Evaluation of a Multimodal Video Annotator for Contemporary Dance

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ABSTRACT

This paper discusses the evaluation of a video annotator that supports multimodal annotation and is applied to contemporary dance as a creation tool. The Creation-Tool was conceived and designed to assist the creative processes of choreographers and dance performers, functioning as a digital notebook for personal annotations. The prototype, developed for Tablet PCs, allows video annotation in real-time, using a live video stream, or post-event, using a pre-recorded video stream. The tool also allows different video annotation modalities, such as annotation marks, text, audio, ink strokes and hyperlinks. In addition, the system enables different modes of annotation and video visualization. The development followed an iterative design process involving two choreographers, and a usability study was carried out, involving international dance performers participating in a contemporary dance "residence - workshop".

Categories and Subject Descriptors

H.5. Information interfaces and presentation: H.5.1 Multimedia Information Systems-*Video*; H.5.2 User Interfaces- *Input devices and strategies*, *Interaction styles*

General Terms

Experimentation, Human Factors.

Keywords

Real-Time Video Annotations, Multimodal Video Annotations, Contemporary Dance, Performing Arts

1. INTRODUCTION

Creative processes of choreographers, or other authors in the performing arts, involve several rehearsal iterations where video based annotation can significantly enhance the process. The TKB (Transmedia Knowledge-Base for contemporary dance) project has the aim to provide a research space for a rigorous, critical exploration of the relationship between linguistics, performing art studies, new digital media and thought/consciousness.

Being a transdisciplinary project, it aims at the design and construction of an open-ended multimodal knowledge-base to document, annotate and support the creation of contemporary dance pieces.

The TKB project proposes to extend the scope and application of the "documentation" concept to contemporary dance in different ways: to develop a strong link between the recent performing arts-research community and the well-established communities in cognitive linguistics [13,16,17] and computer science, by taking a closer look at the cognitive process of "choreographic thinking" [22], and therefore contribute to the domains of multimodal corpora [15], terminological ontologies, cognition and verbal-nonverbal relations.

This project includes two main components: (1) the linguistic analysis and annotation of multimodal corpora; and (2) the development of an original customizable software tool to support choreographic creation processes in real time, while allowing personal annotations of the respective authors.

The second component is what we have called "Creation-Tool" [10]. The novelty here was to design a creation-oriented tool deriving from the results of the annotated video corpora with the aim of feeding back to the choreographic creative process. It was conceived as an auxiliary tool both for the creator's task in real time compositions and for their archiving intentions. Therefore, it requires a familiar interface and setup, so that the usage of the tool would not interfere with an already existing choreographic method.

The Creation-Tool was developed for Tablet PCs, using a bimanual pen and touch interaction. Touch is mainly used for mode and tool switching, exploiting the non-preferred hand [18]. The combination of pen and touch inputs mimics the familiar human interaction with pen and paper [12, 20] using electronic devices. This interaction, with pen and touch, is superior in terms of speed, accuracy and user preference, to other bimanual combinations, i.e., using two hands or two pens [3]. The tool supports the capture and multimodal annotation of video content. In addition, the system explores different modes of annotation and video visualization, in order to provide a more natural and easy method to add notes to dynamic content.

The Creation-Tool was conceived to assist the creative processes of choreographers and dance performers, working as a digital notebook for personal annotations. However, we believe it can be of use to several other purposes, such as in competitive sports, social and anthropological field work, creative video and educational settings.

2. RELATED WORK

Choreography and dance professionals are beginning to take advantage of the potential from the interactive digital media to develop new forms of mediation and new types of resources, making choreographic ideas more accessible. Video is crucial to capture human body movements and choreographies. In order to add and share information, personal or other, to this type of content, video annotators are becoming important in dance environments. Different types of video annotators, with diverse modalities, were developed in the last decades. The different modalities of video annotations try, not only to record and add more real information to video content, but also to reduce interferences in existing creative processes and work methodologies, which could be due to the usage of digital technology.

2.1 Video Annotators for Dance Performance

Danvideo [14] is a system for semi-automatic authoring and access to dance archives, providing methods of annotation and authoring and retrieval tools. Danvideo allows semantic video annotations based on the MPEG-7 standard. The annotator module allows the dance expert to annotate manually the video content using macro and micro annotations. Macro annotations represent macro features of the video content such as dancer's and musician's contacts, music, song, background, tempo of dance steps, date and time of the recording. Micro annotations represent micro features like order of the events, actors of the event, concepts revealed by actors, relationships of the different events, actors, and concepts.

Video Traces [8] allows users to capture video and to annotate it by talking and gesturing. The system enables one to capture and organize video clips. Users can capture video directly from a camera or use previously recorded video content. The audio recording is made using an external microphone connected to the laptop computer. It is also possible to change different video playback features, such as playback speed, freeze a frame or rewind. Audio, gestures, and video playback changes are overlaid on the video and preserved in a resulting "video trace".

A more recent collaborative Web-based video annotation system, the Choreographer's Notebook [21], allows video annotations composed by text, ink and video. A time stamp is used in order to associate the annotations to the pre-recorded video content. The annotations can be displayed on top of the video window or around it. Although it is possible to sketch with a stylus in the Choreographer's Notebook, the system was not specifically designed for Tablet PCs.

The Creation-Tool, presented in this paper, aims at functioning as a digital notebook for choreographers and dance performers. The system explores natural, familiar and user-friendly methods of video annotation, like pen-based annotations or voice annotations. The Creation-Tool can be used to annotate video content from a live video stream, using a camera, or pre-recorded video content.

2.2 Multimodal Video Annotators

Over the last 30 years, different types of video annotators were developed in order to add information to this medium. Aiming at capturing more real and natural annotations, different modalities were tried.

The EVA [19] system, from the late 80's, is one of the oldest systems of video annotation and went beyond text annotations, allowing voice annotations that could be transcribed to text.

Since then, other systems explored multimodal video annotation. The MRAS [1] allowed collaborative audio and text annotations. The AntV [9] explored multimedia annotations, in the form of text, images or videos, over the main video window. In the Ambulant Player [4] the video annotations can be composed of text, audio, ink and images. In this system, the annotations are represented by icons on top of the video window; pen-based annotations are dynamic and have their spatial path explicitly defined by the user. The WaC [7] tool allows ink, text and audio on top of a single pre-recorded video frame. Even though this association is interesting, it loses the temporal dimension of video content. The M4note [11], a previous version of the WaC, also allowed the annotation of a live video stream. Nonetheless, the annotations were also associated to a single frame.

The work, featured in this paper, not only allows a full range of annotation modalities, like text, audio, ink and hyperlinks but also explores real-time and post-analysis video annotation.

3. A CREATION-TOOL FOR CONTEMPORARY DANCE

This section presents the video annotator and the different input modalities and annotation modes. Choreographers and dancers can use the system to analyze and improve their work, by recording and annotating a rehearsal or a live performance, for a later review or for sharing notes with other performers.
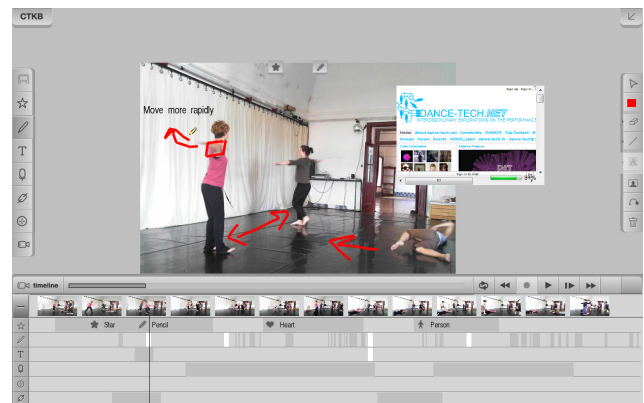

Figure 1. The Creation-Tool and the different annotation types.

The video annotator interface (Figure 1) is composed of a video display area, presenting a live or pre-recorded stream, in which it is possible to augment the content with multimodal annotations. It is also possible to annotate in the area around the video window, avoiding the occlusion of video elements by the user's notes.

The time interval of any given annotation is shown in a timeline, as well as the corresponding video frames, allowing browsing the video content and annotations. The annotation time interval is changeable in the timeline, which is divided in different tracks. Each track is associated to an annotation modality (Figure 1). In order to retrieve a wider view of the annotations, a navigator menu was added to the system. This navigator (Figure 2) shows all annotations associated to the video content and allows its navigation. The video navigation can be made by pressing one annotation, causing a change in the video time position.
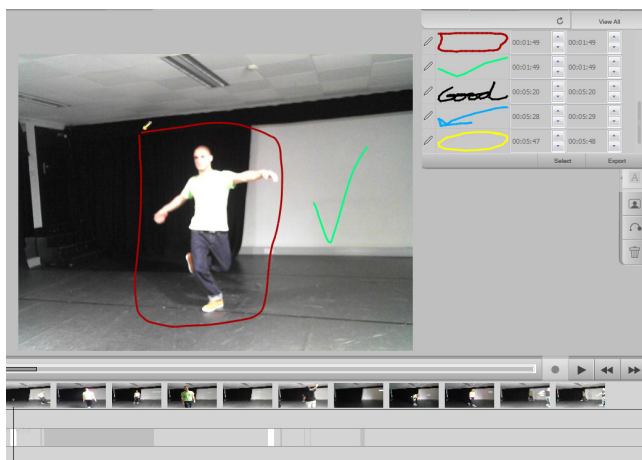
Figure 2. Set of pen-based video annotations with time intervals.

3.1 Video Annotation Modalities

The Creation-Tool supports the capture and multimodal annotation of video content. The annotations associated to video content can be annotation marks, audio, text, ink strokes and hyperlinks. All annotations are stored in a separate XML file [6]. In order to maintain the annotations context, i.e., to maintain the association between a note and the corresponding video feature, graphical video annotations such as text, marks, sketches and hyperlinks, can be combined with motion tracking algorithms [5, 6].

3.1.1 Annotation Marks

Annotation marks are concepts, defined by the user. These marks are represented by a keyword and an icon, in contrast to regular annotations that do not have a pre-defined structure. In order to add a mark, the user should press the corresponding button in the annotation marks bar and press it again for its removal.

3.1.2 Audio Annotations

The Creation-Tool enables the recording of voice annotations. The system produces a sound file for each annotation made and a main sound file for the background sound of the video. Currently, the user explicitly defines the annotation time interval, using the audio annotation button. A wireless microphone and a remote control, implemented in a mobile device, can be used for the recording of remote annotations.

3.1.3 Text Annotations

The text annotations can be made using a physical keyboard or a virtual keyboard. This input method allows the writing of regular text annotations using a text box. Moreover, the Tablet stylus, combined with a handwriting recognizer, can also be used for text annotations, thus replacing the usage of a keyboard.

3.1.4 Pen Annotations

Pen-based video annotations enable the user, in this case the choreographer, to sketch over a video stream, therefore allowing more freedom in the creative process. The system implements the concept of pen-based video annotations, i.e., a set of time ink strokes, with spatial and temporal dimensions [5, 6]. Pen-based annotations can also be used for sketching the icons of annotation marks. The sketched icons are saved as JPEG images and included in the icons library.

3.1.5 Hyperlinks

The system offers two types of hyperlinks: local and external. The local links are composed of other documents owned by the user, such as text, images or other videos. The external links are Web sites defined by a URL. After the user has defined which document or Web site he/she wants to add to the video content, the system will display a thumbnail of the hyperlink.

3.1.6 Grouping/Ungrouping Annotations

The annotations can be grouped, behaving as one single annotation. This allows the control of different annotations at the same type and is particularly useful when two or more input modalities are used, e.g., a sketched arrow pointing at a hyperlink. The group/ungroup operation can be achieved by selecting each annotation or an area. Nonetheless, the original time intervals associated to each annotation are maintained.

3.2 Annotation and Video Modes

Annotating a live event creates a set of interaction challenges: should the user's attention be focused on the tool or in the event? And what if the user wishes to annotate a moment which has already occurred? In order to answer these questions, different annotation and video visualization modes were developed.

The system offers two modes for video annotation: the continuous and the suspended modes. In the continuous mode the video does not stop while the annotation occurs; in the suspended mode a video frame is frozen for the annotation.

The system also allows two modes for video visualization: real-time and delayed. The real-time mode records an event and displays the video simultaneously; by contrast the delayed mode displays the video to the user a few seconds after the event has occurred.

The annotation and video visualization modes can be combined. For example, one can use the continuous mode in the real-time visualization mode or in the delayed mode.

3.2.1 Continuous vs Suspended

In the continuous mode (Figure 3), the annotations are made as the video is captured and directly in that same video window. The
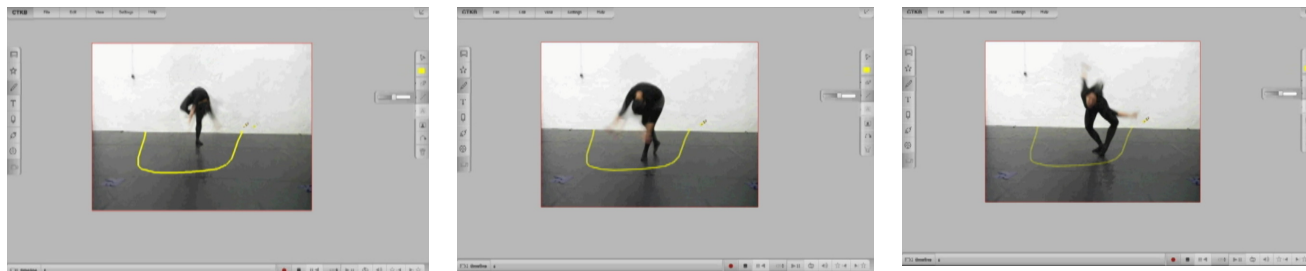

Figure 3. Annotating in the continuous mode: annotation gradually disappears.

annotations are saved along the video segments. This mode allows the user to watch the video being captured continuously and annotate it at the same time. In this mode, the annotations gradually disappear, since their time interval has already ended. After the capture, the system shows the annotations in the same order as they had been made.

Figure 4. Annotating in the suspended mode. Left side: video window. Right side: annotated frame.

The suspended mode copies a particular frame to an area where the user has the opportunity to annotate it. The video stream is displayed on the left side of the interface and when the user presses onto this video window, the corresponding frame is copied to the right side. The annotations can be made on top of this particular frame, as shown in Figure 4, and remain associated to it. The capture itself does not stop or pause while the user is annotating. In the suspended mode, the annotations remain visible, until a mode change occurs or a new frame is picked. In order to visualize the annotations after the capture, the video playback pauses in the annotated frame during a period.

3.2.2 Real-Time vs Delayed

Two modes for video visualization were developed: real-time and delayed. The real-time video mode records an event and displays it simultaneously, enabling a straightforward method for video annotation. However, this mode directs the user's attention to the tool and not to the event, working as a "see through" application. In the delayed video mode, the event is displayed with a time delay, thus allowing later annotation. In this mode, the user' attention can be focused on the event and not on the tool. The delay definition time is configurable by the user, allowing different delay timing for each user.

4. DESIGN PROCESS

The Creation-Tool was designed following an iterative process, in which two choreographers with different working habits and needs were involved from the beginning. Additional input was also obtained from dancers and dance technology experts, first of all in a one-week residence-lab workshop and then during the development process. Usability, user-friendly design and the ability to categorize the information into a coherent structure were the main concerns during the interface design process.
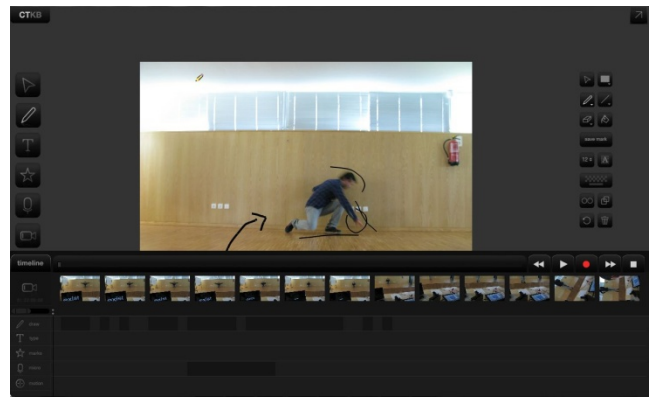

Figure 5. Initial interface design.

In order to have an initial feedback on the tool, a preliminary test was made with one of the choreographers, simulating a dance rehearsal situation. The main interface was well perceived but some minor issues were observed [6] and addressed in a second design of the interface, shown in Figures 5 and 6.
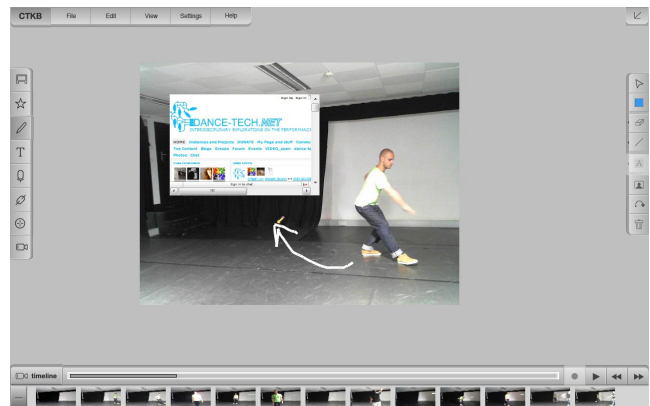

Figure 6. Current interface design.

5. EVALUATION

With the aim of evaluating the prototype and the different modalities, we have conducted a usability test with 12 international dance performers from a contemporary dance "residence-workshop". The participants were divided into 3 separate groups, 4 participants per group. While one participant was doing the usability test, the other three were improvising a performance for the test.

The usability test was composed of 10-15 minutes of tool experimentation, assisted by a member of the development team, followed by a questionnaire. Two main scenarios were sequentially tested by each user: during a live event, with a camera recording the other users; and after the event, using the video stream previously recorded. The questionnaire had three major parts: participants' information, participants' working habits and tool evaluation.

5.1 Participants

The subjects were primarily females (83.33%), the mean of ages was 25 (SD=2.56) and they were all right handed. Most of the subjects had a Bachelors degree (58.33%), a quarter (25.00%) had studied until high school, 8.33% held a Master's degree and the remaining 8.33% had attended elementary school education. Most of the subjects did not have previous experience with pen-based

technology (83.33%) and did not have experience with touch technology either (91.67%).

5.2 Working Habits

All participants were used to recording their work and usually make use of video recordings. Almost all of them use regular paper notebooks (91.67%) and a quarter (25.00%) uses audio recordings.

Almost all of the subjects annotate their work in some way (91.67%). From that percentage, almost all of them use regular paper notebooks (90.91%), more than half use a laptop (54.55%) and only 9.09% use mobile phones, as shown in Figure 7.
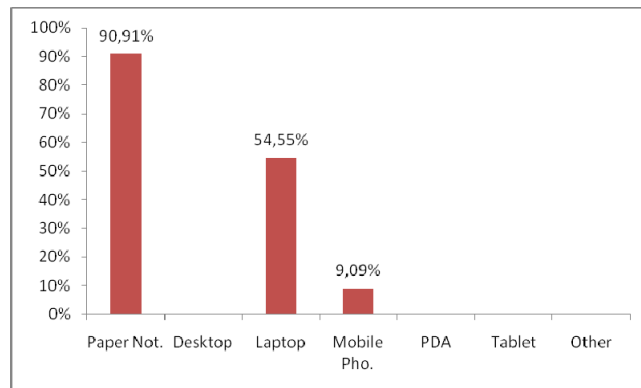
Figure 7. Participants'annotation methods.

Most of the users share their working documents (75.00%), mostly by e-mail (88.89%) or by sharing hardware (77.78%), such as pen drives, CDs or DVDs. Some of them use Web sites (33.33%), instant messaging (33.33%), post mail (11,11%) or other media (22.22%), such as, sharing printed books or network file sharing.

5.3 Tool Evaluation

The tool evaluation was composed of eight questions with five point Likert Scale answers, five about mode usage rate (1 for Rarely - 5 for Frequently) and three about perceived difficulty (1 for Difficult - 5 for Easy); one based on Microsoft "Product Reaction Cards" classification [2] and one open question for comments and suggestions.

In order to compare the mode preferences and the perceived difficulty, paired-samples t-tests (Q1, Q5, Q6 and Q7) and one-way between subjects ANOVA (Q2, Q3 and Q4), were conducted based on the null hypothesis (H0), i.e., the means of the different answers, in each question, were equal. In both tests the alpha level was 0.05, stating that we wish to be 95% confident in the results.

In Q1, the participants were asked to rate the tool usage in two different scenarios: during a rehearsal (MEAN=2.83, SD=1.11) and after a rehearsal (MEAN=4.42, SD=1.16). The t-test presented a significant difference ($t(11)=-3.98, p<0.05$) between the two scenarios, showing that the participants prefer to use the tool after a rehearsal (Figure 8).
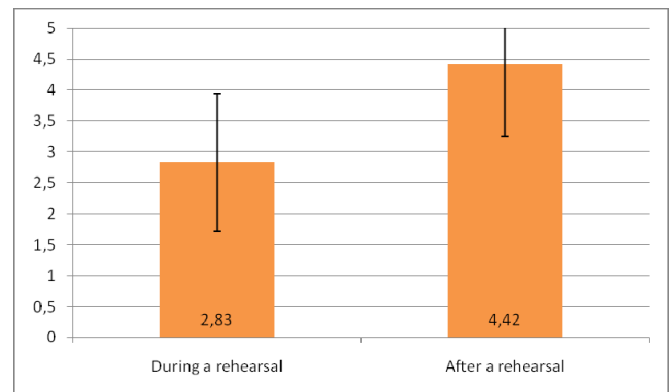

Figure 8. Mean scores for two different usage scenarios: during a rehearsal and after a rehearsal. [1]

Afterwards they were asked to rate the usage of the different annotation types, considering the two scenarios: during a rehearsal (Q2) and after a rehearsal (Q3).

In Q2 (Figure 9), the ANOVA test showed a significant difference ($F_{4,55}=8.02$, $p<0.0001$) between the different annotation types during rehearsal scenario. Post hoc comparisons, using the Tukey HSD test, indicated that the mean score for the sketch (MEAN=4.33, SD=1.15) was significantly different from text (MEAN=2.83, SD=1.27), marks (MEAN=2.50, SD=1.62) and hyperlinks (MEAN=2.00, SD=1.35) but not from audio (MEAN=4.25, SD=1.27). However, the mean score for audio was only significantly different from marks and hyperlinks. The other means did not present any significant differences. These results show a usage preference for sketching, during a rehearsal, since sketch presents more significant differences when compared with the other annotation modalities.
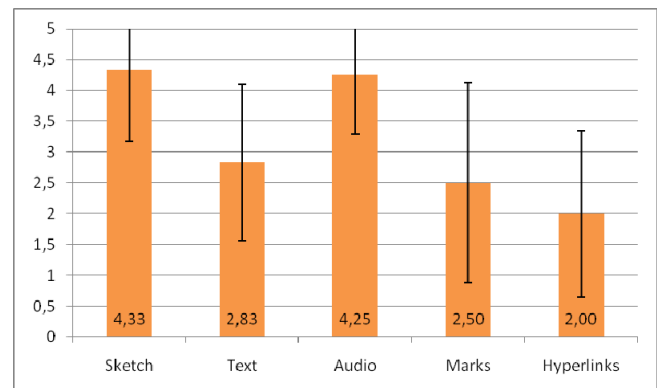

Figure 9. Mean scores for the usage of the different annotation types, during a rehearsal. [1]

In Q3 (Figure 10), the ANOVA test did not present a significant difference ($F_{4,53}=2.45$, $p>0.05$) [2] between the different annotation types in an after-rehearsal scenario.

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[1] Error bars represent the standard deviation.

[2] Due to missing data, we considered only 11 participants for Sketch and Audio and 12 for other annotation types. A second ANOVA was conducted, but not considering the answers of the participant that caused the missing data. The conclusion of this test was the same: there was not a significant difference ($F_{4,50}=2.19$, $p>0.05$).
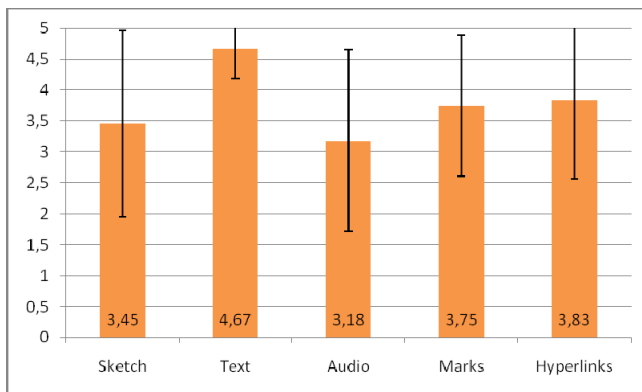
Figure 10. Mean scores for the usage of the different annotation type after a rehearsal.[1]

The perceived difficulty of the different annotation types was studied in Q4 (Figure 11) and an initial ANOVA test presented a significant difference ($F_{4,55}$=3.46, p<0.01). However, the audio annotations were rated, by all participants, with the maximum of 5 points, resulting in SD=0 and Variance=0. A second ANOVA test was conducted without the audio annotations. This second test showed that there was not a significant difference ($F_{3,44}$=1.27, p>0.05) between sketch, text, marks and hyperlinks.
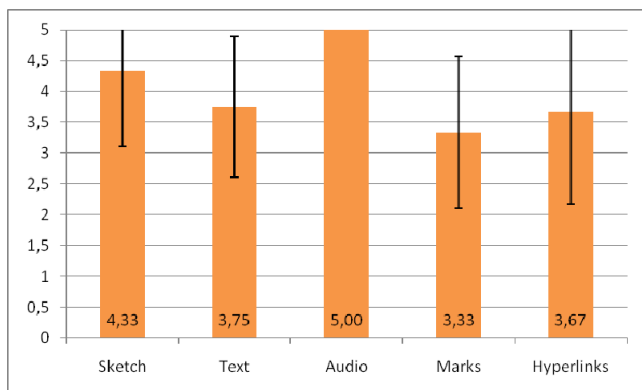

Figure 11. Mean scores for perceived difficulty of the different annotation type during a rehearsal. [1]

We can say that there is a perceived easiness for the audio annotations but this requires further usability studies for confirmation with a larger set of subjects.
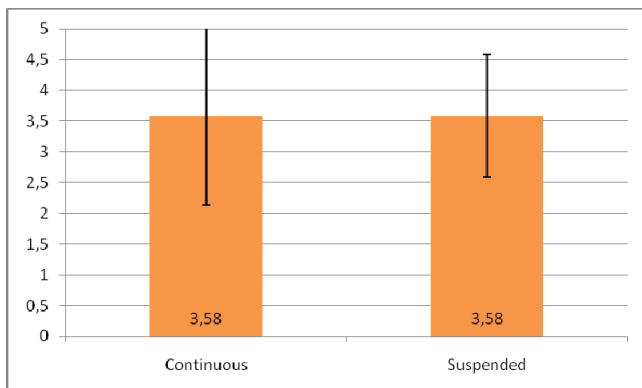

Figure 12. Mean scores for the usage of the different annotation modes: continuous and suspended. [1]

In Q5, participants were asked to rate the usage of two annotation modes: continuous (MEAN=3.58, SD= 1.44) and suspended (MEAN=3.58, SD=1.00). The t-test did not present a significant difference, (t(11)=0, p>0.05) between the means of the two annotation modes (Figure 12). The perceived difficulty of the continuous (MEAN=3.67, SD=1.37) and suspended (MEAN=4.33, SD=0.78) annotation modes was studied in Q6 and the t-test did not also present a significant difference (t(11)=-1.61, p>0.05) between the means of the two annotation modes (Figure 13).
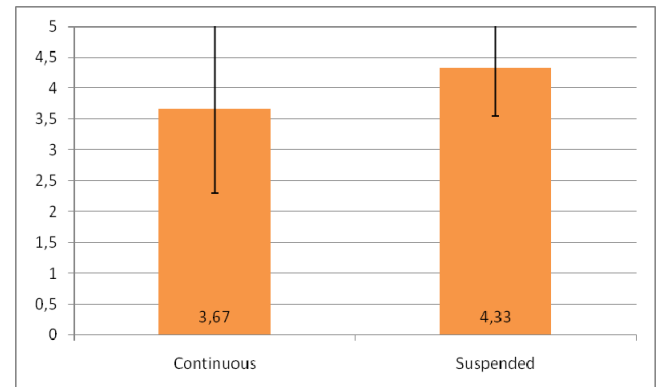

Figure 13. Mean scores for the perceived difficulty the different annotation modes: continuous and suspended. [1]

The answers from Q5 and Q6 show that there is not a preference between the continuous and the suspended mode. These modes need further studies, considering different tool usages.

In Q7, the participants were asked to rate the usage of two video visualization modes: the real-time (MEAN=2.83, SD=1.45) and delayed ones (MEAN=4.5, SD=0.90), during a rehearsal. The t-test presented a significant difference (t(11)=-3.46, p<0.05) between the means of the two video modes, showing the preference for the delayed mode (Figure 14).
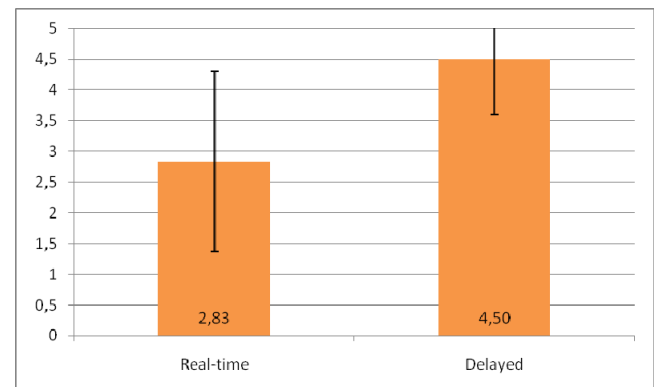

Figure 14. Mean scores for the usage of the different video visualization modes: real-time and delayed. [1]

The perceived difficulty of the tool interaction was rated in Q8, with a MEAN=4.08 (SD=0.90). In Q9, they were asked to classify the tool with 48 words of the Microsoft "Product Reaction Cards" [2]. Figure 15 presents the percentage for each word. The most selected (>50%) words were: "attractive", "useful", "clear", "helpful", "time-saving", "innovative" and "organized".

In Q10, we have asked for open comments and suggestions. There were a few open comments, reporting a positive feedback on the tool.
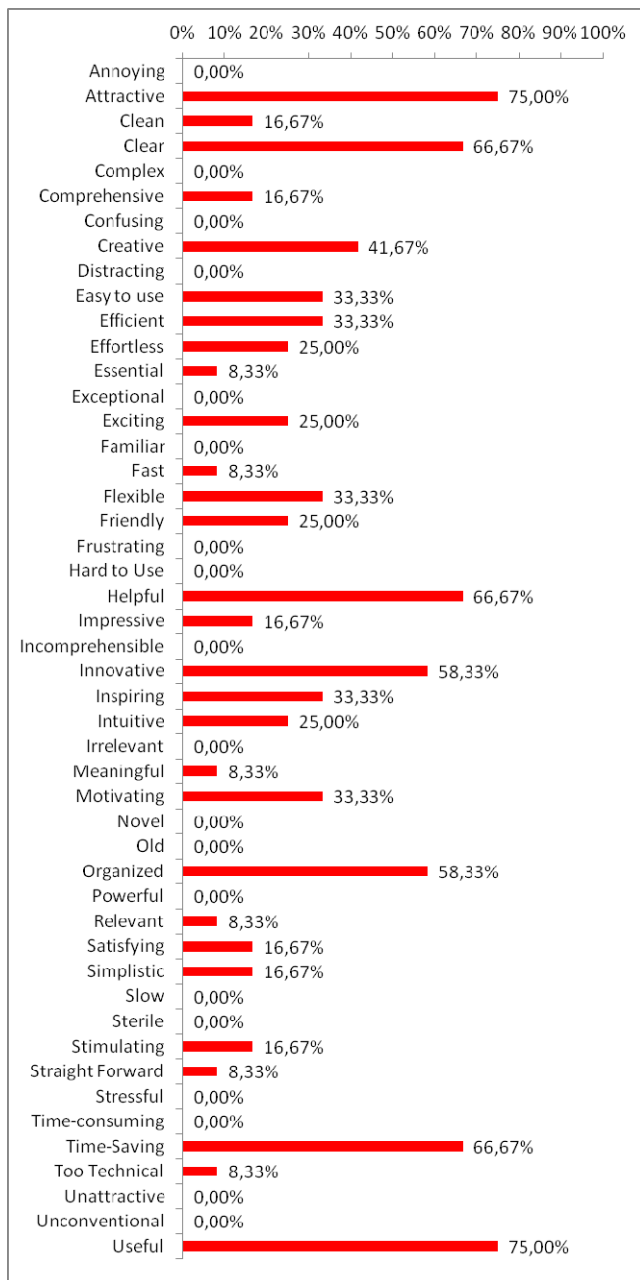
Figure 15. Classification with Microsoft "Product Reaction Cards".

6. DISCUSSION AND CONCLUSIONS

The evaluation of a multimodal video annotator, used as a Creation-Tool for contemporary dance, was described and discussed in this paper.

The prototype was mainly developed for Tablet PCs, exploring pen and touch interaction. The system allows annotations composed of annotation marks, text, ink, audio and hyperlinks. The prototype enables annotations from a live or pre-recorded video streams. The system and its evaluation studied the different annotation types, modes and scenarios.

Regarding the evaluation there are two major results: 1) the interface was well perceived by the testing participants and 2) the

participants have recognized the positive contribution a tool like this can have on creative processes.

There was a tool usage preference for the post-rehearsal scenario. Based in our iterative design process with the choreographers, we believe that this preference depends on the task to perform. Dance performers, during a rehearsal, need to concentrate on their gestures and movements, thus preferring to use the tool after a rehearsal. In contrast, choreographers need to be focused on the different details of the performance. Therefore, they can use it during or after rehearsal.

Regarding the annotation types, there was a preference for sketching, during a rehearsal. If we also consider the high percentages of work documentation using video and work annotation using paper notebooks, we can conclude that sketching is an important modality for video annotation. Our study is not conclusive regarding the perceived difficulty of the different annotation types. Further studies are required on this issue.

The study did not show a clear preference between the different annotation modes, but there was a preference for the delayed video visualization mode, when compared with the real-time mode. This result shows the importance of a mode which directs the user's attention to the real event rather than to the application.

7. ONGOING WORK

The Creation-Tool was designed and evaluated according to expert user's needs, i.e., choreographers and dance performers. Nonetheless, a more "in the field" evaluation, i.e., in longer dance productions, is being made with two choreographers. Due to the long periods of time dance productions can take (often lasting several months), it would be premature now to publish any results of this evaluation.

In addition, an integration of a motion tracking framework with the Creation-Tool is also under development. The usage of motion tracking methods aims to maintain the annotation context, i.e., the association between the annotation and video features, even if these features are constantly moving. In the context of the motion tracking framework development, OpenCV[3] tracking methods were already tried [6] and the development using the Kinect[4] is in progress.

As part of the project, a Web-based archive for dance videos and annotations is also being developed, which can be made using the Creation-Tool or any other source. By being part of an Art&Science project, the Creation-Tool prototype builds upon the experience insights of contemporary creators in order to come to an original tool for performance composition, notation and documentation where the conceptual principles of each choreographer are keywords for their future archive's structure and indexation.

8. ACKNOWLEDGMENTS

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