A comparison of UI presentation methods for an interactive dance choreography assistant tool

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ABSTRACT

This research focuses on which presentation methods are considered to be effective in the user interface (UI) of a choreography assistant tool. Such a tool will assist experts in developing new variations based on existing choreography input. Such variations can be communicated to the end-user using various presentation methods (sound, text and animations). In this research we investigate which methods are considered most effective in the interactive environment by end-users. Based on a literature review, we developed four presentation methods: textual descriptions, 2D animations, 3D animations and auditory instructions. In a user study with 7 experts, we evaluated the effectiveness and user acceptance of these four methods in two different dance styles. The outcome of the expert survey shows that the tool is effective in communicating the variations to the experts and that they express a preference for 3D animations based on the given scores and presented choice. Based on these results, we propose a design for the UI of an interactive dance choreography assistant tool.

Keywords

Dance, technology, presentation methods, choreography assistant tool.

1. INTRODUCTION

In this day and age where technology has become a reliable source of information, it also plays an important role in art forms such as dance. This research focuses on how choreographers and experienced dancers can be supported effectively in a creative process. In a broader sense, this research demonstrates the perspective on how technology can support the creative process of choreographers and experienced dancers in an interactive environment. In the last 45 years, many choreographers and dance educators have investigated methods for implementing computer technology. Technology presents new methods for creating, instructing, and assessing dance as well as opportunities to expand dance resources and redefine the learning process [1]. Like other artistic disciplines, dance intertwines technological elements in teaching, performance and choreography [2].

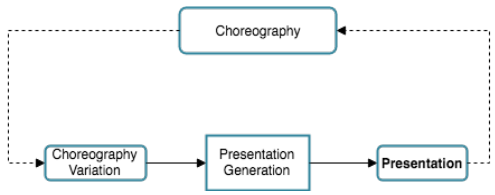

Figure 1. Framework of the choreography assistant tool.

The framework of this study is shown in Figure 1 and outlined in the red box in Figure 2 as well. The choreography variations are the starting point of the study and the focus is on the presentation element of the framework. The goal is therefore to discover which presentation methods work in an effective manner in such a choreography assistant tool. Moreover, it is interesting to explore the interplay between the choreographer, old variations and the presentation methods of the new variations. The term presentation method is used to refer to the way that variations are suggested to the choreographer. The term choreographer is used throughout the paper, however, the choreography assistant tool could also be used by experienced dancers who want to create a dance piece for their own use. The reason for choosing this topic is that we wanted to explore the relation between technology and dance, in particular the process of creating choreographies. This creative process does not have to be limited to the methods people use now, but can be expanded to other dimensions and perspectives. If it is known which presentation methods people prefer, a system can be developed with the chosen methods. In fact, this study could be seen as an element in an iterative process of creating such a system. We created a part of it, tested the presentation methods, received feedback and with the results we presented a design of the system.

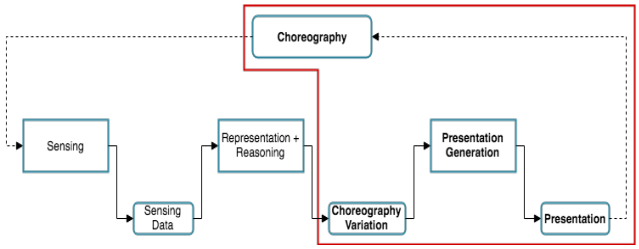

Figure 2. Framework of the larger project.

In order to grasp the idea of this study it is important to understand the bigger picture. One project explored the idea to assist a choreographer to more efficiently engage in the creative process of developing a new dance piece in an adaptive environment. As is shown in Figure 2 the framework integrated a sensing environment, a representation and reasoning tool, and a presentation generator. Firstly, the choreographer starts with the choreography or some variations, which are dance steps that are captured by the sensing environment. *Sensing* is used to detect the movements of the choreographer through motion capture, move recognition or floor sensors. Secondly, the sensing data needs to be transferred to the reasoning tool in real time. *Representation and reasoning* generate variations of the choreography and can produce new choreography parts. Thirdly, the new variations are presented to the choreographer with a *presentation generator*, which can be 3D video images, animated figures or abstract images on the walls or floors. Overall, this study aims to provide new insights on presentation methods that work effectively in the creative process of choreographers or experienced dancers.

2. RELATED WORK

In this section an overview is provided of scientific research about the integration of technology in the creation of dance. It is important to acknowledge what is explored and investigated in the past in order to execute this research and to understand what this research is about.

2.1 Choreography

The background of this research lies in the creative process of creating a choreography or dance piece. Typically, a choreographer starts from a particular stimulus. This can be as varied as a specific physical movement, a musical phrase, a visual image, or a state of mind [3]. It requires choreographers to engage with inner motivations to express feelings as well as to dialogue with the external environment, whether that be visual, aural, tactile or kinesthetic environmental stimulus [4]. Furthermore, the goal of a dance production, as with any other art, is the creative exploration of an idea. Within dance, this exploration takes place through the choices made regarding choreographic expression, musical accompaniment, costuming, lighting, scenic elements, and props [5]. Choreographers can build a piece on their own or with other dancers, either way, this is an iterative and interactive process where technology can play an assistive role. We include the external stimulus to discover what inspires a choreographer in a creative process.

2.2 Dance and Technology

Alongside choreography, the background of this research lies in the relation between the creation of dance and the use of technology.

2.2.1 Integration of technology in the process of creating and performing dance

As technology continues to develop, the possibilities of integrating it in the process of creating dance increases as well. Dawn Stoppiello and Mark Coniglio believed that linking the actions of a performer to the sound and imagery that accompanied them would lead to new modes of creation and performance [6]. Merce Cunningham's "Biped" choreography integrated computer-captured dance movements and interpreted it with hand-drawn graphics, so that animated and abstract dance characters projected on a screen moved along with and among the real dancers [7]. In the media video "Ghostcatching" Bill T. Jones's recorded actions, a portrait of Jones as performer, was used to animate abstract dancers in an 8,5 minute virtual dance [8]. What these dance productions all have in common is that they aim to discover new ways of creating dance and this study has the same goal, however, we are focused on the choreographers' needs in this process and not on the end product that the audience observes.

2.2.2 Dance analysis applications

One way to create or improve dance choreographies is to watch videos of that particular choreography. Tardieu et al. presented a system for content-based browsing of a dance video database where users can interactively propose gestures [9]. Singh et al. presented a tool for choreographers and dancers, which allow multimodal annotation of rehearsal videos [10]. The systems show how choreographies are created in a static way and this research tries to implement a dynamic aspect in the creative process. Perhaps, the static and dynamic elements can be combined for even more support in the creative process.

2.2.3 Tele-immersive environments

Other studies have created systems where interactive environments are used to create or practice choreographies. Chan et al. proposed a virtual reality training application that integrates motion capture technology for dance training in a tele-immersive environment [11]. Brockhoeft et al. presented a system to create interactive augmented reality for live performances [12]. Sheppard et al. developed an application where multiple participants interact independent of physical distance, which resulted in tele-immersive dance (TED), a highly interactive collaborative environment [13]. Nahrstedt et al. created a system where 3D tele-immersive technology is used to offer an array of visual stimulations [4]. It is evident that tele-immersive environments have a similar framework as the choreography assistant tool. Except this tool would give suggested variations and generate it in real-time, that part is missing in the previous mentioned systems.

2.3 Elements of Choreography Assistant Tool

Next to the background of this research, the basis is the choreography assistant tool. The elements need to be explained in order to understand how this tool works. Especially, the possibilities of the presentation element are crucial to be acknowledged, because that is what this research is focused on.

2.3.1 Sensing

It became apparent that several kinds of motion sensing systems exist that are used to capture movements of the human body and transform it into graphic images. As mentioned before, it is used in the sensing element of the framework. Ways to capture movements varies from motion sensing systems such as markerless 3D camera clusters [14], cameras with reflective markers [15], wireless sensor modules worn at wrists and ankles [16], wearable wireless sensor nodes [17], pressure sensing floors [18] and a kinect-based human skeleton tracking system [19]. These studies demonstrate how well movements can be tracked and how motion detection can be used in various forms.

2.3.2 Representation and reasoning

Some studies show representation languages that are used for human movement. One study discusses the Labanotation system that is used for analyzing and recording movement. It comprises a symbolic notation, related to music notation, where symbols for body movements are written on a body parts [20]. One study developed a method to generate coded description from motion-captured data with the Labanotation Editor [21]. As a follow up, the researchers developed XML for Labanotation to represent text and interchange data via the Internet. With LabanXML specific motion patterns can be searched, dance movements analyzed and body motion archived [22]. Wilke et al. used Labanotation to develop a LabanDancer system and translate Labanotation scores into 3-d human figure animations, because most dancers and choreographers cannot read or write the notation [23]. One of the most influential and significant works that used animated figures for choreography is the work of Merce Cunningham. He used a computer system called Life Forms, which is an interface that supports choreography and where the tool becomes a "visual idea generator" [1, 3]. Another paper presents the evolution of Life Forms, DanceForms, which lets choreographers try out ideas and animations before ever meeting with live dancers [24]. These studies show how people interact with computer systems in their creative process. However, this is a static way where people sit behind a computer and create pieces with clicks of a mouse. This research presents the interaction in a more dynamic way. Dancers do not have to sit behind a computer to create choreographies, instead they are able to move however they want and the suggested variations will be presented to them based on the movements they have performed.

2.3.3 Presentation generation

The presentation element can be found in the majority of the previously mentioned studies. This element is divided into two sections: the visual and auditory presentations. As mentioned before, studies show that visual stimuli are used to explore the creativity in a choreography process. This means that dancers are stimulated by visual presentations such as visual effects [12], lighting [25], and 3D virtual rooms [26]. Visual effects could be presented as 2D animations where abstract figures, circles and lines are used or written text is shown to an audience [27, 28, 29]. The effects could be presented as 3D animations as well. One example is texture-mapped drawings around a 3D character [7]. Another example is the study where 3D images are based on a motion-captured human body with kinematic models, hand-drawn lines modeled as mathematical curves and sampled charcoal strokes [8]. There are also studies that use animated human figures such as Figure 5 where the model is based on a hierarchical skeleton [18, 22, 30, 31]. Next to these animated visual effects, dance notation languages such as Laban and Benesh are used as a symbolic approach to write and read dance movements [32, 33]. In addition to the visual presentations, there is the notion of aural stimuli that may be used in the choreography process. These stimuli usually come from music, but from auditory pitches or noises that movements produce as well [34, 35, 36]. The previously mentioned presentations are used as a basis for the development of the presentation methods, because that is where the methods are based on and inspired from.

3. PROBLEM STATEMENT & APPROACH

The aforementioned studies have shown that it is possible to use computer systems and interactive environments to create choreographies. However, these studies do not discuss which presentation methods should be used and how it should be presented to choreographers. In this research, we will discover which possibilities the presentation methods propose and in what ways they should be presented. If the presentation methods were known, the choreography assistant tool could aid choreographers in their creative process. Properly presenting the suggested choreography variations could lead to, for example, new ways of creating dance. Based on the literature and introduction, this research attempts to discover how we can effectively support the creative process of choreographers by answering the following question:

"Which presentation methods are considered most effective for the interactive dance choreography assistant tool?"

The first part of the research started with an extensive literature study to discover what was known about the presentation element and which presentation methods could be used in the user study. The reason for choosing the methods in this manner was to reuse what had been experimented with before and know in advance what worked. The second part of the research started with a development phase to create the presentation methods. These were tested in the user studies and assessed in the survey. Eventually, a design for the interactive dance choreography assistant tool is proposed.

4. DESIGN OF PRESENTATION METHODS

In this section the development of the four presentation methods is discussed. The methods are based on the studies found in the presentation element in Section 2.3.3 and is followed by a description of the pilot studies.

4.1 Development phase

The development phase was introduced where four presentation methods were created[1] and where each method demonstrated three variations, which are suggested dance steps. As stated in the previous paragraph, the methods are based on the studies found in the literature review. The methods consisted of visual and auditory presentations. The visual methods consisted of textual descriptions, 2D animations and 3D animations and the auditory method consisted of voice-overs. The reason for choosing the methods is that they differ from each other in the sense that they each present a different approach but propose the same variation. The methods also differ as a presentation method, meaning that the methods are distinct enough and consist of recognizable features. Furthermore, the methods differ in fidelity, which means how close one method comes to reality. The auditory instructions and textual descriptions are further away from what dance steps actually represent. However, the 2D and 3D animations are closer to the real representation of dance steps. To exclude the dependency on dance styles, the methods were created for the styles dancehall and hip-hop. In the text box below an overview of the styles is shown to provide an explanation and background. The two styles included four presentation methods and three variations each, which led to a total of 24 versions. Important to note is that the three variations were the same for every method, so in total there were six different variations, three variations for the style dancehall and three variations for the style hip-hop. The three variations for dancehall consisted of the steps "Willie Bounce", "Thunder Clap" and "World Dance". The three variations of hip-hop were based on the steps in the first three parts of Miran Kirakosian's tutorials on YouTube[2].

Dancehall is a Jamaican music and dance culture that originated in the late 1970s in Kingston. Dance crews demonstrated the style and way of living and people created their own dance steps or choreographies. Dancehall had worldwide success in the 2000s and other dancers and choreographers took their own interpretation and spread it to the wide public. This style brings along a wide variety of steps, which are inspired by every day experiences.

Hip-hop is an African-American music and dance culture that originated in the late 1970s as well. The dance style includes styles such as breaking, locking and popping, which were also demonstrated by dance crews. There are dance steps that are familiar to the wide public, but the style produces more free movements and freestyles (improvisations) than dancehall.

[1] https://github.com/analizatjon/masterthesis.git

[2] https://www.youtube.com/watch?v=ujREEgxEP7g

4.1.1 *Textual descriptions*

The textual descriptions were based on notation languages such as Laban and Benesh, however, the assumption was made that the participants of the user studies did not acquire the knowledge to interpret these notations. Thus, written descriptions were developed instead. The method did not require downloading software and the variations were therefore written in Microsoft Word. Every movement was described as clearly and explicitly as possible. After all, the participant had to read and understand the movements in order to execute the variations. An example is shown in Figure 3.

Step 2

1. Beginpositie: de benen een schouderbreedte uit elkaar en iets zakken door de knieën.
2. Het gewicht op de benen wisselt van links naar rechts.
3. Als het gewicht op rechts is, dan zijn de armen uit elkaar naast het lichaam.
4. Als het gewicht op links is, dan kruisen de armen naar beneden en gestrekt voor het lichaam.
5. Herhaal stap 1 t/m 4.
6. Draai het lichaam een kwart naar rechts en stap met de rechtervoet uit. De armen zijn gebogen en gaan horizontaal omhoog.

Figure 3. Example of textual description in Dutch.

4.1.2 *2D animations*

The 2D animations were created with Stykz[3], which is a multi-platform animation program to develop stick figures. The software is frame-based, so every frame can be customized individually. Therefore, every movement can be animated and modified as desired. This type of animation is less flexible and explicit than the ones created in DanceForms, nonetheless, Stykz had enough possibilities to create the movements. The interface is shown in Figure 4, where the starting point always is a standard stick figure. The body parts were created with added lines and adjusted by clicking on the points and dragging them in the wanted direction. The timeline and speed could be adjusted with the controller panel and the play button generated the end product in another window without the dots.

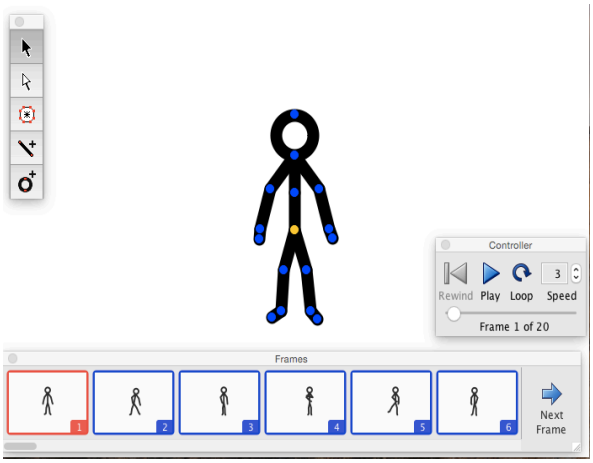

Figure 4. Development of 2D animations.

[3] https://www.stykz.net/

4.1.3 *3D animations*

The 3D animations were created with the choreography software DanceForms 2[4], which is designed to visualize dance steps or entire routines in an easy-to-use 3D environment. The 3D animations for this study consisted of one character and were made from scratch, however, large groups of characters or existing sequences from the DanceForms database could be used as well. In Figure 5, an example is shown of the development of one of the variations. On the left side, OpenGL renderer is used to present the character, which is also the end result of this presentation method and what the participants observed in the user studies. On the right side, the studio allows users to modify the movements of the body. Every body part was adjustable by clicking and dragging it or by using the axes for more accurate modifications. Next to the skeleton, the various perspectives are shown so that the user is able to see in what position the body is shaped. At the bottom, the score of the movements were presented with a panel to adjust the timeline and speed.

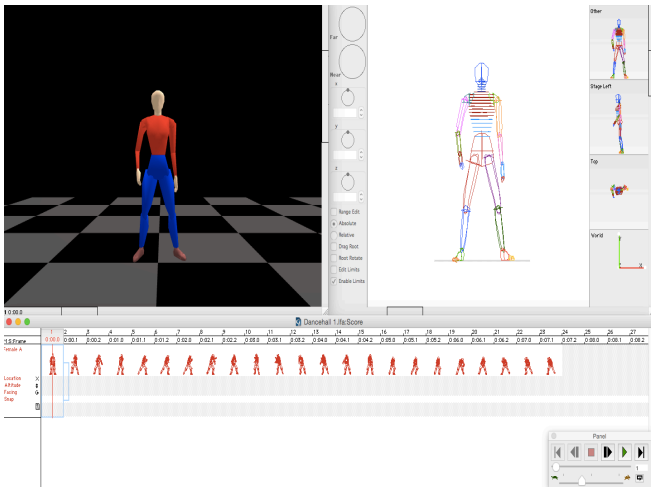

Figure 5. Development of 3-d animations.

4.1.4 *Auditory instructions*

The auditory instructions were based on the aural stimuli found in the literature review. However, music and sound pitches were not sufficient because the participants needed to listen and understand the auditory instructions in order to perform the variations. The instructions were developed with Google Translate[5] for the voice-overs. The textual descriptions were imported and the listening tool was activated as shown in Figure 6, which is outlined with the red box. While the voice over was playing, it was recorded with Quicktime Player. This resulted in the final recordings for the variations of the two dance styles.

[4] http://charactermotion.com/products/danceforms/

[5] https://translate.google.com/?hl=nl

Figure 6. Development of auditory instructions in Dutch.

4.2 Pilot Studies

After creating the variations for each presentation method and dance style, they were tested and assessed in pilot studies. The purpose of these pilot studies was to receive feedback on the created variations, so that they could be improved and/or changed. Three pilot studies were conducted as followed: Pilot study version 0.1 tested the 3D animations of the style dancehall. Pilot study version 0.2 tested all the presentation methods of the style dancehall. Pilot study version 0.3 tested everything including the two dance styles. The last pilot study resulted in the third and final version and was used in the user studies.

5. USER EVALUATION

After the development phase, the experiments were conducted to test the final version. For the experiment seven experts were used as participants to simulate a realistic creative process. These participants were gathered from Beatz Dance Studio in Nieuwegein[6]. Six of them still follow dancehall classes and one follows hip-hop, however, the former have followed hip-hop classes in the past. As part of the user study, a survey was conducted to discover background information of the participants, which presentation methods they preferred and considered to be effective. The results of the survey were used to answer the main research question.

5.1 Experimental Setup

First of all, the user study started with telling the participants that they needed to imagine that a camera was capturing the motions and that the tool generated the suggested variations in real-time. The participants learned 16 counts of steps instead of performing a choreography they created or showing movements on the spot. This choice was made to assure that the suggested variations would correspond with the movements. Furthermore, the researcher presented the suggested variations manually to recreate the effect of processing and capturing motion in real-time.

[6] http://www.beatzdancestudio.nl/

5.1.1 Framework of user study

The lay out of the user study is shown in Figure 7. The participant usually was positioned in front of the screen and the researcher in the back with the laptop and beamer.

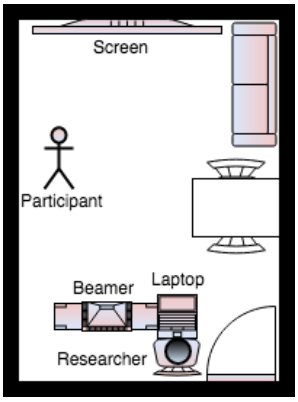

Figure 7. Lay out of user study.

Before the user study started the participants were asked to sign an informed consent letter. In phase 0, they filled in the questions of the survey on an iPad. This part consisted of questions that provided background information of the participant. In phase 1a, the camera recorder was turned on and the 16-count dancehall choreography was taught. In phase 1b, the participant performed the steps as if it was being captured by the system and the presentation methods were shown. Below is the order in which the methods were presented, where M stands for the presentation methods and v stands for the suggested variations:

- M1: 3D animations with v1, v2, v3.
- M2: Textual with v2, v3, v1.
- M3: 2D animations with v3, v2, v1.
- M4: Auditory with v1, v3, v2.

When every variation was presented, the participant showed the movements to familiarize with the presentation methods. In phase 1c, the participant evaluated the methods by filling in the questions of the survey. In phase 2a, the 16-count hip-hop choreography was taught. In phase 2b, the participant performed the steps as if it was being captured and the presentation methods were shown. Below is a different order than before in which the methods were presented, where M stands for the presentation methods and v stands for the suggested variations:

- M1: Textual with v3, v1, v2.
- M2: 2D animations with v1, v3, v2.
- M3: Auditory with v1, v2, v3.
- M4: 3D animations with v2, v3, v1.

As stated in the previous paragraph, the participant showed the movements to familiarize with the presentation methods when every variation was presented. In phase 2c, the camera recorder was turned off and the participant evaluated the methods by filling in the questions of the survey. In phase 3, the participants filled in the final questions of the survey to provide an overall assessment of the presentation methods.

5.1.2 Presentation methods in user studies

In Figures 8, 9, 10 and 11 on the following page the presentation methods are shown during the user studies. Each participant was asked to execute the movements to demonstrate that they understood the presented variations.

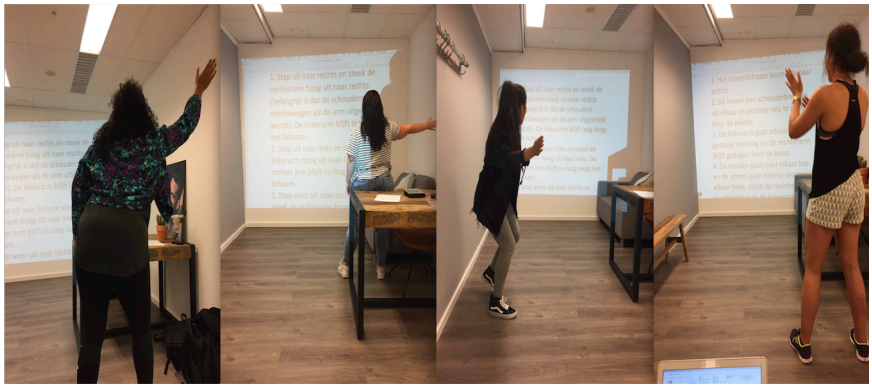

Figure 8. Textual descriptions in user studies.

Figure 9. 2D animations in user studies.

Figure 10. 3D animations in user studies.

Figure 11. Auditory instructions in user studies.

5.1.3 Survey

A survey was conducted during the user studies and consisted of four parts. Part one consisted of questions about the background of the participant to discover information about their dancing experience, experience in creating choreographies, the process of creating choreographies, what tools they use and whether they have used computer programs when creating choreographies. Part two and three consisted of essential questions about four features to discover the participants' attitude towards the presentation methods. The evaluation of the features determined the effectiveness and user acceptance of the presentation methods. Part two referred to the style dancehall and part three to the style hip-hop. The main elements presented four essential questions: *"What is the overall assessment of the presentation methods?", "Are the presentation methods stimulating the creativity?", "Are the dance steps clear to understand?"* and *"Are the presentation methods interrupting the creative process?"*. The participants were assigned to give scores from 1 to 10 when they answered these questions. 1 represented a negative score and 10 represented a positive score. Part four consisted of more general evaluation questions to discover the participants' attitude towards the presentation methods regarding which methods they would like to use and what the pros and cons are of the methods. The entire survey can be found in appendix B.

6. RESULTS

The findings of the user study are divided into four sections: the first section represents the initial findings, the second section the overall assessment of the styles dancehall and hip-hop separately, the third section the assessment of the other features as well where the styles are combined and the fourth section represents the additional results. Details of the survey results can be found on GitHub[7].

6.1 Initial Findings

In table one, a part of the background information of the participants is shown that covers part one of the survey. The age ranged from 22 to 32 and the average dance experience is 11,3 years. They all have experience in teaching dance classes where two participants have taught in the past and five still teach, therefore, they have a professional relation to dance and make weekly choreographies.

Table 1. Background information of participants.

Participant	Gender	Experience (in years)	Amount of choreography creation
I	F	15	Weekly
II	F	5	Weekly
III	M	10	Weekly
IV	F	12	Monthly
V	F	12	Weekly
VI	F	15	Monthly
VII	F	10	Weekly

[7] https://github.com/analizatjon/masterthesis

As is shown in Figure 12, there are three approaches that the participants use as supportive tools and inspiration to make choreographies. The participants mostly record videos for support and mostly watch videos of choreographies as inspiration. Besides these results, it became apparent that all participants had no experience with computer programs (software) to make choreographies. Furthermore, the most commonly described choreography process was that they listen to music, then freestyle on beat/text/rhythm/feeling and eventually refine the steps.

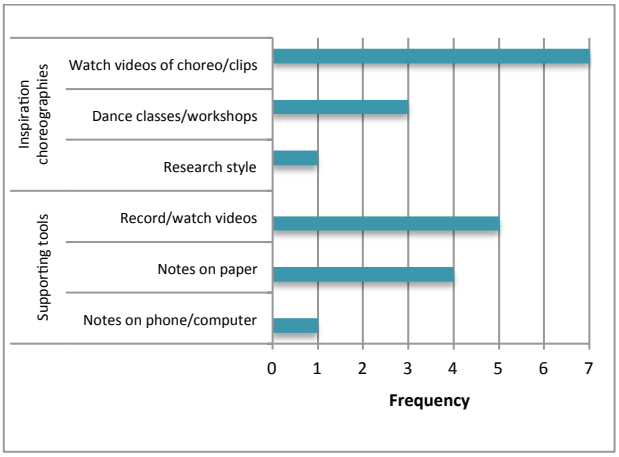

Figure 12. Frequency of participants' answers.

6.2 Overall Assessment

Part two and three of the survey covered questions about the overall assessment of the presentation methods. In Figures 13 and 14 below, the boxplots of the two dance styles are shown. The box plots present the variance, dispersions and skewness of the data. The bottom and the top of the box are the first and third quartiles and the line inside the box is the second quartile, i.e. the median. The bottom and top of the whiskers represent the minimum and maximum of the data. In Figure 13 the minimum values only differ 0,5 point from the first quartile, that is why the values are presented as equals. The overall assessment of the presentation methods is shown separately at first, because we want to discover whether there is a significant difference between the two dance styles.

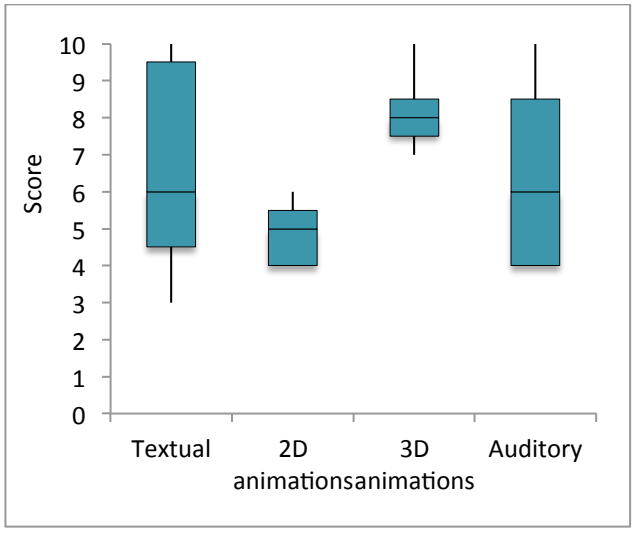

Figure 13. Boxplot of the style dancehall.

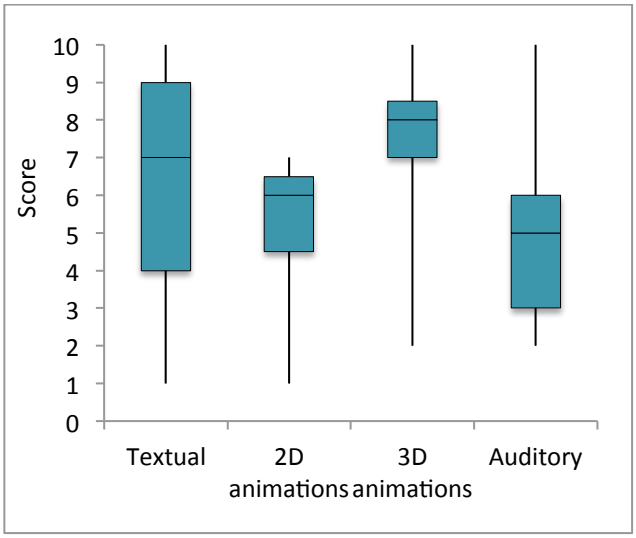

Figure 14. Boxplot of the style hip-hop

6.3 Features Presentation Methods

Next to the overall assessment of the presentation methods, part two and three also covered questions about other aspects of the methods that are shown in table two. Feature one represents the overall assessment, feature two the stimulation of creativity, feature three the clear understanding of the variations and feature four the interruption of the creative process. The scores of the styles are combined in this section, because there is a minimal difference in evaluation and we have presented the difference in styles in the previous section. In the table below the mean (μ) and standard deviation (σ) of the two styles combined are shown. The mean is used to represent the center of the data and the standard deviation is used to measure how far the data is spread apart. We can see that the highest means are underlined and highlighted in bold.

6.4 Additional Findings

Part four covered general evaluation questions where five participants chose 3D animations and two participants chose textual descriptions as the presentation method that they would like to use in a computer program. Moreover, five out of the seven participants would use a computer program that would present suggested dance steps. Regarding the question what the advantages were of the presentation methods, participants responded with answers such as *"the presentation methods inspire me"*, *"the methods improve the creativity and it is useful for new ideas"*, *"the methods are helpful when you get stuck or forget a dance step and want to learn or use new steps"*. Regarding the disadvantages, the participants responded with answers such as *"some methods were not that clear"* and *"the feeling of the movements does not really come across"*. Further remarks were *"when you know the steps, they are recognizable"*, *"maybe describe the feeling of a movement next to the animations"* and *"maybe add the option to listen to music during the process"*.

7. DISCUSSION

This section provides the interpretation and explanation of the previously presented results, which leads to an answer to the main research question. Furthermore, a design is proposed for the UI of the interactive dance choreography assistant tool.

7.1 Key Findings of User Study

The key findings of the user study cover the interpretation of the overall assessment and the other features of the presentation methods as well, because those elements of the user study and survey contain the answers to the main research question. These two elements are crucial in this study and the main purpose was to discover which presentation methods were most effective according to the experts.

7.1.1 General evaluation

The overall assessment of the presentation methods of the two dance styles shows that both datasets are approximately balanced around the same scores. Evidently, the medians in all cases differ at most with one. However, the variance of the style hip-hop is substantially higher because the bottom whiskers are lower in comparison to the bottom whiskers of the style dancehall. This suggests that the attitude towards the presentation methods of the style hip-hop is slightly more negative than the attitude towards the style dancehall. A possible explanation could be that most of the participants still follow dancehall classes and are therefore more familiar to the presented variations. Furthermore, it is possible that the research design of the dancehall presentation methods was more structured than the research design of the hip-hop presentation methods, which might make the variations more clear and understandable. Also, it is possible that the variations of the style dancehall were less complex and easier to interpret than the variations of the style hip-hop due to the previously mentioned explanations. Next to this observation there is one aspect that stands out the most, which are the scores of the 3D animations. Despite the range of the 3D animations of the style hip-hop, half of the participants gave a score higher than eight and this is the same for the style dancehall. The given scores of the 3D animations are significantly higher than the scores of the other presentation methods, which means that the participants prefer this method more than the others.

Table 2. Mean and sigma of two dance styles combined.

	Feature 1: Overall assessment		**Feature 2: Stimulation of creativity**		**Feature 3: Clear understanding of dance movements**		**Feature 4: Interruption of the creative process**	
	μ	σ	μ	σ	μ	σ	μ	σ
Textual	6,5	3,1	5,4	2,6	6,7	3,3	6,1	3,1
2D animations	5,4	1,9	5,8	2,3	5,5	2,2	6	3
3D animations	**7,7**	2	**7,1**	2,2	**7,7**	2,1	**7,7**	2,5
Auditory	5,6	2,8	4,7	2,6	6,3	2,6	5,6	2,9

7.1.2 Features of presentation methods

The evaluation of the features of the two styles combined shows that the average of all scores are approximately higher than five and the standard deviation varies from two to three. The spread of the data is possibly caused by the variance of the style hip-hop where lower scores were given. Furthermore, this means that there is quite a difference in interpretation of the presentation methods and that more data points (more participants) are needed to obtain significant results. The participants were neutral towards the 2D animations and the auditory instructions. Regarding the 2D animations they were less positive about the clear understanding of the variations and more positive about the level of interruption in the creative process. This suggests that the animations were not clear enough to understand and requires further development. Moreover, this means that the animations were not interrupting the process. Regarding the auditory descriptions the participants were less positive about the stimulation of creativity and more positive about the clear understanding of the variations. This indicates that the voice-overs were not that inspiring, however, they were indeed clear enough to understand. The participants were overall more positive about the textual descriptions, yet they have a similar attitude towards the stimulation of creativity and clear understanding of the variations. The participants were the most positive about the 3D animations where the lowest average of 7,1 is represented by the stimulation of creativity and the highest averages of 7,7 are represented by the other features. This suggests that the effectiveness and user acceptance are considered the highest for the 3D animations. The previously mentioned findings are demonstrated as well in the total average of the two dance styles combined, where the 3D animations received an average score of 7,6. This is followed by a 6,2 for the textual descriptions, a 5,7 for the 2D animations and a 5,6 for the auditory instructions. Moreover, the results of the additional findings correspond with the evaluation of the 3D animations, because five participants chose this presentation method and two chose the textual description to use in a computer program that gives suggested variations.

7.1.3 Main research question

Overall, the results show that the participants have a neutral or positive attitude towards the four presentation methods. However, the scores of the 3D animations were significantly higher than the other presentation methods. Thus, the participants prefer the 3D animations as a method to stimulate their creativity, which is clear to understand and does not interrupt the creative process. This presentation method is considered to be the most effective and accepted for the interactive dance choreography assistant tool.

7.2 Proposed Design for the IDCAT

The previously mentioned findings together with the results of the initial and additional findings are used to propose a design for the UI of the interactive dance choreography assistant tool (IDCAT). One result in the additional findings shows that five out of the seven participants would use a program that presents suggested variations, thus, a design is a logical outcome of this finding. The purpose of the IDCAT is to support the choreographer in the creative process of making choreographies by not only capturing movement, but also generate real-time variations based on the movements of the choreographer. As mentioned in the introduction this tool contains three elements, which are sensing, representation & reasoning and presentation generation.

Firstly, the design of the UI starts with the sensing element where an easy-to-use, cost-effective and markerless motion capture system[8] is chosen. This type of technology is similar to what Sheppard and Yang et al. used in their research. The movements are captured with cameras, which do not include markers or sensors on the body [13, 14]. This allows users to move freely and behave in the same way as when no tool would support the process. Secondly, the design continues with the representation & reasoning element where a motion database and motion matching are chosen to process the captured movements and link them to developed variations in the database. Chan et al. used these types of technology in their research and proved that real-time generation of information worked, which is useful for the next element as well [11]. Thirdly, the design finishes with the presentation generation element where a 3D graphics generator is chosen to process the variations into 3D animations and present them to the user. Once more, Chan et al. implemented this in their research. Due to the evaluation of the textual descriptions and the remark of describing the feeling of the movements, it is optional to choose text that describes the steps and feeling. Thus, the 3D animations are presented as default and in addition it is possible to display an integrated textbox.

In addition to these elements, there are several options that can be included as well. Based on the results of the supportive tools, the UI gives the possibility to create a personal account where sessions can be recorded, saved and watched. Users are able to add notes to the videos in separate files as well. Furthermore, based on the remarks in the additional findings, the UI integrates music by linking Spotify or YouTube to the tool that allows users to choose songs during a session. YouTube can also be used as an additional database that turns movements into 3D animations and variations, so that users are not only inspired by variations in the database, but also by the variations of the chosen video. This option is based on the result of participants being inspired by watching videos of other choreographers/artists. Lastly, the movements of the user are turned into 3D animations as well and saved as variations in the database. In Figure 15, the global design of the IDCAT is shown.

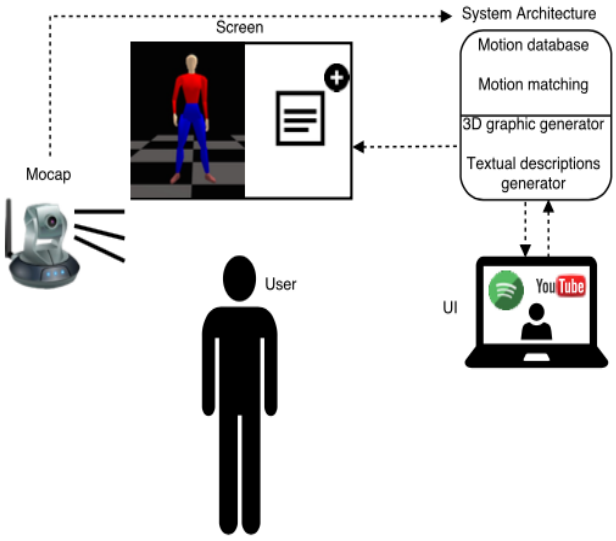

Figure 15. Global design of the UI of the IDCAT.

[8] http://www.organicmotion.com/mocap-for-animation/

7.3 Scope and Limitations

We will discuss several aspects to acknowledge the scope and limitation of this research. Firstly, the user study was conducted with seven participants, which desirably would be extended to a higher amount of participants to achieve more data and results. Secondly, this brings us to how generic the results are, which means how the results are linked to the variables that were set up in the user study and which presentation methods were used for testing. The question is whether other presentation methods produce the same results and whether four methods are enough. The same goes for the two dance styles, which leads to a similar question, whether other styles produce the same results and whether two styles are enough. These aspects are important to acknowledge, not only for future research, but also for the purposes of this research.

8. CONCLUSION

The aim of this research has been to discover how to improve the creative process of choreographers and which presentation methods are considered to be effective in the UI of an interactive dance choreography assistant tool. The study started with an extensive literature review to determine which presentation methods were going to be developed to present the suggested variations. The presentation was not generated in real-time, however, the researcher did this manually. The methods were compared and evaluated by seven experts in a user study including a survey. As a result, the 3D animations received the most positive evaluation and are therefore preferred the most by the experts. Overall, the 3D animations are considered to be the most effective presentation method, which is followed by the textual descriptions. To complete the research, the findings are integrated in the design for the UI of the interactive dance choreography assistant tool.

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REFERENCES

[1] Parrish, M. (2007). Technology in dance education. In *International handbook of research in arts education* (pp. 1381-1397). Springer Netherlands.

[2] Risner, D., & Anderson, J. (2008). Digital Dance Literacy: an integrated dance technology curriculum pilot project 1. *Research in Dance Education*, *9*(2), 113-128.

[3] Calvert, T. W., Bruderlin, A., Mah, S., Schiphorst, T., & Welman, C. (1993, May). The evolution of an interface for choreographers. In *Proceedings of the INTERACT'93 and CHI'93 Conference on Human Factors in Computing Systems* (pp. 115-122). ACM.

[4] Nahrstedt, K., Bajcsy, R., Wymore, L., Sheppard, R., & Mezur, K. (2007). Computational model of human creativity in dance choreography. *Urbana*, *51*, 61801.

[5] Latulipe, C., Wilson, D., Huskey, S., Gonzalez, B., & Word, M. (2011, November). Temporal integration of interactive technology in dance: creative process impacts. In *Proceedings of the 8th ACM conference on Creativity and cognition* (pp. 107-116). ACM.

[6] Coniglio, M. (2005). The importance of being interactive. *New Visions in Performance*, 5-12.

[7] Abouaf, J. (1999). " Biped": a dance with virtual and company dancers. 1. *IEEE MultiMedia*, *6*(3), 4-7.

[8] Dils, A. (2002). The ghost in the machine: Merce Cunningham and Bill T. Jones. *PAJ: A Journal of Performance and Art*, *24*(1), 94-104.

[9] Tardieu, D., Siebert, X., Mazzarino, B., Chessini, R., Dubois, J., Dupont, S., ... & Visentin, A. (2010). Browsing a dance video collection: dance analysis and interface design. *Journal on Multimodal User Interfaces*, *4*(1), 37-46.

[10] Singh, V., Latulipe, C., Carroll, E., & Lottridge, D. (2011, November). The choreographer's notebook: a video annotation system for dancers and choreographers. In *Proceedings of the 8th ACM conference on Creativity and cognition* (pp. 197-206). ACM.

[11] Chan, J. C., Leung, H., Tang, J. K., & Komura, T. (2011). A virtual reality dance training system using motion capture technology. *IEEE Transactions on Learning Technologies*, *4*(2), 187-195.

[12] Brockhoeft, T., Petuch, J., Bach, J., Djerekarov, E., Ackerman, M., & Tyson, G. (2016, June). Interactive Augmented Reality for Dance. In *Proceedings of the Seventh International Conference on Computational Creativity*.

[13] Sheppard, R. M., Kamali, M., Rivas, R., Tamai, M., Yang, Z., Wu, W., & Nahrstedt, K. (2008, October). Advancing interactive collaborative mediums through tele-immersive dance (TED): a symbiotic creativity and design environment for art and computer science. In *Proceedings of the 16th ACM international conference on Multimedia* (pp. 579-588). ACM.

[14] Yang, Z., Yu, B., Wu, W., Diankov, R., & Bajscy, R. (2006, October). Collaborative dancing in tele-immersive environment. In *Proceedings of the 14th ACM international conference on Multimedia* (pp. 723-726). ACM.

[15] Wechsler, R., Weiß, F., & Dowling, P. (2004). EyeCon: A Motion Sensing Tool for Creating Interactive Dance, Music, and Video Projections. In *Proceedings of the AISB 2004 COST287-ConGAS Symposium on Gesture Interfaces for Multimedia Systems* (pp. 74-79).

[16] Aylward, R., & Paradiso, J. A. (2006, June). Sensemble: a wireless, compact, multi-user sensor system for interactive dance. In *Proceedings of the 2006 conference on New interfaces for musical expression* (pp. 134-139). IRCAM—Centre Pompidou.

[17] Park, C., Chou, P. H., & Sun, Y. (2006, March). A wearable wireless sensor platform for interactive dance performances. In *Pervasive Computing and Communications, 2006. PerCom 2006. Fourth Annual IEEE International Conference on* (pp. 6-pp). IEEE.

[18] Srinivasan, P., Birchfield, D., Qian, G., & Kidané, A. (2005, June). A pressure sensing floor for interactive media applications. In *Proceedings of the 2005 ACM SIGCHI International Conference on Advances in computer entertainment technology* (pp. 278-281). ACM.

[19] Alexiadis, D. S., Kelly, P., Daras, P., O'Connor, N. E., Boubekeur, T., & Moussa, M. B. (2011, November). Evaluating a dancer's performance using kinect-based skeleton tracking. In *Proceedings of the 19th ACM international conference on Multimedia* (pp. 659-662). ACM.

[20] Loke, L., Larssen, A. T., & Robertson, T. (2005, November). Labanotation for design of movement-based interaction. In *Proceedings of the second Australasian conference on Interactive entertainment* (pp. 113-120). Creativity & Cognition Studios Press.

[21] Nakamura, M., & Hachimura, K. (2002). Development of multimedia teaching material for Labanotation. In *ICKL (International Council of Kinetography Laban) Proceedings of the Twenty-second Biennial Conference* (pp. 150-160).

[22] Nakamura, M., & Hachimura, K. (2006). An xml representation of labanotation, labanxml, and its implementation on the notation editor labaneditor2. *Review of the National Center for Digitization (Online Journal)*, *9*, 47-51.

[23] Wilke, L., Calvert, T., Ryman, R., Fox, I., & Bureau, D. N. (1932). From dance notation to human animation: The LabanDancer project. *New York Times*.

[24] Calvert, T., Wilke, W., Ryman, R., & Fox, I. (2005). Applications of computers to dance. *IEEE computer Graphics and Applications*, *25*(2), 6-12.

[25] El-Nasr, M. S., & Vasilakos, A. V. (2008). DigitalBeing–using the environment as an expressive medium for dance. *Information Sciences*, *178*(3), 663-678.

[26] Jung, S. H., & Bajcsy, R. (2006). A Framework for Constructing Real-time Immersive Environments for Training Physical Activities. *Journal of Multimedia*, *1*(7), 9-17.

[27] Bailey, H. (2007). Ersatz dancing: Negotiating the live and mediated in digital performance practice. *International Journal of Performance Arts and Digital Media*, *3*(2-3), 151-165.

[28] Gonzalez, B., Carroll, E., & Latulipe, C. (2012, October). Dance-inspired technology, technology-inspired dance. In *Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design* (pp. 398-407). ACM.

[29] Latulipe, C., & Huskey, S. (2008, September). Dance. Draw: exquisite interaction. In Proceedings of the 22nd British HCI Group Annual Conference on People and Computers: Culture, Creativity, Interaction-Volume 2 (pp. 47-51). British Computer Society.

[30] Zordan, V. B., & Hodgins, J. K. (1999). Tracking and modifying upper-body human motion data with dynamic simulation. In *Computer Animation and Simulation'99* (pp. 13-22). Springer Vienna.

[31] Neagle, R. J., Ng, K., & Ruddle, R. A. (2004, March). Developing a virtual ballet dancer to visualise choreography. In *Proceedings of the AISB* (pp. 86-97).

[32] El Raheb, K., & Ioannidis, Y. (2011, May). A labanotation based ontology for representing dance movement. In *International Gesture Workshop* (pp. 106-117). Springer Berlin Heidelberg.

[33] Özen, F., Tükel, D. B., & Dimirovski, G. (2017). Synchronized dancing of an industrial manipulator with humans on arbitrary music. *Acta Polytechnica Hungarica*, *14*(2).

[34] Hagendoorn, I. (2004). Some speculative hypotheses about the nature and perception of dance and choreography. *Journal of Consciousness Studies*, *11*(3-4), 79-110.

[35] Sevdalis, V., & Keller, P. E. (2011). Captured by motion: Dance, action understanding, and social cognition. *Brain and cognition*, *77*(2), 231-236.

[36] Qian, G., Guo, F., Ingalls, T., Olson, L., James, J., & Rikakis, T. (2004, June). A gesture-driven multimodal interactive dance system. In *Multimedia and Expo, 2004. ICME'04. 2004 IEEE International Conference on* (Vol. 3, pp. 1579-1582). IEEE.

APPENDIX A: Survey questions

In this appendix the survey questions (in Dutch) can be found that were asked during the user study. The link below presents the form in Google docs that the participants used on the tablet to answer the questions.

https://docs.google.com/forms/d/e/1FAIpQLSffTchCha34zTwUYK8mlJYHnHFBZPTutgXN2FEDveNh9aIi7A/viewform?usp=sf_link

Part I

Wat is uw geslacht?	Man / Vrouw
Wat is uw leeftijd?	… jaar
Hoeveel danservaring heeft u?	0-1 jaar / 2-3 jaar / 4-5 jaar / overig
Wat is uw relatie tot dansen?	Professioneel / recreatief.
Hoeveel uur in de week danst u?	0-1 uur / 2-3 uur / 4-5 uur / overig
Heeft u ervaring in het maken van choreografieën?	Ja / Nee

Hoe vaak maakt u een choreografie? Dagelijks / wekelijks / maandelijks / overig

Kunt u het proces beschrijven van het creëren van choreografieën?

……
……
……

Wat voor hulpmiddelen gebruikt u bij het maken van choreografieën?

Notities op papier / notities op telefoon of computer / choreografie filmen of video bekijken / dansnotaties zoals Laban of Benesh (symbolen voor danspassen) / overig

Heeft u ervaring met computer programma's (software) voor het maken van choreografieën? Met een computer programma wordt bijv. geen software bedoeld als Microsoft Word, maar software zoals DanceForms waarin je je eigen choreografie maakt met animaties of software zoals Dance Designer waarbij je choreo's aanpast m.b.v. beeldmateriaal, formaties en notities.

Ja / Nee

Waar haalt u inspiratie vandaan voor het bedenken van de choreografieën?

……
……
……

Part II - Dancehall

Wat is uw algemene beoordeling van de modaliteiten? 1 zeer negatief, 5 neutraal, 10 zeer positief.

DanceForms	1	2	3	4	5	6	7	8	9	10
Tekst	1	2	3	4	5	6	7	8	9	10
Stickfigure	1	2	3	4	5	6	7	8	9	10
Auditief	1	2	3	4	5	6	7	8	9	10

In hoeverre stimuleren de modaliteiten uw creativiteit? 1 niet stimulerend, 5 neutraal, 10 zeer stimulerend

DanceForms	1	2	3	4	5	6	7	8	9	10
Tekst	1	2	3	4	5	6	7	8	9	10
Stickfigure	1	2	3	4	5	6	7	8	9	10
Auditief	1	2	3	4	5	6	7	8	9	10

In hoeverre zijn de danspassen duidelijk te begrijpen? 1 niet duidelijk, 5 neutraal, 10 zeer duidelijk

DanceForms	1	2	3	4	5	6	7	8	9	10
Tekst	1	2	3	4	5	6	7	8	9	10
Stickfigure	1	2	3	4	5	6	7	8	9	10
Auditief	1	2	3	4	5	6	7	8	9	10

In hoeverre verstoren de modaliteiten het creatieve proces? 1 zeer storend, 5 neutraal, 10 niet storend

DanceForms	1	2	3	4	5	6	7	8	9	10
Tekst	1	2	3	4	5	6	7	8	9	10
Stickfigure	1	2	3	4	5	6	7	8	9	10
Auditief	1	2	3	4	5	6	7	8	9	10

Part III – Hip hop

Wat is uw algemene beoordeling van de modaliteiten? 1 zeer negatief, 5 neutraal, 10 zeer positief.

DanceForms	1	2	3	4	5	6	7	8	9	10
Tekst	1	2	3	4	5	6	7	8	9	10
Stickfigure	1	2	3	4	5	6	7	8	9	10
Auditief	1	2	3	4	5	6	7	8	9	10

In hoeverre stimuleren de modaliteiten uw creativiteit? 1 niet stimulerend, 5 neutraal, 10 zeer stimulerend

DanceForms	1	2	3	4	5	6	7	8	9	10
Tekst	1	2	3	4	5	6	7	8	9	10
Stickfigure	1	2	3	4	5	6	7	8	9	10
Auditief	1	2	3	4	5	6	7	8	9	10

In hoeverre zijn de danspassen duidelijk te begrijpen? 1 niet duidelijk, 5 neutraal, 10 zeer duidelijk

DanceForms	1	2	3	4	5	6	7	8	9	10
Tekst	1	2	3	4	5	6	7	8	9	10
Stickfigure	1	2	3	4	5	6	7	8	9	10
Auditief	1	2	3	4	5	6	7	8	9	10

In hoeverre verstoren de modaliteiten het creatieve proces? 1 zeer storend, 5 neutraal, 10 niet storend

DanceForms	1	2	3	4	5	6	7	8	9	10
Tekst	1	2	3	4	5	6	7	8	9	10
Stickfigure	1	2	3	4	5	6	7	8	9	10
Auditief	1	2	3	4	5	6	7	8	9	10

Part IV

Welke modaliteiten zou u willen gebruiken in een computer programma?

DanceForms, tekst, Stickfigure, auditief, geen van allen

Zijn er voordelen aan het gebruik van de modaliteiten?

……
……
……

Zijn er nadelen aan het gebruik van de modaliteiten?

……
……
……

Zou u gebruik maken van een computer programma (software) die u ondersteunt in het maken van choreografieën door suggesties te geven voor volgende danspassen? Hierbij kunt u aannemen dat de suggesties aansluiten bij de gemaakte choreografie.

……
……
……

Waarom wel/niet?

……
……
……

Heeft u op- of aanmerkingen m.b.t het onderzoek?

……
……
……