Participatory Conceptual Design of Accessible Digital Musical Instruments using Generative AI

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ABSTRACT
This paper explores the potential of AI text-to-image diffusion models (e.g. DALLE-2 and Midjourney) to support the early phase design of new digital musical instruments in collaboration with Disabled musicians. The paper presents initial findings from two speculative design workshops attended by Disabled participants who are affiliated with the London-based inclusive arts organisation *Joy of Sound*. The workshops included activities that enabled participants to co-create speculative images of new instruments, drawing on their own contributions. These included the overall appearance of the instrument, constituent materials and other design characteristics. The paper discusses the generated images and examines how diffusion models can be a useful tool to support the conceptual co-design phase of bespoke accessible instruments. The project findings indicate that diffusion models can be useful as a facilitatory tool for idea generation in the initial stages of instrument design.

Author Keywords
ADMI, Accessibility, Participatory Design, AI.

CCS Concepts
• **Human-centered computing** → **Accessibility**→ Accessibility design and evaluation methods; • **Human-centered computing**→ **Interaction design** → **Interaction design process and methods** → Participatory design;

1. INTRODUCTION
Creating visual imagery is a critical step in the prototype stage of new technologies as they can give us an insight into the designer's intension and help to situate ourselves within unknown worlds [28]. There are many ways to involve individual end-users in conceptual design of objects and tools [24] including methods specifically intended to support the participation of Disabled people [6]. This paper contributes a novel approach using AI text-to-image generators to catalyse the participatory co-design process. Participatory and collaborative design methods typically acknowledge that people who are affected by a design decision, event or product should have an opportunity to influence it [1]. This has been previously explored in for Accessible Digital Musical Instrument (ADMI) design by Ward who suggests that the users and those who work closely with them will best know their needs in terms of interacting with an instrument [29].

The design and development of bespoke ADMIs is often a long process which can use a lot of resources [9]. Due to the bespoke nature of the instruments, designers may go through several revisions before reaching a playable and suitable interface for the end user [16]. Although there are advancements in rapid prototyping technologies such as 3D printing and CNC milling, the design of bespoke instruments remains a process only available to the minority of Disabled musicians that will benefit from bespoke interfaces [10].

The approach presented in this paper invites end-users to shape instrument design from the outset in line with their own stylistic and artistic preferences. In order to explore the potential of new accessible ideation methods for traditional design processes, two workshops were organised with Disabled participants from the inclusive arts organisation *Joy of Sound* [17]. The workshops explore new ways to co-design musical instruments using text-to-image generative AI, focusing on the use of rapid visualisation tools to encourage participation and interpret and explore participants' instructions. The main objective of this work is to investigate the potential of AI image to text generators and diffusion-based image generation systems in the design of ADMIs for disabled people.

The remainder of the paper sets out the context of ADMIs and generative AI before introducing the key motivation for this work. The workshops are discussed in Section 4 which encouraged workshop participants to develop a speculative design of new musical instrument designs using DALLE-2. The workshop outcomes are shown in Figures 1 and 2 are discussed in initial findings of the paper. The paper closes with concluding remarks and proposals for future development.

2. BACKGROUND
The strive to make music and creative arts activities accessible to the greater population has resulted in a wide range of novel approaches and technologies [9]. ADMIs is a term which is gaining popularity, especially within the NIME community as enabling technological tools, used for musical purposes [18] which act as an interface to active participation in the arts. ADMI technologies enable people who cannot play traditional musical instruments to engage in musical activities, without external sources assisting in the music process [11].

Several systematic literature reviews look at the impact of participatory arts for wellbeing and music and has identified music making as having a positive effect on stress, mental health stigma, social isolation, social capital, autonomy, self-esteem, identity, and a sense of achievement [8]. Bespoke musical instruments have the potential to provide Disabled people with access to music making [14]. O'Donnell's review shows that music making can provide many benefits for health and wellbeing for Disabled people. By removing barriers to enable full participation in music making, ADMIs can be an interface to social activities and access to the arts for the greater population.

The Inclusive Design methodology emerged in the mid 1990s to challenge misguided but deep-seated assumptions about ageing, disability, and social equality [5]. Inclusive design is aligned with the social model of disability which states that we live in a world increasingly shaped by human intervention where design can enable or disable people [4]. By acknowledging the social model of disability

NIME' 23, May 31–June 2, 2023, Mexico City, Mexico.

and inclusive design practice, this research seeks to create a collaborative process in which Disabled people are active stakeholders who drive the design process.

Speculative Design is a methodology used within many design practices to envision a future where one is to use design as a means of speculating how things could be [7]. Speculative design has shown great potential as critical approach to dealing with social issues [20] as well as generating new ideas around specific design enquires [7]. Within the field of HCI, speculative design is also a way for making, building, and understanding the nature of our emerging interactions of futures with technology [28]. This paper incorporates several speculative design methods which will be discussed within the workshop plan in Section 4.

Speculative design and AI has been used previously [22] and the collaboration between human-AI interactions and has brought up discussion on the design and social adoption of technologies [25]. Generative AI is a field of AI that creates new content such as images, text, and music based on input data or prompts [30]. It utilises machine learning algorithms and deep neural networks to learn patterns and features in a data set to produce novel and unseen data [23]. This paper explores workshops utilizing DALL-E 2, a generative AI program that generates images from text prompts [3].

The ethical use of AI image-to-text generators is currently a highly discussed topic. Several articles which question whether text to image generators are taking artist's jobs [13], replacing programmers [12] as well as highlighting the racial and sexist bias [25] within the resulting images. Whilst acknowledging the problems associated with large data sets and image creation, this paper seeks to focus on the use of these technologies to benefit the underrepresented communities within tech innovation and the arts [14]. The research centres on the people who stand to be adversely affected by the technology with a broad view on the possible ways that technology can benefit minority communities [20].

Although there are several ADMIs success stories [9], their development can be resource intensive. This can be due to creating new physical prototypes along the design journey, each using new materials and adapting form for each individual user. Bespoke or modular ADMIs customised for individual users may offer more potential creative output.

3. MOTIVATION

This collaborative study seeks to trial new image generation algorithms in order to rapidly generate visual media during the conceptual design phase of novel ADMIs. The motivation for trailing this method stems from the authors direct experience designing ADMIs with disabled musicians in circumstances where it was not possible to visualise the user's preferences within the initial design workshop or meeting. The initial motivation was to question if this technique would engage people in designing instruments and enable a wide range of people access to ideation which is often not accessible for people with disabilities [6].

4. WORKSHOPS

Two workshops were organised with *Joy of Sound* (JOS) volunteers and the participants were associates or regular attendees to their events. JOS is an inclusive arts organization who practice and promote social inclusion through music and creative arts in weekly year-round participatory music sessions and regular combined arts projects [17]. 70% of JOS participants identify as ethnic minorities and over 30% are wheelchair users [21]. JOS uses a variety of accessible acoustic musical instruments which include some bespoke instruments co-designed with participants and associated instrument makers [21]. The first author has volunteered and worked for JOS as a facilitator and instrument maker for several years and have a good working relationship with the core team and volunteers.

The purpose of the pilot workshop was to primarily understand:

- The participants' preferred movements and gestures to play instruments
- The participants' preferred instrument designs and aesthetics
- Which topics and preferences do participants want in their designs
- The utility of DALL-E 2 in ideation design processes
- Identifying actions to advance inclusive participatory techniques and gather expert input from various communities.

4.1 Workshop Overview

The initial pilot study (Workshop 1) was conducted at a residential care home located in London. Participants were invited to take part in the workshop via a poster which advertised in the care home. The participants included six individuals, four of whom were male and two were female, with multiple learning difficulties and residing full-time at the care home. During the study, the participants were accompanied by five care and support workers, including three female and two male adults who do not identify as disabled. The workshop used a large LED monitor to clearly display the images and workshop materials. DALL-E 2 was displayed on the monitor so that all the participants could see the process of image creation.

The second workshop (Workshop 2) was run before a regular JOS workshop in London and it was organised directly with participants and their families. The participants included three individuals, all of whom were male and learning difficulties who regularly attend JOS workshops. One participant (participant 2) was non-verbal and communicated through the iPad app 'Proloquo2GO AAC'. Both workshops were guided by the same workshop plan and followed the same methods.

4.2 Workshop Description

The workshop began by using speculative design techniques to introduce a playful environment and draw the participants' attention to an imaginary future [7]. The focus was on a factional machine called "Noma" that can create any musical instrument from any material, with customizable playing methods. The goal was to inspire participants to think creatively, unconstrained by practical and technical limitations.

Workshop participants were shown example instruments which were made by "Noma", and which were discussed by the group. Participants were invited to discuss what the instruments looked like, what they resembled and how they might be played. The prompt words which were used to create the images were then revealed to the group to give an understanding to the participants of how the system worked. An example of this is shown in Figure 1.

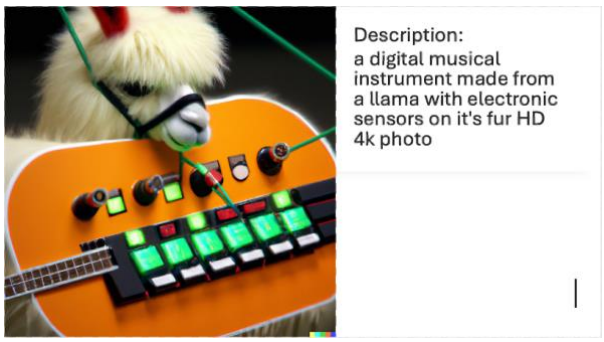

Figure 1 – Workshop introductory image

Workshop participants were then invited to make their own instruments one by one. The workshop gave the opportunity for every participant to design a new instrument and the workshop facilitators incorporated any answer that was given. The aim was to create an inclusive and accepting space with no 'wrong' answers and participants were invited to contribute any suggestions into the design of their instruments.

The workshops provided an opportunity for participants to design visual representations of personalised instruments for their own use. The facilitators encouraged attendees to contribute based on their own interests and lead the direction of the instrument's style. Examples of questions asked by the facilitators included:

- "If you could have an instrument that looks like anything, what would you like it to look like?"
- "What size would it be?"
- "Which colour would it be?"
- "What would it sound like?"
- "Can you show me which gesture or movement you would use to play the instrument?"

The workshop leader facilitated the process with participants, who had widely varying contributions. The process of instrument creation varied based on the interests and access requirements of the individual. Through the workshops, it became evident that DALL-E 2 can be a useful tool in quickly interpreting and visualising people's ideas, encouraging imagination, and fostering open contributions in a collaborative space as discussed in detail in Section 6.

4.3 Workshop Outcomes

The primary goal of the workshop was for every participant to design a visual prototype of their own instrument. The final images of the participant's instruments are included in Figure 2. The image prompts developed by the participants to create these images were:

- "a big blue instrument that look like a wolve from thriller"
- "a pink musical instrument with a microphone that looks like a violin"
- "a red musical instrument that is made from chicken nuggets that you play with your elbows"
- "a big blue musical instrument made from forks and footballs MK Dons"
- "a big light blue anything that makes a dit dit dit sound "
- "a kangaroo musical instrument in cartoon style"
- "a icicle xylophone "
- "a eye of the tiger instrument "
- "a yellow musical instrument made from snooker balls in the shape of a newton cradle"
- "a triangle shaped white guitar that you play with your hands "
- "a musical instrument made from park clothes and holes"

5. INITIAL FINDINGS

The findings of this workshop are preliminary, and a comprehensive thematic analysis will be conducted on the data collected at a later date.

Preliminary Findings:

- Personal preferences and hobbies were significant factors in the design of the instruments as revealed in workshop transcripts.
- The most common topic was preference for specific colours, with 7 out of 11 instruments stating a colour preference.
- The names of pre-existing instrument designs were the basis for some instruments, yet the participants wanted tore-design or adapt these pre-existing instruments to fit their personal preferences.

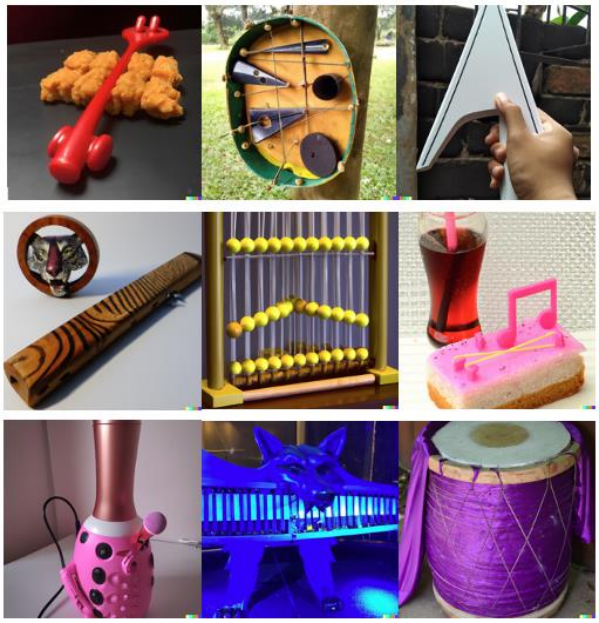

Figure 2 - A collection of instruments co-designed by Joy of Sound participants and volunteers

Several participants expressed a desire to see their instruments generated in the workshop brought to real life. This is demonstrated in a conversation between facilitator (F1) and participant (2) below.

F1: "Are you happy with the instruments that you made today?"
P2: "Happy, yeah"
F1: "Would you like it if the instrument was brought to real life?"
P2: "Real life, yeah"
F1: "Is there anything that you don't like about the instruments you made today?"
P2: "I don't like playing guitar or drums, I don't like it"
F1: "Would you prefer to play this?" *points to their instrument*
P2: "Yes"
F1: "Why?"
P2: "Cos I like it."

This conversation states that the participant likes the instrument that they created, and it suggests that it provides something different to pre-existing instruments like a guitar or drums. On the other hand, other participants wanted their instruments to resemble pre-existing instruments which is demonstrated in a conversation with another participant:

F1 – "…what do you want your instrument to be made from?"
P7: – "What shape is the guitar? Is it a triangle?"
F1 – "Do you want it to be triangle shape?"
P7: – "yeah!"

This shows that participant (7) wanted to use a pre-existing instrument design as the basis for their instrument but clearly stated that the shape is an important factor for their instrument design.

6. DICUSSION

The initial findings of this study could be of value to other designers and researchers in the field. There were several instances during the workshops where the participants directed the design inquiry, as evident in the example above. This approach has the potential to democratise the design process by allowing for wider participation in the creative aspects of instrument design. This is in line with the literature on inclusive speculative design, as discussed earlier by Larsen [22], which highlights the challenges of designing for inclusiveness. The interaction between the facilitator and the participant was

flexible and adaptive, allowing the instrument to accurately reflect the participant's intent whilst developing relationships between the facilitator and participants. This approach allowed for a co-creative design process, where the participant was at the forefront of shaping the outcome whilst in collaboration with the facilitator.

This approach also helps designers and participants to share a common understanding of their ideas in a short time frame, ensuring that the direction of travel aligns with the expectations of both stakeholders. This is a key benefit of the technology as it presents an adaptable outcome which can be edited and discussed [28]. The resulting images can be used in prototyping new instruments and the participant's ideas can be clearly reflected in the next stages of the bespoke design processes.

There are also benefits for the organisations in this workshop method as it provides a low cost and quick way to develop ideas with participants with minimal workshop materials. Large LED screens were available on site to use for both workshops described in this paper and the facilitator had to provide a laptop alongside the workshop plan. This results in a very adaptable and affordable workshop which can be run in a variety of venues and has multiple benefits for participants, facilitators and the organisations involved.

However, there are also limitations to this technique that must be considered. The findings suggest that several of the participants would like a physical prototype of their instrument designs and the gap between speculation and the actual design outcomes could be substantial. Additionally, the expectations of designers and participants could be higher than what can be produced in an allotted time frame. This will be tested within future iterations of the workshops and the feasibility of the designs will discussed and edited with participants alongside the speculative methods.

Finally, we must consider the ethical implications of using AI-generated images in the design process, including issues of bias [25]. As such, it is important to carefully consider the limitations and ethical implications of this technique.

7. ACKNOWLEDGEMENTS

Our thanks to all the workshop participants for all their contributions and guidance in the process and to the *Joy of Sound* volunteers for their help in the organising and co-facilitating of the workshops.

8. FUTURE WORK

A subsequent study will be conducted to materialise the prototypes generated from the images produced in the workshop methods. This will provide a physical representation of the designs, enabling a more comprehensive evaluation of the viability and functionality of the proposed designs. The physical prototypes will serve as tangible representations of the results and provide valuable insights into the potential applications of the design concepts.

9. CONCLUSION

This paper has explored how AI text-to-image generation can be a useful tool for generating ideas within group design workshops. DALLE-2 was a useful tool due to several attributes including the low entry point, the speed of the image generation and adaptability of the technology.

The workshop demonstrated that AI image generation can be a good starting point for co-design workshops to generate conversations around instrument design, promote movement activities and develop relationships between designer, co-designer and stakeholder organisations. The workshop also helps the stakeholder organisations to offer a new activity to their participants. This facilitates a more symbiotic relationship between researcher/designer and the organisation, which can help to build trust for future projects.

Despite the absence of physical objects, participants mimicked the way they would play their instruments, indicating which part of their bodies they would use, and the range of movement required to play an instrument. The data collected about participants' range of movement can be a crucial attribute for designing ADMIs and learning about participants' hobbies and desires fostered open contributions in a collaborative space. DALLE-2 can be a powerful tool for ideation in the early stages of design, offering many benefits for instrument designers to work with and understand the requirements and perspectives of end-users. The project has explored ideation with disabled participants and it is crucial that the first steps will go on to be refined, developed, and contextualised into more formal design prototypes.

10. ETHICAL STANDARDS

Full ethical approval was received from University of the West of England Research Ethics Committee on the 05/01/2023 for the duration of this project.

Ethics Review Application Form: FET-2122-92.

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