When is a Guitar not a Guitar? Cultural Form, Input Modality and Expertise

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ABSTRACT

The design of traditional musical instruments is a process of incremental refinement over many centuries of innovation. As a result, the shape and form of instruments are well established and recognised across cultures. Conversely, digital musical instruments (DMIs), being unconstrained by requirements of efficient acoustic sound production and ergonomics, can take on forms which are more abstract in their relation to the mechanism of control and sound production. In this paper we consider the case of designing DMIs that resemble traditional instruments, and pose questions around the social and technical acceptability of certain design choices relating to physical form and input modality (sensing strategy and the input gestures that it affords). We designed four guitar-derivative DMIs to be suitable for performing strummed harmonic accompaniments to a folk tune. Each instrument possesses a combination of one of two global forms (guitar-like body and a smaller tabletop enclosure) and one of two control mechanisms (physical strings and touch sensors). We conducted a study where both non-musicians and guitarists played two versions of the instruments and completed musical tasks with each instrument. This study highlights the complex interaction between global form and input modality when designing for existing musical cultures and varying levels of expertise.

Author Keywords

cultural form, input modality, sensor topologies, expertise

CCS Concepts

•Applied computing → Sound and music computing; Performing arts;

1. INTRODUCTION

Within the NIME community 'instrument-like' controllers, or DMIs that resemble traditional instruments, have been a persistently popular area of exploration [29]. Similar trends can also be seen in the commercial world where many novel instruments and controllers resemble traditional instruments [22]. It is often suggested that a reason for this focused energy is that it allows the re-use of playing techniques from traditional instruments and hence offers a route to faster uptake. However this viewpoint leaves out important factors related to an instrument's social acceptability, and we should ask ourselves whether the popularity of DMIs emulating traditional instruments comes more from their control characteristics or from their physical form.

Therefore there is a question of what it means to be 'instrument-like': does it mean sharing interaction modalities or does it mean having the cultural appearance that stands in for a traditional instrument? In this study we sought to disambiguate the two by deliberately testing congruent and incongruent pairings of design cues of a guitar-like DMI. We designed four instruments which mix and match from two physical forms (guitar shaped and tabletop) and two interaction modalities (strings and touch sensor), seen in Figure 1. Every participant played two of the four instruments, either a congruent or incongruent pair. Our particular interest is in the incongruent case where people have to choose between something which preserves either the interaction modality or physical form. Our aim was to interrogate which design cues made the DMI more instrument-like and more enjoyable to play: physical form or interaction modality.

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NIME'18, June 3-6, 2018, Blacksburg, Virginia, USA.

2. RELATED WORK

Of primary importance to the design of digital musical instruments (DMIs) are the techniques used to capture the movement of a performer, namely, the sensing strategy [23], and how this is mapped to a sound engine [13]. Increasing importance is being given to the physical form and tangible qualities of an instrument which carry cultural connotations that influence the musical gestural language a performer uses [2]. Essl and O'Modhrain [10] introduce the enactive approach to instrument design as a means of preserving the coupling between sensorimotor perception and our understanding of the physical properties of tangible objects. By utilising 'familiar sensorimotor experiences' mapping can become less of a digital question and more of a physical one. Many of the physical aspects of DMIs are defined by the demands of the sensing strategy but studies into the influence of physical form in instrument design have demonstrated how simple modifications to the material, form and dynamic behaviour of an input device can have great implications for how a performer interacts with an instrument [18, 6]. In this paper, we discuss a group of DMIs which embody aspects of the enactive approach, allowing us to explore similar concepts of sensorimotor familiarity, by utilising two sensor topologies designed explicitly for strummed or plucked string instrument performances.

2.1 Technical Role of Instruments

Baily [1] proposes acoustic musical instruments as movement transducers: as the performer makes contact with the 'active surface' of the instrument it converts patterns of body movement into patterns of sound. Acoustic instrument design focuses on how this transduction takes place by shaping how the performer's body fits to the instrument, and how the mechanism efficiently converts this into sound. Dobrian and Koppelman [9] emphasise the importance of relating DMI design to its acoustic ancestry as an example of a relationship between gesture and sound is at once intuitive and complex.

With DMIs the translation of action to sound is not direct but rather relies on a complex chain of mediation - the sensors involved in capturing movement and the type of movement that the sensor encourages, the rate and fidelity at which movement is captured, the mapping of this reduced representation of movement to sound parameters, and the quality of the sound generation and its reflection of the performers' movements. *Control intimacy* is a concept introduced by Moore [24], and further explored by Wessel and Wright [30], as a means of talking about the richness of this translation of movement to sound. Acoustic instruments often display high control intimacy: instruments such as the voice, violin, sitar, allow the micro-gestural movements of the performer to create a wide range of affective variation of musical sound, whereas with DMIs this is highly dependent on design choices.

In DMI design relating control strategies to those of acoustic instruments can be a method of leveraging existing expertise, although exactly which design elements are responsible for this remains unclear: as Cook points out "copying an instrument is dumb; leveraging expert technique is smart" [8]. Approaches to this have included preserving a sense of energy transfer in digital system of an instrument [20] and building upon everyday tangible interactions [10].

2.2 Social Role of Instruments

In his theorisation of tangible user interfaces Horn points out that the evocation of cultural forms can tap into users' existing cognitive, physical and emotional resources, activating existing forms of social activity [12]. For Rojas, as a performer becomes acquainted with a particular musical instrument they gain an understanding of a musical topographical space that maps out, not only the coupling of action and sound, but also how the engagement of performer and instrument relates to aesthetic, ecological, and technological threads contained within the instrument's structure [26]. This understanding echoes Small's notion of 'musicking' [27] which defines music as something that we 'do': an activity that is surrounded by a set of strict behavioural laws that are imposed on both performers and perceivers. Much ethnomusicology is dedicated to the study of the cultural specificity and importance of musical practices, and how they relate to these behavioural laws. A particularly relevant example comes from Bates who, when reflecting on the materiality of musical instruments, offers the following statement on the *social life of musical instruments*:

> Much of the power, mystique, and allure of musical instruments [...] is inextricable from the myriad situations where instruments are entangled in webs of complex relationships between humans and objects, between humans and humans, and between objects and other objects. Bates [2, p. 364]

Bijsterveld and Schulp [7] discuss tensions surrounding innovation in traditional instruments, through discussions with instrument manufacturers who have employed innovative approaches in their designs. A key example is the Pellegrina viola, a radical redesign of the traditional form

Figure 1: Four 'guitar-like' instruments. Clockwise from top left: Strings-Guitar (SG), Strings-Tabletop (ST), Touch-Guitar (TG) and Touch-Tabletop (TT). Congruent and Incongruent pairs are shown.

allowing performers to access higher positions on the neck without risk of injury or discomfort. The Pellegrina's striking, asymmetrical shape led to initial shock amongst other orchestra players and garnered substantial press attention.

Lubet [19] cites the 'highly standardized' performance requirements of classical musicians as a disabling factor for musicians with impairments, but also acknowledges that disability status can shift across musical cultures: an example being Django Reinhardt, whose impaired left hand would prevent him from performing classical guitar pieces, but who nonetheless became a highly proficient jazz soloist.

Benford [5] refers to the 'social demands of musical etiquette' when describing the aversion to technology during folk sessions in Irish pubs. Despite the ubiquity of technology during the preparation for the sessions (predominantly the use of the web and social networks), members upheld an appearance of tradition by eschewing technology during the sessions themselves. Bell [3] posits the guitar's 'high value in cultural capital' as a factor in the explosion of Guitar Hero games during the previous decade, suggesting that such games allow entry into a 'musical experience that is enmeshed in popular culture'. Bell also cites the guitar's cultural value as a compelling argument for improving the accessibility of the guitar and its associated pedagogy to disabled musicians and beginners, an argument that is reinforced in the design philosophy of the KellyCaster[1], designed by John Kelly, a musician with access needs, and Drake Music[2]. The requirement for an instrument that carries the same cultural weight (not to mention interaction techniques) as a guitar was paramount in its design.

3. STUDY

This study's purpose was to examine the influence of physical form and interaction modality on social and technical

[1] http://cdm.link/2017/09/take-a-look-at-the-kellycaster-a-unique-and-accessible-instrument-built-by-dmlabs/

[2] http://www.drakemusic.org/

factors relating to guitar playing. We also aimed to discover whether musicianship and familiarity with the guitar would influence participants' reasoning and playing techniques. The musical tasks described below relate to the specific focus of this paper. A secondary aim of this study was to look in more detail at the behaviour of the stringed instruments, the results of which are presented elsewhere [15].

3.1 Instrument design

We developed four guitar-derivative DMIs with varying combinations of overall form (guitar-shaped vs. tabletop) and interaction modality (plucked strings vs. touch sensor). The resulting instruments can been seen in Figure 1 and are herein referred to as SG (Strings-Guitar), ST (Strings-Tabletop), TT (Touch-Tabletop) and TG (Touch-Guitar). Our intention was to create a series of 'technology probes' [14] which were created in order to serve three goals: the social science goal of understanding the needs and desires of users in a real-world setting, the engineering goal of field-testing the probe, and the design goal of provoking users to reflect on their interaction with the probe. In relation to musical instruments this is an approach that has identified interesting behavioural patterns in previous studies [11, 16].

3.2 Physical construction

A single enclosure for the 'Guitar' instrument was commissioned for this study. The enclosure is constructed out of hardwood with a sculpted neck with six push-buttons roughly at the position of the lower frets. The buttons are arranged in two rows of three, set to chords I, IV and V in the key of G on the top row, with their relative minors on the row below. The body is hollow, allowing the sensor(s) to be swapped between the string modules or touch sensor.

We designed two similar enclosures for the tabletop instruments, which were intended to reflect design cues from boutique tabletop music hardware, such as modular synth controllers. The push-buttons were placed in the lower left-hand corner, with the strumming area placed at a 45 degree angle, which was found to be a comfortable method of strumming on a tabletop.

The string instruments feature six short lengths of .040 gauge bass guitar string held over a 'strummable area' of about 10 cm. At one end, the strings are terminated over a block of felt-covered foam, with six individual bridge-pieces at the other with integrated piezo disc sensors, and held to a low tension using adjustable zither pins. This provides a signal similar to the attack of a guitar string when plucked. The thick strings and low tension produce a short decay and fewer resonant properties than a typical guitar string.

The touch instruments use a capacitive touch slider derived from the TouchKeys keyboard overlay design [21] to detect finger position. Six 'string areas' are equally spaced along the sensor. We applied several layers of paint in thin strips to the surface of the sensor, to provide tactile cues as to the location of each string area. We chose this type of sensor for its 'swiping' and 'tapping' affordances - gestures commonly associated with touchscreen interfaces but which have a direct analogy to strumming and finger-picking.

We used an implementation of the Karplus-Strong plucked string algorithm [17] to simulate six virtual strings which are excited in real time using signals from the piezo and touch sensors. An excitation waveform was recorded by plucking one of the strings and recording the audio signal directly from the piezo. For the string instruments, a peak-detection algorithm is used to detect peaks in the amplitude of the piezo sensors output, and trigger the excitation waveform each time a peak is reached. For the touch sensor, the excitation waveform is triggered when one of the six string areas is tapped or swiped across.

3.3 Study design

We recruited 32 participants: 16 'competent' guitarists, and 16 non-musicians. Participants were asked to self-identify at the recruitment stage using the following statements: *'you are comfortable strumming and playing along to a tune'* (competent guitarists) and *'you have no or very little experience playing an instrument'* (non-musicians). In order to account for within-group variability in musical skill, we asked participants to complete the self-report questionnaire section of the Goldsmiths Musical Sophistication Index (GoldMSI) test battery [25].

Participants were given one of two combinations of instruments, either the congruent pair SG-TT (Strings-Guitar and Touch-Tabletop) or the incongruent pair ST-TG (Strings-Tabletop and Touch-Guitar). An equal number of guitarists and non-musicians were given each combination, resulting in four groups of 8 under test. Within each group, the order of presentation of the two instruments was reversed for half the participants.

3.3.1 Musical tasks

The participants were presented with the first instrument without seeing the second. They were asked to improvise and explore with the instrument for 7 minutes. They were then given a further 7 minutes to rehearse and perform an accompaniment to a record of a folk song performed on fiddle and electric bass. We chose folk for this study due to the role of fretted string instruments as rhythmic harmonic accompaniments which are often strummed, allowing for a relatively accessible musical task to be set up, as well as to provide some cultural context to the task. We recorded a piece taken from the folk-RNN songbook [28] for this purpose. The recording had added percussion to allow participants to follow the beat. The chord structure of the song used chords I, IV and V in the key of G. We added coloured stickers to the buttons to indicate these chords and printed a colour-coded score for participants to follow while playing. We also produced a video file displaying the chord colours and positions on screen as they appeared in the score, in a similar manner to the Guitar Hero games. Participants were allowed to use either or both of these methods to follow the backing track but were encouraged to use the printed score if they felt comfortable to do so. The buttons and score are presented in Figure 2. Both the improvisation and score-following tasks were repeated with the second instrument.

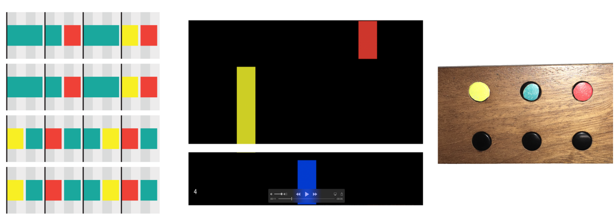

Figure 2: L-R: colour-coded paper score, screenshot of on-screen chord visualiser, colour-coded buttons

3.3.2 Structured interview and questionnaire

Following the musical tasks, we asked participants to fill out an on-screen questionnaire, providing ratings for each instrument on factors split into technical, social, and general preference subgroups. The questionnaire and results are presented in Section 4.2. Following the questionnaire, we

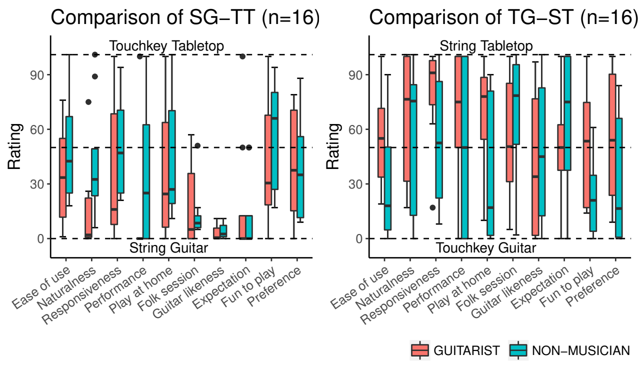

Figure 3: The medians and IQRs of the ratings for all participants with each instrument pair.

conducted structured interviews with questions relating to techniques used with each instrument, and general thoughts on their experiences with the instrument.

4. FINDINGS

We shall now report the ratings given by each participant group in relation to the instrument pairs and summarise the reports from the structured interviews.

4.1 Participant data

19 participants were male (13 guitarists and 6 non-musicians), and 13 were female (3 guitarists and 10 non-musicians). Participant age ranged from 18 to 62 with an average 32 years old. The average GoldMSI score for each group were 89 (SD = 11, minimum = 72) for guitarists and 55 (SD = 11, maximum = 70) for non-musicians.

4.2 Ratings

Figure 3 displays participants' questionnaire responses, which indicate preference for either instrument. We have divided the questions into those that relate to technical factors (ease of use, naturalness of playing, responsiveness, and proficiency with the instrument), social factors (preference for playing in different environments, similarity to a guitar, how the sound met expectations) and general preference (how fun each instrument was to play, overall preference). These results are summarised as follows (unless otherwise stated, responses were given by placing a continuous slider on a horizontal plane, with 'Instrument 1' on the left and 'Instrument 2' on the right):

Technical

- **Which instrument was easier to play?** whereas on average the non-musicians rated TG as easier to play in comparison to ST, guitarists varied in their responses for this pair. For the SG-TT pair guitarists rated the SG as easier to play, with the non-musicians showing no preference for this combination.
- **Which instrument allowed you to play in the most natural way?** Guitarists strongly rated strings as more natural on average, non-musicians differed in their response. No noticeable effect of global form.
- **Which instrument was most responsive to your style of playing?** Guitarists rate string more responsive in both pairs, non-musicians differed in response.
- **How well did you play the accompaniment on each instrument?** *(Two 5-point likert scale normalised to 0-100 by making 0 indicate performance is better on instrument 1, 100 indicate performance is better on instrument 2 and 50 represent an equal rating)* Guitarists rated themselves as playing much better on SG and ST, non-musicians are undecided.

Social

- **Which instrument would you prefer to play at home?** Guitarists generally prefer strings, non-musicians tend towards the guitar form.
- **Which instrument could you imagine playing in a folk session?** Both groups strongly prefer the SG in comparison to TT. For the ST-TG combination non-musicians preferred ST, Guitarists split in opinion.
- **Which instrument was most similar to a guitar?** In the case of SG-TT there is strong agreement between groups that SG is more similar. In the case of ST-TG both groups do not reach an agreement.
- **Did the instrument sound like you expected?** *(Two 5-point likert scale normalised to 0-100 by making 0 indicate instrument 1 is more expected, 100 indicate instrument 2 is more expected, and 50 representing an equal rating)* In the case of SG-TT the SG meets expectations of both groups. In the case of ST-TG neither groups display a preference.

General

- **Which instrument was more fun to play?** No agreement between guitarists, non-musicians rate touch sensor as more fun to play in both combinations.
- **Which instrument did you prefer to play?** Non-musicians prefer the guitar form. No agreement between the guitarists, wide variation on a participant by participant basis regardless of group.

4.2.1 Trends across all participants

To further cluster the responses of all the participants into related groups we performed a principal component factor analysis (PCA) with Varimax rotation (Kaiser Normalisation). Two components with an eigenvalue greater than 1.0 were found (the component loadings are shown in Table 1). **Component 1** includes the factors related to the participants' reported enjoyment and preference for a particular instrument. **Component 2** includes factors relating to the instrument's playability and relationship to a guitar.

4.2.2 Structured interviews

The structured interviews were transcribed and the responses thematised using thematic analysis. We present in Table 2 paraphrased quotes from both groups in relation to the incongruent pair ST-TG, organised into the key themes that emerged from the thematic analysis. Additional quotes are employed in the discussion.

Table 1: Components found by the PCA and their loadings with associated means and SDs (n=32).

Component 1	Loading	Mean(SD)
play at home	.932	46(37)
preference to play	.930	42(33)
fun to play	.841	46(37)
ease of use	.791	43(31)
Component 2		
play at folk session	.755	38(36)
guitar likeness	.743	24(34)
responsiveness	.740	54(35)
naturalness	.679	45(38)

Table 2: Selected paraphrased quotes from the structured interviews

Theme	Aesthetics	Comfort/Ease	Comparison	Authenticity	Familiarity
Non-Musicians					
Quote	*'ST looks too traditional, not innovative, but TG looks better'*	*'TG is more comfortable to play but the sensor is not very clear'*	*'ST is kind of like a guitar, it has strings so this looks and sounds like a guitar'*	*'TG felt more like holding a guitar so the instrument felt more authentic'*	*'With ST I see the strings and know what to do, but with TG it was weird'*
Guitarists					
Quote	*'TG said guitar to me as soon as I saw it. With ST I thought of lap steel'*	*'TG is more comfortable as a guitar player'*	*'ST is much more preferable because it's like an auto-harp'*	*'TG felt more like a game controller but ST felt like a real instrument'*	*'The tactility of the strings [ST] lends itself to more innate skills'*

5. DISCUSSION

Results from the questionnaire show the effects of the congruent vs. incongruent pairings as they relate to form and input modality. The SG-TT combination represents a congruent relationship: it is clear what the guitar form with strummable strings is designed to do and this was reflected in both groups rating of 'guitar-likeness' and their comments. The ST-TG combination introduces an incongruence between form and modality. The result was that participants were less clear on which was more guitar-like. In general for this pairing we saw a greater difference between the two participant groups: non-musicians gave higher ratings to the TG instrument, which shared the physical form of a guitar but lacked strings, whereas guitarists gave higher ratings to the ST instrument that had physical strings but a compact tabletop form. An exception was the 'folk session' rating, for which non-musicians tended towards the ST instrument.

5.1 Input modality

In general, trends related to input modality concerned sensing strategy and the reinforcement of the participant's control through the physicality of the input device.

Guitarists: This group generally gave higher ratings to the stringed versions of the instruments regardless of the global form. From the structured interviews there were reports of the strings feeling more natural to play and allowing the use of existing techniques that they had from the guitar. The tactility of the strings was mentioned as an important factor as this provided a physical support for their gestures.

Criticisms of the touch sensor from this group repeatedly focused on the lack of an anchor, or reference point that would tell them where their hand was positioned. Their hands would often drift away from the sensing area if they were not visually monitoring it.

Non-musicians: There were diverse reports of preference from this group with a relatively even split between the two input modalities. Many in this group commented positively on the presence of the strings mentioning that when they saw the strings they knew what to do, whereas with the sensor it was less clear what gesture was expected.

For the string instruments there was an increase in unconventional techniques reported in the structured interview (tapping on bridge pieces, tapping and pushing down stings, flat rolling of fingers to trigger strings). This group was more inventive in their interpretation of the strings than the guitarists. The touch sensor input modality was rated as more fun to play than the strings by the non-musicians regardless of global form. This suggests that the novelty of this interaction could have advantages with this group.

The difference between the groups highlights an interesting point about design that echoes Benford et al.'s expected, sensed, desired framework [4]. There are often gestures that fall outside of the category of expected and desired yet are chosen by participants due to their efficiency in producing sound. Although the strings represent a certain canon of musical gesture this is easily completely side-stepped when the performer has no knowledge of this canon.

The strings input modality also seemed to act as a strong social cue: the tabletop instrument with strings was still compared to a guitar, preferred for folk performance and reported as more natural. This suggests that the strings are strongly associated with 'authentic' guitar performances even when global form is radically different.

5.2 Physical form

The social aspects at play that are influenced by the physical form are complex and varied with each individual and their experience, but we observed some interesting trends:

Guitarists: In the ST-TG pairing we still observed guitarists siding with the string version of the instrument regardless of global form. This held across the majority of the quality ratings aside from guitar-likeness and suitability for a folk session, where there was no consensus in the group. Perhaps this suggests that the guitarists consider a guitar-like instrument to be most socially acceptable in a folk context, but do not agree which instrument is indeed most guitar-like. Two guitarists in the ST-TG group reported preferring the TG to ST: the ergonomics of the guitar form, in terms of positioning of the right hand and being able to hold the instrument like a guitar, were given as reasons. Their solution with the ST instrument was to lift it up or place it on their lap to make it easier to play.

Non-musicians: Global form had more of an influence on this group than the guitarists. In the case of the ST-TG instrument pairing the guitar form was generally preferred. This could suggest that this group placed importance on embodying the gestural language of guitar playing.

We attempted to treat global form and input modality as separable concepts, however in practice this is not necessarily the case. Each input modality has their own visual cues which contribute to perceived social acceptability. The stringed instruments were more readily accepted as a folk instrument, while the touch sensor elicited comparisons to game controllers and MIDI devices. The results in Table 1 reflect this: while the relationship between factors for component 1 is clear ('play at home', 'preference to play', 'fun to play' and 'ease of use' relate to overall enjoyment of playing the instrument, regardless of social acceptability), component 2 contains factors relating to both social cues ('play at a folk session' and 'guitar likeness') and technical ('responsiveness' and 'naturalness'). Perhaps a common theme amongst these factors is the 'instrument-like' qualities of the instrument, which have less to do with overall enjoyment but might relate to a perceived *authenticity*. In terms of designing new DMIs for existing musical cultures, an *authentic* instrument might be described as one which encompasses both the 'macro-level' social cues and the 'micro-level' interaction of existing instruments.

6. CONCLUDING REMARKS

In this paper we have tried to address the following question: which is more important to a performer's impression of an instrument, global form or input modality? Whilst agreement amongst all participants was strong for the 'congruent' strings guitar and touch sensor tabletop group, there was less parity across and between groups for the 'incongruent' touch sensor guitar and strings tabletop group. The results hint at a preference for the technical familiarity of the stringed instrument amongst the guitarists. Non-musicians tended to prefer the touch guitar instrument, which could be due to the relative ease of use of the touch sensor, or the 'cultural load' of the guitar form.

7. ACKNOWLEDGMENTS

We would like to extend our gratitude to Ailish Underwood for crafting the guitar body and to the participants that took part in this study. This work is supported by EPSRC under grants EP/N005112/1 (Design for Virtuosity) and EP/G03723X/1 (Doctoral Training Centre in Media and Arts Technology).

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