since the gesture/sound relationship is not necessarily one-to-one, we must understand what works in order to communicate to audiences. Fels et al. [23] contribute the notion of transparency, asserting that the audience and performer must share a common understanding of input-output mapping in order for communication to take place. Sheridan [24] argues that an audience must understand the *performance frame* created and used by performers.

Despite this consensus, there is not much indication of how an effective expressive gesture might look, or how we might craft interfaces to support effective gestures. Schloss [22] states that a 'visual component is essential to the audience' and that 'effort is important', but goes no further.

There is some indication of effective gesture characteristics by Reeves et al. [25]. They define the input/output relationship to be made up of *manipulations* and *effects*. By placing these two elements on axes from *hidden* to *amplified*, and a taxonomy of gesture can be extracted:
Magical: Amplified effects, hidden manipulations
Secretive: Hidden effects, hidden manipulations
Suspenseful: Hidden effects, amplified manipulations
Expressive: Amplified effects, amplified manipulations

This taxonomy suggests that both the performer's manipulations and the effects should be amplified. But, it does not tell us how big a gesture has to be to be 'amplified', if amplification a function of the gesture itself or the scale of that gesture, or how the design of the interface might impact that gesture and amplification.

We were motivated, therefore, to test whether the size of the gestures used to play a DMI have effect on audience perception. By using a DMI in two versions - one large, one small - we presented to a performer one set of sound controls but two different sets of affordances, resulting in two gesture repertoires. We then tested these with separate audiences against a laptop performance, and measured the relative effects using a combined methodology of post-hoc and real-time data. This paper presents this study, results, and a discussion of the implications for DMI design.

2. INSTRUMENT DESIGN: MOAI

MOAI stands for Multiply Oscillating and Actuated Interface, and was designed in consultation with the members of Ex-Easter Island Head. ('Moai' is the term for the monolithic human figures of Easter Island.)

MOAI is composed of three boxes (see Figure 1) identical in materiality, proportions, internal hardware, and response, but different in scale. The three boxes are made of wood and covered in black vinyl, and they taper towards the player where they end in a rounded front that can be easily grabbed. We produced MOAI in two sizes: large (each box 40x30x20cm) and and about 3.5 times smaller (each box 12x15x5cm). For each version, each of the three boxes are attached a flexible steel bar clamped to a table, such that the boxes oscillate up and down when struck. Each box attaches to the central control interface via a cable, in which an embedded system [26] processes the three streams of analogue sensor data and produces the audio output. See Figure 2.

The sound design, hardware and interaction are identical for both versions of MOAI. There is one core sound, produced from a 60Hz background hum in NASA's audio recording of the Apollo 11 moon landing. This hum was isolated and made into a percussive sound by adding an envelope. This sound is applied to Box 2, transposed up by a minor third for Box 3, and transposed down by the same interval for Box 1. As well as its core sound, each box can produce 2 other possible sounds: the core sound with added high frequency partials, or the core sound with added low frequency partials.

The hardware inside each box is a 7-element piezo network (a velocity-sensitive trigger for samples) and an accelerometer (that constantly measure the box's oscillation, switching between sound-producing states). Each box senses interaction independently, but all three data streams are processed by the central embedded system.

Figure 2. Left: MOAI control box. Right: Contrast of large and small size elements.

3. STUDY DESIGN

3.1 Data gathering methodology

Audience studies in NIME unanimously use post-hoc data to draw audience conclusions, but the recall abilities of humans, especially with respect to speed, time and duration, are well established as poor [27]. This study is part of a larger work on risk and error in electronic music performance [28] and this work takes place in live context, we are motivated to see what dimensions real-time data might lend to study outcomes, and to see if new insights are possible by using combined data sets. To this end, we have developed a data-gathering methodology that uses a combination of real-time and post-hoc data, and this section provides some detail about our approach.

3.2 Post-hoc collection

We collected post-hoc data in the form of surveys, consisting of two short post-performance surveys to be filled out straight after each performance (asking for quick quantitative and qualitative impressions), and a longer post-concert survey filled out at the end (collecting demographic detail and asking more reflective questions). [1]

3.3 Real-time data collection

When looking for an existing solution for real-time data collection, we found all commercial applications to be some combination of expensive, cumbersome, or not fit for purpose. To address our specific needs we built a system called Metrix [2] .

Metrix leverages the ubiquity of smartphone technology in our research context, and runs in any mobile browser. (An in-depth description of Metrix's design and function can be found in [29].) When a spectator connects to Metrix they are assigned a username, which they then note on their survey book. This enables us to later relate and compare their post-hoc and real-time data. The Metrix interface is made active during performances and inactive afterwards by the investigator via a remote control interface.

The active Metrix interface splits the mobile phone screen in half, into two buttons (see Figure 3). The buttons allow participants to indicate two states: 'I am enjoying this' (indicated by a smile emoticon), and 'I heard an error' (indicated by an X). We designed this interface to be unobtrusive to use during a performance, using symbols to reduce cognitive load and employing discrete buttons. These buttons are easily used during a performance by tapping either side of the screen, and don't require the participant to look at or monitor the interface (to maintain a neutral slider position, for example).

[1] Link to survey questions: http://bit.ly/2jLNLFP
[2] [Github link removed for review]

Table 1. Average hits per audience member by performance

	Audience 1		Audience 2	
	MOAI (L)	Laptop	MOAI (S)	Laptop
Enjoyment	21.31	7.62	17.17	13.50
Error	1.77	4.54	2.75	5.33

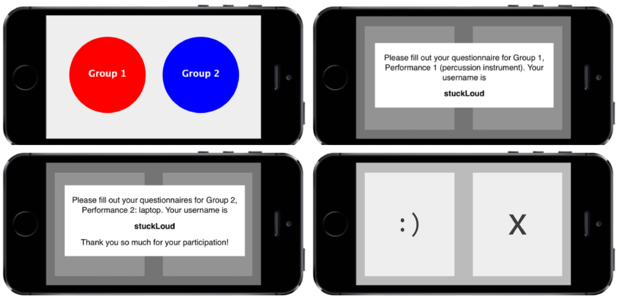

Figure 3. Metrix interface, v2. Clockwise from top left: Group selection screen; screen between performances; screen at end of concert; active interface.

3.4 Method

Two performers were recruited for this study:
Benjamin Duvall, the leader of percussion group Ex-Easter Island Head [3] . He composed for MOAI and rehearsed with both versions of the interface for 4 weeks ahead of the performances. He played the same composition for both audiences.
Joanne Armitage, a laptop performer [4] . She wrote software for live coding improvisation using the MOAI sounds.

Precedent effect was a major consideration. We could not have the entire audience watch both versions of MOAI and compare ratings, as the novelty factor of the first performance would be a major confounding factor. For this reason, we split the audience into two: Audience 1 (A1), N=14; Audience 2 (A2), N=15. Each audience one pair of performances - one version of MOAI, and one laptop performance.

Joanne performs seated at a laptop, using very little visible gesture. The gestures of laptop music are generally far subtler than those used in percussion, and less obvious as instrumental gestures (Zicarelli pinpointed this issue as being related to the association between computer interfaces and office work [30]). We did not project Joanne's code during her performance, to ensure that the visual content for all performers was constrained to the performer and instrument only. The laptop performances, which were similar for each audience, acted as a minimal-gesture baseline against which the perception each MOAI could be evaluated.

We also controlled for sound variations: The sounds that Joanne manipulated were the same sounds designed for MOAI, to provide timbral consistency.

At the concert, the audience was divided into two groups in the performance space, according to where they chose to sit. They were briefed together on the use of Metrix and shown a 2-minute video explaining its function.

The performances were structured as follows:
Audience 1: P1: MOAI large, BD; P2: laptop, JA
Audience 2: P1: MOAI small, BD; P2: laptop, JA

Before the performances, the entire audience stepped outside of the performance space. Snacks were provided. A1 came in to watch the performance while the A2 continued to enjoy snacks and then the group swapped, thus ensuring

[3] exeasterislandhead.com
[4] https://joannnne.github.io/

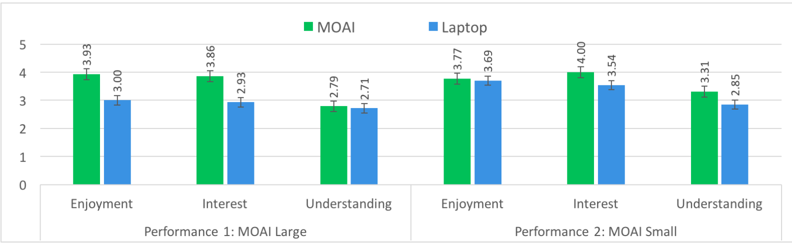

Figure 4. Average ratings of Enjoyment, Interest and Understanding for MOAI and laptop, by audience. Error bars show the standard error.

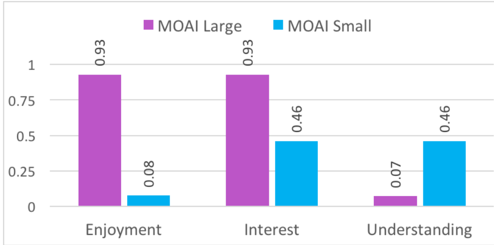

Figure 5. Difference in ratings between instrument and laptop, by audience

that no group was denied a break or snacks before watching their performances. The MOAI and laptop performances were each about 5 minutes in length.

4. RESULTS

4.1 Post-hoc Results

The post-hoc surveys collected some demographic detail. 62% of both groups were within the 25-34 age range, and the two groups had similar years of experience with musical practice, composition, and/or research (3.04 years for A1, and 4.16 years for A2).

4.1.1 Quantitative results

The first comparison we made was of the ratings of Enjoyment, Interest and Understanding for each version of the DMI vs the laptop (see Figure 4).

First, we looked at the *difference* in the MOAI vs laptop ratings, for each audience. In these results, the performance on the large DMI was rated higher than the the laptop performance for Enjoyment and Interest (ΔE=0.89, ΔI=0.47). For the rating of Understanding, the small MOAI rated higher (ΔU=0.39).

We performed t-tests on the qualitative ratings to assess the validity and significance of these observations. We found that, for the large MOAI vs the laptop, the increases in Enjoyment rating were statistically significant (MOAI mean=3.928, laptop mean=3.00, t=2.25, df=24, $p<0.05$). We also found that the increase in Interest rating for the large MOAI was significant (MOAI mean=3.86, laptop mean=3.00, t=2.07, df=23, $p<0.05$). No significance was found between the ratings of either instrument and any other aspect.

4.1.2 Qualitative Results

Each post-performance survey asked two qualitative questions: *What did you like about the performance?* and *What did you dislike about the performance?*

We performed a thematic analysis on these answers using an inductive method, grouping themes until saturation. Four themes emerged:
Music-related: Features of sound, rhythm, composition
Performance-related: Features of the performer's actions
Interaction-related: Features of the interface/instrument separate from performer
Effect-related: Value judgments, combinations of the above

These results are summarised in Table 2. Some features we observed are:

1. The Effect theme was mentioned more often as a dislike of the laptop performance (A1=69.2% , A2=53.8%)
2. Aspects of novelty ('novelty', 'suprise', 'I liked not knowing how it works') were mentioned by 38.5% of A1 (large MOAI). This group did not mention the instrument itself.
3. 'The instrument' was mentioned by 38.5% of A2 (small MOAI). This group did not mention novelty aspects.

4.2 Real-time data

4.2.1 Button tap counts

To compare the incidence of 'error' and 'enjoyment' taps with the qualitative data, we looked at the average number of these tap events per audience member, by performance (summarised in Table 1).

Across all performances we found that participants indicated more 'enjoyment' taps than 'error' taps. We found that the large MOAI had a greater number of 'enjoyment' taps than the laptop (Δ13.69). For the small MOAI there were also more 'enjoyment' taps, but the difference was not as great (Δ3.67).

Both laptop performances had an increase of 'error' taps than either version of MOAI. A1 (large MOAI) had an increase of Δ2.77. A2 (small MOAI) had an increase of Δ2.58.

4.2.2 Correlations with post-hoc ratings

We tested for correlations between the rates of real-time 'enjoyment' and 'error' button taps and the post-hoc ratings of Enjoyment, Interest and Understanding. In both A1 and A2 there was a respondent that tapped these buttons far more than any other participant (an increase of 105 taps for A1 and 91 for A2). These outliers were excluded.

We did 24 correlations (Enjoyment/Interest/Understanding vs error and enjoyment taps for each instrument, for each audience). We found no correlations of any statistical significance, except for one: In A2, there was a moderate negative correlation with 'error' taps and ratings of Understanding ($r=-0.62$ $p<0.05$). It should be noted that, given that we performed 24 correlations, this apparent significance may be due to chance.

5. DISCUSSION

5.1 Size (probably) matters

The large version of MOAI was rated significantly higher than the laptop for Enjoyment and Interest. While the small MOAI also rated higher than the laptop for these qualities,

Table 2. Summary of qualitative results indicated as likes and dislikes, by theme. (Figures are percentage of each audience.)

	Audience 1: MOAI Large				Audience 2: MOAI Small			
	Likes		Dislikes		Likes		Dislikes	
	P1: MOAI (L)	P2: Laptop	P1: MOAI (L)	P2: Laptop	P1: MOAI (S)	P2: Laptop	P1: MOAI (S)	P2: Laptop
Musical	61.5	46.2	38.5	23.1	92.3	38.5	61.5	46.2
Performative	15.4	15.4	30.8	0	15.4	38.5	0	7.7
Interaction	46.2	15.4	0	0	46.2	61.5	0	7.7
Effect	30.8	23.1	7.7	69.2	0	15.4	15.4	53.8

the difference was not statistically significant. While not conclusive, we suggest that this effect could be because the larger MOAI produced a more expressive interaction, as both the manipulation and the outcome were amplified.

Despite the larger gestures, Understanding showed greater divergence from the laptop on the smaller MOAI, though the effect was not significant. However, in the final survey we asked respondents to describe how the instrument worked, and this qualitative data shows that actual understanding was similarly low for both groups, (23% and 30% respectively, a separation of one respondent), so this rating is not necessarily indicative of anything but over-confidence. Our previous work [28] shows that knowing how an instrument works is not indicative of increased enjoyment, so it is not surprising that the instrument rated higher for understanding was not considered more enjoyable.

The qualitative data was the source of more insight. Both laptop performances had very high rates of Effect-related comments cited as dislikes (the dislikes in this theme for MOAI were much lower). This suggests that a dislike relating to overall effect of a performance has a negative impact on audience ratings. By contrast, 30.8% of the audience for the large MOAI mentioned positive Effects, whereas the small MOAI audience did not mention Effects at all. This suggests that comments about overall Effects might be good indicators of enjoyment, rather than comments about specific performance or sound features.

Comparing large and small MOAI cannot be separated from the quality of the laptop performances: The large MOAI performance receiving significantly higher ratings than the laptop performance may simply indicate that the second laptop performance was better than the first. However, the qualitative data between the laptop and two MAOI performances showed no obvious distaste, and words such as 'boring' were equal between them. Moreover, qualitative responses for the large MOAI cited novelty, as well as words like 'immediate' and 'physical'; these descriptors were not applied to the small MOAI at all. This suggests that the difference in ratings reflects a different perception of the large and small MOAI, and are not due to differing quality of laptop performances.

5.2 Real-time + post-hoc data

Though using the real-time data to extract performance features is beyond the scope of this paper, this data set did lend an additional dimension to the post-hoc results. The number of 'enjoyment' taps was highest for the performance with the highest Enjoyment rating. However, the rate of enjoyment taps doesn't correlate with quantitative ratings. Similarly, the number of 'error' taps was highest for the lower-rated laptop performances, but again no meaningful correlation was found. This suggests that audiences use different criteria for post-hoc judgments, and correlations do not account for how often different people choose to tap the buttons - but as a group these reinforce the post-hoc findings. There is also the possibility that when audiences are really enjoying something and less inclined to tap buttons. However, button use did not drop off during the second performance, suggesting continuous engagement.

Though we could identify differences in tap rates, no performance was off the charts for either 'enjoyment' or 'error' or indicated as simply low-quality. This suggests that the difference in results is due to gesture size.

5.3 Implications for DMI design

This study suggests two implications for DMI design.

First, we suggest that the physical design of a DMI does impact the scale of the gestural repertoire used to play it. This was particularly evident in the differing qualitative responses for large and small MOAI (Section 5.1). The implication is that DMI designers affect gesture through the physicality of their instruments, and these differences in gestures affect audience perception.

Second, we suggest that this method of comparing the gestures across two versions of the same instrument may be a way to gain more insight into this instrument-gesture relationship. As well as comparisons of structural components of instruments [11] and the possible ways they can be played [12], we suggest that comparing different scales of DMIs could be a method to improve our understanding of how DMI design impacts affordances and gesture repertoires.

It is important to note that though we scaled gesture and size proportionally and the bigger was preferred, many gesture/size relationships are possible. We also acknowledge that this is a preliminary study, and that more examination is needed to reach specific conclusions on how gesture size affects audiences, and how DMI design might impact gesture size. Nevertheless, comparing gesture size on a single DMI does reveal an intriguing avenue of exploration, and suggests that the designer of a DMI plays an important role in influencing the gestures used to play it.

6. CONCLUSIONS

In an audience study, we examined how the scale of a gesture affected audience perception of a performance by comparing audience responses to one DMI (MOAI), made at large and small scales, with a laptop performance in which gestures were minimal. We collected and compared post-hoc and real-time data, and our findings were: That the large version was rated significantly higher than the laptop for Enjoyment and Interest; that though real-time button taps do not correlate to ratings, they do reinforce and add dimension to post-hoc findings; that DMI designers may be able to affect the gesture repertoires of performers through the physical scale of instruments. Though this is a preliminary study, we suggest that these results indicate a new avenue for exploration wherein using one DMI at multiple sizes to compare how audience perception and instrumental gestures change might lead to new understanding of instrumental gestures.

7. ACKNOWLEDGMENTS

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