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Etruscan dress in context: from digitisation to motion capture

Introduction

From 2019–2021, the Marie Skłodowska-Curie project, *TEXDANCE (Textiles in Etruscan Dance, Individual Fellowship, grant agreement ID 839799)* was hosted at the University of Copenhagen, in partnership with the University of Oxford. This proposed an original study of an aspect of Etruscan ritual and religious practices. It explored dance, which had a key role and constituted an important form of non-verbal religious communication, and its props, primarily textiles. The scope was to examine how textiles make the movements of dance, their ritual functions, their diversity, their performativity, the ritual function of costumes in dance, and the social relations which intertwine. *TEXDANCE* combined three kinds of sources: primarily the iconographic representations as they constitute the most important documentation for Etruria; Latin and Greek texts as there are no usable Etruscan texts; and archaeological evidence. Among the issues the project addressed, the most important were: what kind of textiles and dress were used in dance? How were they used in this context? How did they indicate movements, and which ones? Were they Etruscan productions and can this be confirmed by archaeological finds? If not, what did a Mediterranean origin for the textiles mean in ritual practices and beliefs? What social differences do the textiles reflect among dancers? Did textiles make sounds during the dance?

These questions have been answered through the following objectives: 1. Types of dress and textiles in dance: materials, colours, forms; 2. Motion textiles: the study of dress movement in dance; 3. Textiles acoustics: the sounds of dancing dress; 4. Circulation and fashion: Etruscan dress identity; 5. Textiles

and aristocratic lifestyle: community organisation, ritual practices and dance; 6. Ritual textile making: aristocratic female education and lifestyle; 7. Visuality of dance textiles on artefacts: a narrative system (<https://ctr.hum.ku.dk/marie-sklodowska-curie-projects/previous-marie-sklodowska-curie-projects/textdance/>).

TEXDANCE helped to explain the types of textiles used, how they were made, the sound they produced in the ritual, and their specificities compared to those of the Mediterranean area. The textiles of pre-Roman Italy and in particular of Etruria have been the subject of several important works by Larissa Bonfante (1975, updated 2003), and Margarita Gleba (2008). These studies provide a remarkable analysis of the production and use of Etruscan and pre-Roman textiles and dress. *TEXDANCE* proposed a different angle of research, by emphasising the performative and ritual use of textiles.

Recontextualising Etruscan dress

The project entitled *Digital recontextualization of ritual textiles from classical Etruria (fifth century BCE)* that has been carried out since January 2023 at the University of Lille, France, with the Research Federation Visual Sciences and Cultures (FR-SCV) and the State-Region plan contract (CPER) *ENHANCE – Embedding a Human Dimension in Cultural Heritage*, aims to continue the research begun with *TEXDANCE*. Based on the results produced, the objective is now to recontextualise the dress and textiles specifically used in Etruscan dance, by emphasising the experience of textiles, the relations and interactions between textiles and the body, and by using new digital tools. The research is exploratory and as such focuses on specific case studies, which



are the *Tomba del Triclinio*, *Tomba del Letto Funebre*, *Tomba dei Leopardi*, *Tomba Bartoccini*, and the *Tomba del Cacciatore* from the necropolis of Tarquinia (Italy). Three research objectives were defined as: 1. To reconstruct the dress used in Etruscan dance (real and 3D reconstruction); 2. To test the real reconstructions made, and record their potential movement using motion capture (now MoCap); 3. To replace the data in a digitally-reconstructed historical context, which will help understanding of the forms of Etruscan dance and of the textiles used, the impact of dress in dance, and the temporality of specific Etruscan ritual practices. It will also help better understanding the sources of ancient dance and textiles (primarily iconography). Thus, this project plans to produce unprecedented documentation and new tools for research, for scientific community and students. Targeting museums and

a large audience, it will offer innovative means of interaction for public dissemination using digital technologies. Also, as it raises crucial methodological questions, it will foster epistemological reflections on the use of digital tools in the study and dissemination of information about past societies.

Digitisation of the Tomb of the Triclinium

The project has primarily engaged with the digital study of the Tomb of the Triclinium. Discovered in 1830, the monument is located in the Monterozzi necropolis (Calvario) of Tarquinia (Italy). It is a single funerary chamber, almost square in plan, dug into the rock. Its dimensions are as follows: height 252 cm; left and right walls height 195 cm; length 430 cm; width 350 cm. The tomb, which is accessible by a staircase also dug into the rock (*dromos*), is dated circa 470 BCE.



Fig. 1: Study of the Tomb of the Triclinium, Tarquinia (Italy): a – (top left) paintings kept in the Archaeological Museum, Tarquinia (Italy), being studied by engineers Nicolas Bremard (UMR 9189 CRISTAL & PIRVI, France) and Jérémy Cundekovic (University of Lille and FR-SCV, France); b – (top right) digital reconstruction of the paintings; c – (bottom left) inside the tomb, with engineer Nicolas Bremard (UMR 9189 CRISTAL & PIRVI, France); d – (bottom right) digital reconstruction of the architecture (Images: Audrey Gouy and University of Lille, France)

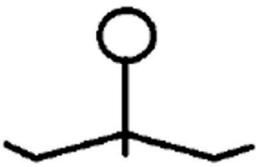
Phase 1	Phase 2	Phase 3	Phase 4
			



Fig. 2: Hypothetical reconstruction of the movements of the Etruscan castanet player ©Audrey Gouy: a – (left) bronze showing phase 1 of the castanet dance (private collection); b – (middle left) bronze showing phase 2 (Opera del Duomo Museum, Orvieto, Italy); c – (middle right) bronze showing phase 3 (Archaeological Museum, Bologna, Italy); d – (right) bronze showing phase 4 (Soprintendenza per i Beni Archeologici dell’Emilia Romagna, Bologna, Italy) (Images: *The Christos G. Bastis Collection, Sotheby’s, New York, Thursday December 9, 1999, New York, 118–121; Bizzarri 1972, 26, n. 24; Sassatelli 1988, 293; Ortalli 2002, 71*)

The frescoes which covered its walls (entrance wall, side walls, back wall, and double-sloped ceiling) show several scenes: a banquet on the back wall, horsemen on the entrance wall, and dance scenes on the side walls. It is on these dance scenes, in which textiles play a crucial role, that this project focuses. All of these frescoes were detached in 1949, and taken out of their archaeological context, which has modified the understanding and experience of them. Since then, these paintings have been kept at the Archaeological Museum of Tarquinia (Italy).

To retrieve and offer the most accurate experience of the tomb to researchers and a large audience, it has been decided to digitally replace the detached paintings in their original archaeological context, and thus to reinsert the frescoes in the tomb. Therefore, a study mission was carried out in May 2023, which consisted of digitising the entire Tomb of the Triclinium, namely

the paintings preserved at the Archaeological Museum (fig. 1a and fig. 1b), and the architecture of the tomb (fig. 1c and fig. 1d) where these paintings came from. In both cases, the digitisation was carried out using lasergrammetry (FARO), supplemented by numerous photos, both wide and detailed, in order to ultimately obtain a high-quality reconstruction of the tomb. On the frescoes, both ultraviolet light and RTI were used to differentiate traces of restoration and modern additions.

Back in Lille, the engineers involved in the project juxtaposed the digitisation of the frescoes with that of the tomb’s architecture. The presence of remains of pigments and frescoes in the chamber facilitated the superimposition of the paintings on the architecture. The digital juxtaposition revealed the dialogue that was originally meticulously created between the architecture and the paintings, something that has



been lost since the detachment in 1949. The result of this digital juxtaposition is a reconstructed 3D model of the tomb, into which the digital recordings of the dance movements and textiles will subsequently be inserted, with the aim to better understand the possible use of the tomb's space, the ritual represented on the walls and its whole experience, as well as the process of creation of Etruscan iconography.

Digitising motion

In 2019-2021, one of TEXDANCE's objectives was to study the motion of dress in Etruscan iconography. The project highlighted that clothing expressed several types of movement, and thus contributed to the definition of dance, and to its understanding. The project now at the University of Lille aims to test these movements and to record them using MoCap.

MoCap is the process of recording patterns of movement digitally. It is now regularly used for different human movements, such as dance. This technique is often associated with modern practices and applications (sport, medicine, animation), but also can be useful to test ancient movements and choreographies. Before testing MoCap on dress, some dance movements for which several hypotheses were proposed in the author's PhD thesis on Etruscan dance (EPHE-PSL, Paris and Ca' Foscari University, Venice, 2017). One on those hypotheses concerns the castanet player, who regularly appears in ecstatic and dance scenes with arm movements. The study of Etruscan iconography assumed that the choreography performed by this player included a progressive gradation, and different moments (fig. 2). Indeed, it initially consisted of having a very measured posture. The arms remained close to the body and moved very little. The figure might have been walking. As the dance progressed, the walking became faster, the arms alternated more and more widely, until they were swinging from one side to the other. The figure's bust and head also tilted and swayed more and more from one side to the other. The final moments consisted of twirls, with the arms and hands raised above the head. These hypotheses have been recorded using MoCap and are available on Zenodo (DOI 10.5281/zenodo.10201929).

The three-dimensional capture of the castanet player's possible choreography is relevant for several research and dissemination issues. It contributes to a biomechanical analysis of the movements, and as such to the study of specific techniques, postures, and gestures possibly performed by this player in Etruscan dance. It also questions the spatial and temporal aspects of ancient choreography, and contributes to insights into the kinematics and dynamics of ancient movements.

Moreover, the record of these movements constitutes a digital archive of hypothesis, which provides a basis for future research, and enables researchers to discuss, compare and share interpretations. Eventually, the capture of ancient dance movements, thanks to avatars, can be integrated into virtual and augmented reality environments. These can be used to create immersive dance experiences and interactions, and in particular to recreate ancient dance events, providing audiences with a new way to experience and learn about ancient ritual practices.

The motion capture of dress

The MoCap system usually records the movement of objects and living beings based on their inherent fixed skeleton. As such, it precisely tracks the position and motion of various body parts in a three-dimensional space. In textile research, MoCap has been used by the Centre for Textile Research, University of Copenhagen, to record the body movements of specific spinning and weaving processes. But what about textiles themselves? To what extent MoCap could benefit research on ancient textiles and dress practices? Recording and capturing the motion of textiles presents several challenges, notably due to the lack of a fixed structure and the great variability of the material. But there are also opportunities.

Research objectives

The use of MoCap involves four crucial steps: 1. To place the sensors/small reflective markers on the body, which fixes them on rigid and articulation parts such as ankles, knees, elbows or shoulders; 2. To strategically position and synchronise multiple high-speed cameras around the subject, allowing the capture of its movements from different angles; 3. To collect the data captured by the cameras – a specialised software processes the exact position and orientation of each marker in three dimensions (the University of Lille uses Qualisys); and 4. The data gathered are post-processed, for analysis in animation or simulation.

While usually used for replicating realistic human and object movements, MoCap can play a role in the study of ancient dress practices, and can provide valuable insights into how clothing and textiles behaved when worn. As such, it can help in the study of ancient dress by testing and experimenting with archaeological hypothesis.

Therefore, the aim is now to investigate and understand the behaviour of dress in Etruscan ritual practices, and to recreate and test the functionality of ancient clothing in practical scenarios, primarily in dance performances. This should provide practical insights



Fig. 3: MoCap test preparation details: a – (left) the skirt in viscose selected for the preliminary experimentation; b – (right) the Velcro strip being attached to the lower part of the garment (Images: FR-SCV)

into how clothing was used, how it was experienced by the dancers, and its impact on both the dancers and the ritual. MoCap focuses on four crucial aspects: 1. Understanding draping and fitting, i.e. assessing how ancient clothing was draped and placed on the body, how it might have been adjusted or pinned for optimal fit; 2. Analysing fabric behaviour, i.e. revealing how textiles and fabrics moved, stretched, and wrinkled based on the different movements performed, helping us to understand the characteristics of the fabrics used and how they influenced wearability; 3. Assessing ergonomics, i.e. evaluating how well (or badly) dress accommodated the movements and needs of dancers; and 4. Reconstructing dress movements, which contributes to gain a better understanding of how the different garments functioned together during dance. However, the motion capture of ancient dress requires careful consideration of historical accuracy and the use of appropriate fabrics and materials for the capture. Thus, MoCap should be combined with other research methods, such as textile analysis, archaeology, historical research, iconography analysis, and experimental archaeology.

Preliminary tests and results

Before testing and capturing the movements of reconstructed Etruscan clothes as planned, preliminary tests have been performed with a skirt in viscose (fig. 3a). The aim of these tests was to remove existing doubts about the possibility of digitally capturing

the movements of dress, and to determine what difficulties needed to be solved when working with objects as unstable as textiles. The tests were carried out on the FR-SCV digital platform, with Laurence Willard Delbarre, instrumentation and experimental techniques engineer.

Recording a human body is easy. The markers are placed on fixed bones and joints. The distance between two joints will likely not vary during motion capture, such as between the elbow and wrist – the arm amplitude will remain stable. It is not the same for dress. Recording textiles presents several challenges due to the absence of a fixed structure as emphasised previously. The first phase of the experimentation, which consists of placing the sensors on the cloth, is therefore crucial. It was decided to resolve as much as possible the problem of variability between two sensors, by multiplying the sensors over the area to be recorded, and by placing them very close to each other. The aim was to keep as much of a continuous trace in the structure as possible.

The investigation began by focusing on the movement produced by the lower part of the garment selected for the experiment. The aim was to see how it behaved in relation to the movements of the dancing body. Thus, a Velcro strip was stuck all along the hem of the garment (fig. 3b), to which the sensors were attached (fig. 4a). This resulted in a horizontal strip of sensors in the lowest part of the skirt. And in order to give the garment an orientation, two



Fig. 4: MoCap test preparation details: a – (left) the skirt to be recorded, with the sensors stuck on the Velcro strip; b – (right) dancer wearing the skirt (Images: FR-SCV)

sensors were placed vertically on the front part (fig. 4b). The next phase of the experiment was to record the movement of the skirt. This skirt, worn by a dancer, was positioned in the centre of the MoCap system, and therefore was surrounded by multiple high-speed cameras. To set the fabric in motion, the movements performed were as follows: 1. walk; 2. turn around; 3. turn from side to side; 4. alternating walk and lift of each leg; and 5. alternating jump and lift of each leg. The recording is available on Zenodo (DOI 10.5281/zenodo.10201976, see test 1). The first results were very satisfying since it was possible to follow the different movements

of the fabric. Some sensors tended to occasionally disappear from the capture, notably during the first four seconds of the recording, then occasionally during the recording. This is due to minor issues with calibration and placement of the cameras around the body. Despite these minor issues, it was possible to track and calculate the movement of the cloth. However, there was missing information regarding its height, its overall movement, and its movement relative to the upper body. So, vertical lines of sensors were added on the right and left sides of the fabric (fig. 5a), and the wearer put on the MoCap upper jacket with sensors placed on



Fig. 5: MoCap test preparation details: a – (left) the skirt to be recorded, with the sensors stuck on the lower part and sides of the garment; b – (middle) dancer wearing the skirt, with sensors on the upper body (front); c – (right) dancer wearing the skirt, with sensors on the upper body (back) (Images: FR-SCV)

several crucial articulation points (fig. 5b and fig. 5c). Subsequent testing and recording, based on a similar sequence of movements, yielded more results on the overall trajectory of the garment, on the relationship between the fabric and the moving body, on fabric behaviour, and ergonomics. This second recording is also available on Zenodo (DOI 10.5281/zenodo.10201976, see test 2).

Research perspectives

These preliminary tests showed great potential for understanding dress movements and determined that it was possible to capture the behaviour of the future reconstructions of dress used in Etruscan dance, as planned for the future. The next tests should be carried out with linen and wool skirts to see the differences in behaviour depending on the type of fabric and fibres. The experiment will be expanded to also study different types of clothing such as mantles, as well as other types of dance and movements. Finally, these tests will be expanded with the capture of the reconstructed Etruscan dress. Since the dress responds to movement based on its design, construction, and materials with the capacity of enhancing (or restricting) the dancer's performance, future testing will consider complementary aspects of dress, such as stretch and flexibility, drape and flow, cut and fit, pleats and folds, linings and undergarments, fastenings and closures. As further tests will be performed, additional papers will be published to document and question the experiment. The data collected will contribute to the understanding of the impact of dress and textiles in performative rituals such as dance, but also to put into perspective the iconographic sources of Etruscan dance and thus to better understand the creative process at work in the visual construction and codification of dance and textiles in ancient iconography.

Conclusion

The study of ancient dress and textile practices usually involves a combination of archaeological, anthropological, literary, iconographical, and textile analysis approaches and techniques, which allow researchers to reconstruct and understand the dress and textile practices, including the materials, techniques, functions, and cultural significance of those practices in various societies and time periods. Digitisation, and MoCap, can definitely complement these methods, by documenting, analysing, and sharing information, and in doing so they foster advanced analysis and interpretation, but also make information more accessible, and preserve valuable data.

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