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Pathways to Live Visuals in Dance Performances: a Quantitative Audience Study

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Abstract

INTRODUCTION: We present an audience study investigating the impact of different technologies to create visuals in dance performances.

OBJECTIVES: We investigated four conditions: motion capture, sensors, camera image, and minimal interaction; and four variables: how much did the audience perceive a connection between the body and the visuals; the visuals as merely copying the dancer; how much distracting were the visuals; and how much did the audience enjoy the visuals.

METHODS: We used a questionnaire to collect data. We analyzed it using Friedman's test, and Spearman's correlation test.

RESULTS: The audience perceived a stronger connection in the camera condition, but in the same condition, visuals tend to be merely copying the dancer. We also suggest that the perceived connection has a positive correlation with enjoyment, while distraction has a negative correlation.

CONCLUSION: Our results help to highlight the impact that different technology have on live visuals for dance.

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1. Introduction

There has been a growing interest in the use of interactive live visuals in contemporary dance performance. Some important examples include the works of Robert Wechsler, Frieder Weiss and collaborators [1], Klaus Obermeier [2], OpenEndedGroup [3] and Rhizomatics [4]. However, there is still a lack of research regarding how audience members value the inclusion of live visuals in dance performances and how they perceive the interactive aspect of these live visuals.

We organized a public performance in order to gain an understanding of the audience's perception of live visuals in contemporary dance, and what interaction design elements might be more conductive to audience enjoyment and understanding of the visuals. The performance consisted of four different dance pieces with four choreographies, using four different designs for live visuals. During the performance, we conducted an audience study: we asked audience members to fill in a questionnaire, with questions related to the visuals. The same questions were asked for each of the four performances.

In this paper, we start by presenting related work and literature, then we briefly describe the different choreographies and the design of the visuals. Then we describe the methods used for the audience study. We then present the results, and a discussion on implications for the design of interactive visuals for contemporary dance.

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2. Background

2.1. Live visuals in performance arts

With the developments in multimedia computing since the last part of the 20th century, performance arts in general have been adopting interactive visuals ("real-time visuals" or "live visuals") in performance. Live visual artists within music performances (also named as VJs or Video Jockeys) wish to "adapt and appropriate technology in order to attain expression through visual media" [5]. In some cases, live visuals may lead to additional understanding for audiences regarding electronic music performances, particularly laptop performances, where the musical interaction might be harder to perceive [6]. Live visuals have also been extensively used in theatre, and have become embedded in the dramaturgy: the "story is being told by both mediums", enabling the audience to "focus attention on the connection between performer and digital environment" [7].

In dance, artists have been exploring "the role of digital visualization in choreography, dance performance and documentation" [8]. An example of this exploration is the project Choreographic Morphologies [8], where motion capture data is used for 3D visualizations. Another relevant example is the project Phantom Limb, which proposes "virtual body extensions": digital visuals conceived as artificial composites of the performer's body [9]. Advances in machine learning have also been used to create visuals, trained with dancers' data, allowing to respond to "the idiosyncratic movements of an individual dancer" [10]. Masu et al. conducted a study with dancers and choreographers aiming to understand how dance artists wish to use technology in dance, in particular live visuals [11].

2.2. Audience studies in digital performance

The growing use of technology in dance, and performance arts in general, has led to several audience studies regarding the reception of these technologies. In music, a relevant topic has been the connection between the technology adopted and the audience enjoyment of the performance. Bin et al. examined the impact of familiarity with a Digital Musical Instrument (DMI) on the understanding and enjoyment of a performance [12]. The results of this study suggested that previous knowledge about the DMI facilitated the understanding of the performance, but not the enjoyment. In a follow-up study, the same authors investigated the effect of gesture size on audience perception of DMI performances [13]. The results suggested that the size of the instrument (and consequently of the gesture) might have an impact on the audience appreciation of performances. Another topic that emerged in related literature is the understanding of errors in performance with digital technology. Another study by Bin and colleagues investigated the perception of error in DMIs performances, and how this affects the enjoyment of the performance [14]. Interestingly, they did not find any strong correlation between error perception and lack of enjoyment of the performance.

A recent study investigates the combination of audio and visual elements in audiovisual performances [6]. The results suggest that two design strategies might support audience understanding of an audiovisual performance: audiovisual entities, an object-oriented approach to composition consisting of multiple sounds, each with unequivocally associated images; and sounding figurations, visual elements that can be drawn during the performance and whose parameters are mapped into sound. In theatre, Cesar et al. [15] have studied the impact of tele-presence in performances, using galvanic skin response sensors to analyze the engagement of remote theatre audiences. Radbourne et al. [16] conducted focus groups to assess quality in theatre plays, particularly regarding potential re-attendance.

Regarding dance, the research project "Watching Dance: Kinesthetic Empathy" [17] combined qualitative methods and neurophysiological research to analyze how spectators respond to dance, both during and after the performance. Albert [18] studied how dancers and audience members react to movement in social dance (both improvised and choreographed) by using conversation and video analysis. The understanding of movement qualities by audiences was the focus of a study by Mentis and Johansson, relying on qualitative methods and analysis of recorded material [19].

3. Research Questions and Hypotheses

3.1. Research Questions

The above related research proposes strategies to use technology and visuals in dance, and presents several approaches towards audience studies in performance arts. However, there is a lack of investigation in the actual audience reception of live visuals in dance. Therefore we propose the following Research Questions (RQ).:

- RQ1 What technological settings for interactive visuals in dance a) allow to understand the connection between the body of a dancer and the visuals, b) allow to create visuals that are not redundant and merely copying what the body is already visibly doing?

- RQ2 What perceived elements in visuals impact the overall enjoyment of a dance performance? In particular, we will focus on three perceived elements (related to RQ1). The perceived elements are: a) the perception of a connection between the

visuals and the dancers; b) the level of novelty that the visuals introduced to the performance as compared to the body movement of the dancer(s) on stage; and c) the level of distraction that the visuals introduce to the performance.

We conducted our research by implementing four technological conditions, using common interactive technologies in dance for gathering data from the dancers' body: motion capture, sensors and video camera. Condition C1: full-body motion capture (tracking suit) as input; condition C2: specific information about the body using sensors, either biological data or position, as input (be it in-body or off-body); condition C3: the image of the body with a camera as input; condition C4: small amount of movement data captured from the body, used rarely (minimal interaction condition), specifically: sporadically tracking speed of movement of the dancer using a camera and mapping this to subtle visual effects (such as a slight rotation of graphics).

The four dependent variables we collected data on are: V1) the perception of a connection between the visuals and the dancers; V2) the added value the visuals introduced to the performance as compared to the body movement – to measure this we asked it in a reversed manner, inquiring if the visuals were merely copying the body; V3) the level of distraction that the visuals introduce to the performance; and V4) the overall enjoyment of the visuals in the performance.

The first two dependent variables are grounded in previous phases of the project and previous literature, and derive from the design guidelines we developed during a participatory stage between a team of designers, developers and dancers [11]. Regarding connection to the design guidelines, dependent variable V1) is connected to guideline 3c) "Technology should facilitate adding information contributing to multiple meanings of the performance". Dependent variable V2) is connected to guideline 3a) "Technology should not repeat the information that the dancer is already giving with their movement".

Concerning previous literature, this work is also grounded in the studies developed by Bin and colleagues [12–14]. In their work, the authors explored the effect of different elements of musical performance in either audience understanding or enjoyment. Another recent study that influenced the design of our research was conducted by Correia et al. [6], investigating which design strategies might better support audience understanding of an audiovisual performance. Their research defined specific conditions in which visuals support the understanding of a performance. In addition to those elements derived from the guidelines, we collected information about how much the visuals were distracting (variable V3), and how much they contributed to enjoyment (V4).

3.2. Hypotheses

RQ1 What technological setting for interactive visuals?

- H1 The main hypothesis is that the distributions of the values of the four variables in the four conditions are not equal; in detail we have the following specific hypotheses related to the four variables :
- H1a) related to V1 - Connection: we expect that in the camera condition C3 will have higher rates than the sensors condition C2 and the minimal interaction condition C4, this is because the camera as input has a strong relationship with the actual image of the dancer.
- H1b) related to V2 - Merely copying: we expect that the camera condition C3 will correspond to a higher perception of duplication and redundancy, while sensors C2 will have lower values, because the information acquired as input in the interaction of the visual is less related to body and only to specific parameters. We also expect minimal interaction C4 to have lower values, due to the lack of input data.
- We have no expectation on the distributions of the V3 - distraction and V4 - enjoyment variables.

RQ2 What perceived elements in visuals impact the overall enjoyment?

- H2a) V1 connection and V4 enjoyment: the perception of a connection between the visuals and the dancers should increase the enjoyment of the visuals.
- H2b) V2 merely copying and V4 enjoyment: the level of novelty that the visuals introduced to the performance as compared to the body movement should increase the enjoyment of the visuals.
- H2c) V3 distraction and V4 enjoyment: the level of distraction that the visuals introduce to the performance should decrease the enjoyment of the visuals.

4. Methods

4.1. Description of performances

The performance consisted of four contemporary dance pieces:

- The Beautiful Glitch - Condition C1: motion capture (tracking suit)
- E-motional Landscapes - Condition C2: sensors as input

- Connection Retrieval - Condition C3: camera as input
- A Dance to Remember - Condition C4: minimal interaction

In The Beautiful Glitch, a piece for two dancers, there is an exploration of the limits of motion capture, and the expectations of the audience regarding the reliability of technology. Only one dancer is tracked by the motion capture system (a suit incorporating motion sensors). The visuals include real-time visualizations of the body, created through motion capture data. E-motional Landscape explores the relation between the dancer's body and the space. Data from the dancers is collected based on a breath sensor and their position on stage, tracked by a camera. In a smaller segment, another camera is used to film the space, which is shown in the visuals, but this is considered out of scope for our study (as we are focusing on connection of visuals to the body, not the space). Connection Retrieval explores the connection between two dancers, who are either trying to connect or avoiding each other. In parts of the piece, one of the dancers is represented through the visuals on the screen, sparking a reaction from the other dancer. In other parts, both dancers are represented on the screen, affecting the movement on stage. In this piece, the camera is used as an input. A Dance to Remember is a solo piece, and consists of a dialogue between a dancer and an on-screen abstract avatar, that reacts to the movements and attitudes of the dancer and gives her advice. The avatar is actually controlled off-stage by the choreographer, creating the illusion of a virtual assistant. There is minimal captured data from the dancer as input.

All the performances took place in the same space, a black box theater at Tanzhaus NRW (Düsseldorf), in October 2019. In the scope of the Moving Digits project (movingdigits.eu) the dancers have been part of a team that, on average, participated in two previous design workshops, in the same year. The performances were the result of a two-week residency where the choreographers and the technologists worked together. Before the performances the dancers, the choreographers and the technologists rehearsed the four performances in a five-days workshop.

4.2. Questionnaires

The questionnaires contained a demographics section and the following questions, repeated 4 times (one group of questions per performance):

- a) Did you perceive a connection between the actions of the dancers and the visuals?
- b) Were the visuals on the screen merely copying the actions of the dancers?
- c) Did the visuals distract you from following the dancers' performance?
- d) Describe with a couple of words the relation between the actions of the dancers and visuals:
- e) Did you enjoy the visuals in the performance?
- f) Please add a couple of words regarding your opinion on the visuals:

Questions d) and f) are open-ended, and out of scope for this study. The other questions consist of 5-point Likert scales, where 1 represents "strongly disagree" and 5 "strongly agree".

4.3. Participants

We distributed the questionnaire to the audience members of the performance. The choice of filling the questionnaire was voluntary. 24 members out of a total audience of 26 (11 female and 15 male, age ranging between 24 and 62) filled in the questionnaire fully. This scenario of participants is imposed by the setting (a public performance). It might introduce some bias, as it can result in involving more interested audience members. This represents a limitation of this study.

4.4. Description of procedure

The audience members were asked to fill in a questionnaire at the end of each performance, played in succession, one after the other. The test was repeated with four different performances. At the beginning of each performance, the audience members were asked to read the questions; this way, we aimed to limit the bias/learning effect form the performance. At the end of each performance, the participants were asked to answer the respective questions. The procedure involved repeated measures, as the same audience rated all the variables in four performances.

4.5. Analysis

Friedman's test is used to test for differences between groups when the dependent variable being measured is ordinal and Spearman's correlation test is a non-parametric measure of the strength and direction of association that exists between two variables measured on at least an ordinal scale.

Comparison of the four conditions. To compare the four variables in the four conditions, we used a Friedman test. As we obtained statistical validity in rejecting the null hypothesis in all the four variables, we proceeded with pairwise comparisons. A detailed analysis is reported below. We performed a Friedman test comparison among conditions because:

- we had four groups;

- we had repeated measures / related samples;
- we had Likert scales, that is, an ordinal data set, therefore, the parametric assumption was not met.

We repeated the Friedman test four times, one for each variable.

Correlation of the dependent variables. We also studied the correlation between 1) the connection between the visuals and the body and enjoyment; 2) visuals merely repeating the body and enjoyment; 3) the distraction of the visuals and the enjoyment. To study the correlation, we considered the four performances as the same dataset and performed a correlation using Spearman's p (rho) correlation as:

- we had to correlate two variables;
- we had Likert scales, an ordinal data set, therefore the parametric assumption was not met.

We repeated the Spearman's test three times, one for each comparison.

5. Results

5.1. Comparison of the four conditions

Concerning the comparison among the four conditions, the results of the analysis support us in rejecting the null hypothesis about the distribution in each of the four variables. Below we detail the results for each variable.

Independent Variable: V1) Connection. Concerning the perceived connection between the visuals and the body variable, a Friedman's test for related samples was used on the recognition scores in the four conditions. Differences across conditions were significant, Fr(2)=18.149, p<.05. (Table 1)

Table 1. Results of Friedman test on Connection Variable

N	24
Test Statistic	18.149
Degree of Freedom	3
Asymptotic Sig.	<0.001

We also found statistical significance in two pairwise comparisons. Significance has been adjusted by the Bonferroni correction for multiple tests. We found significance in the following pairs:

- condition 2 – condition 3 (test statistic = -1.27, p = 0.004, effect size = 0.25)
- condition 1 – condition 3 (test statistic= -1.08, p = 0.022, effect size = 0.22)

Independent Variable: V2) Merely Copying. Concerning the visuals merely copying the body variable, a Friedman's test for related samples was used on the recognition scores in the four conditions. Differences across conditions were significant, Fr(2)=27.817, p<.05 (Table 2).

Table 2. Results of Friedman test on Merely Copying Variable

N	24
Test Statistic	27.817
Degree of Freedom	3
Asymptotic Sig.	<0.001

We also found statistical significance in two pairwise comparisons. Significance has been adjusted by the Bonferroni correction for multiple tests. We found significance in the following pairs:

- condition 2 – condition 3 (test statistic = -1.16, p = 0.010 ,effect size = 0.23)
- condition 3 – condition 4 (test statistic = -1.77, p < 0.001, effect size = 0.36)

Independent Variable: V3) Distraction . Concerning the distraction of the visuals variable, a Friedman's test for related samples was used on the recognition scores in the four conditions. Differences across conditions were significant, Fr(2)=8.186, p<.05 (Table 3)

Table 3. Results of Friedman test on Distraction Variable

N	24
Test Statistic	8.186
Degree of Freedom	3
Asymptotic Sig.	0.042

We did not find statistical significance in any pairwise comparison, for the variable distraction.

Independent Variable: V4) Enjoyment. Concerning the enjoyment of the visuals variable, a Friedman's test for related samples was used on the recognition scores in the four conditions. Differences across conditions were significant, Fr(2)=9.582, p<.05 (Table 4)

We did not find statistical significance in any of the pairwise comparisons, for the variable enjoyment.

Table 5 reports the medians of the four variables in the four conditions.

5.2. Correlation

We also performed a Spearman's test to investigate the correlation between each of the first three variables with the enjoyment of the visuals. For correlation, we looked at the four conditions together.

Table 4. Results of Friedman test on Enjoyment of the Visuals Variable

N	24
Test Statistic	9.582
Degree of Freedom	3
Asymptotic Sig.	0.022

Table 5. Overall trend of the 4 variables with the 4 conditions ([*] or [**] – statistical validity in pairwise comparison)

Variables	C1 Motion Capture	C2 Sensors	C3 Camera Image	C4 Minimal Interaction
Connection	4 [*]	3.5 [**]	5 [*] [**]	4
Copying	2	2 [*]	4 [*] [**]	1 [**]
Distraction	3	3	2.5	1
Enjoyment	4	3	5	3.5

Correlation between V1) connection and V4) enjoyment. Results of the Spearman rho test show a significant correlation (r = 0.497) between the perceived connection between visuals and the body and the enjoyment of the visuals ($p < 0.001$). High connection corresponds to high enjoyment.

Correlation between the V2) merely copying variable and the V4) enjoyment of the visuals. Results of the Spearman rho test show a non-significant correlation (r = -0.349) between the visuals merely copying the body variable and the enjoyment of the visuals ($p = 0.636$). This correlation is not statistically significant.

Correlation between the V3) distraction and the V4) enjoyment of the visuals. Results of the Spearman rho test show a significant correlation (r = -0.349) between the distraction of the visuals and the enjoyment of the visuals ($p < 0.001$). Low distraction corresponds to an increase in the enjoyment of the visuals.

6. Discussion

Based on the results of our analysis, we can propose the following reasoning related to our hypotheses.

6.1. Research Question 1

Concerning H1a): we can confirm that the camera condition C3 was more effective in creating a direct connection with the body (V1) compared with the sensors condition C2 and the motion capture tracking suit condition C1. Therefore we can argue that our hypothesis H1a), related to which condition was more effective in creating a connection between visuals and dancers, was partly verified (C3 was more effective than C2).

This result is not surprising, as the camera was acquiring the full body information of the dancer, while the sensors could obtain only specific parameters. The camera condition C3 also had a higher median than the motion capture condition (tracking suit) C1. This is of interest because the tracking suit still has a connection with the full body (though possibly less obvious, as it is reconstructed visually as an avatar). More relevant is also that the pairwise comparison between the camera C3 and the minimal interaction C4 condition had no statistically significant difference. Therefore, we have to reject the hypothesis of the second part of H1a) concerning connection (C3 was not more effective than C4). This is particularly interesting, as the visuals in the minimal interaction C4 condition were not based on significant information from the body. We speculate that in the minimal interaction condition, the direct connection was so absent that the participants created their own connection based on the dramaturgical development of the piece.

The visuals merely copying the body (V2) median was higher in the camera condition C3 compared to the sensor C2 and minimal interaction conditions C4; this confirms our hypothesis H1b) (visuals in C3 were copying the body more than in both C2 and C4). This result is not surprising, but it is still a contribution to the debate on how to use visuals in dance.

6.2. Research Question 2

Concerning correlation, the results of our statistical analysis allowed us to confirm two out of our three hypotheses. In particular, the connection between the visuals and the dancers has a direct correlation with the enjoyment of the visuals (hypothesis H2a). This means that the audience appreciated the fact of perceiving a connection between the performer's actions and the visuals. This result is also aligned with the previous study on audiovisual performance by Correia et al. [6].

Our results also verify our correlation hypothesis H2c): the level of distraction of the visuals has a negative correlation on the enjoyment of the visuals. This is aligned with the focus group in the preliminary phase to this study [11]. Again, this result is not surprising, but it still contributes to the discussion on visuals in dance. Concerning H2b): our results are aligned with our hypothesis (negative correlation between merely copying and enjoyment), but we did not have statistical validity to confirm this.

7. Limitations and future work

This study relied on four different performances. Although the development team was the same among the four pieces, this was not a controlled experiment type of study. For this reason, other elements, such as: choreographic or dramaturgical choices that are

idiosyncratic to each choreographer; individual dance style of the dancers; or the specific visual effects that each piece used; probably had some impact over the results. This is the main limitation of the study.

The choice of the setting, a public performance, is another limitation, as it could have induced bias from more interested participants. This is derived by the main framing of the project Moving Digits, whose primary goals are related to core artistic production. The choice of an in the field setting offered us the possibility to observe and study the impact of the different technologies in a scenario that represents well the real context of dance performance, where the different elements are not separated, nor separable, in a complex ecology.

We advocate that future studies, that point toward a more controlled-condition context, might be useful to further investigate the topics discussed in this article. Another element that might also deserve specific investigation is the impact of different visual choices over the perception of interaction. Based on the limitations described, we suggest the reader to approach our results as recommendations, or suggestions, rather than prescriptive or strict guidelines.

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