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Blazing fire or breezy wind? A story-driven playful experience for annotating dance movement

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The annotation of animated motion-captured segments is a challenging, interdisciplinary task, especially when it comes to characterizing movement qualitatively. The lack of intuitive, easy-to-learn-and-use frameworks is considered to be one of the biggest challenges in this process; another is the lack of approaches able to motivate a wide audience of users, from the broader public to dance experts, researchers and performers, to contribute with annotations. In this paper we present Motion Hollow, a story-driven playful experience that uses metaphors based on Laban Movement Analysis, an established framework for movement analysis and annotation, to familiarize novice users with the process of qualitative characterization of dance moves. This work proposes a first step into introducing movement annotation to non-expert users, and as such, its main goal is to explore the implications and potential of such an approach. The evaluation of the experience confirms its potential to transform the annotation of dance movement segments into an engaging and enjoyable experience as well as to foster a deeper understanding of movement annotation both as a concept and process.

KEYWORDS

movement annotation, metaphors, dance and movement, Laban Movement Analysis, game elements, story-driven experience, narrative-based experience, playful experience design

1. Introduction

Movement analysis through observation is a highly complex and time consuming process that applies to a variety of fields including dance, cultural and anthropological studies, rehabilitation, as well as digital analysis and preservation of movement-based traditions. Traditionally, movement analysis is done by trained experts, known as Certified Movement Analysts (CMA), and by using theoretical frameworks such as Laban Movement Analysis (Laban and Lawrence, 1947), a system that was proposed by Rudolf Laban and evolved through the years by other movement practitioners and researchers (Hackney, 2003; Bartenieff and Lewis, 2013; Wahl, 2019).

Movement analysis is a process that usually goes hand in hand with movement notation, applying notation systems such Labanotation/Motif (Hutchinson Guest, 2005), Benesh Movement Notation (Benesh and Benesh, 1956), and Eshkol-Wachmann Movement Notation (Eskhol and Wachmann, 1958), where the notator or movement analyst writes down exactly what the body does at each moment using a specific codification.

Over the last decades, the development of technologies such as motion capture, eXtended Reality and online platforms have created new opportunities and challenges for the dance creation, research and education. The early collaborations of Merce Cunningham with computer scientists (Wilke et al., 2005), as well as the experimentations of Forsythe (2011) and the latest collaborations of choreographers (McGregor et al., 2013; Plone, 2019) with cognitive scientists and Artificial Intelligence experts, have successfully established a research niche of applying digital technologies to represent, analyse and capture the movement of the body and the knowledge that lies behind in the digital realm (Leach, 2014; Leach and Delahunta, 2017; Rizzo et al., 2018).

Many researchers, in collaboration with dance researchers and artists, have worked on developing tools to manually characterize or algorithms to automatically compute the qualitative aspects of movement, i.e., not only what the body does (e.g., running or turning or raising an arm) but how this movement is done (e.g., fluently, heavily, etc.) (Alaoui et al., 2013; Camurri et al., 2016; El Raheb et al., 2018; El Raheb et al., 2022). The need for characterizing recorded or motion-captured movement through the enrichment with verbal or other tags is emerging into a challenging interdisciplinary field that can serve a variety of purposes such as learning and teaching rhythm (dos Santos et al., 2018); assigning labels and descriptive tags on dance content to help with the memorization of step sequences by dancers (Alaoui et al., 2014); becoming part of a choreographic process (Leach, 2014; Blades, 2015; Ribeiro et al., 2016); and facilitating an interdisciplinary dialogue among different dance genres and cultures (El Raheb and Ioannidis, 2021). In parallel, the number of digitized dance motion segments is growing through the use of motion capture, creating the need for automatic algorithms which describe dance segments and make them discoverable through different tags. While designing an annotation tool for the expert users to characterize movement is a complex and multifaceted endeavor on its own, the characterization of time-based recordings such as 3D animations that have been created through motion capture is an additional problem.

Acknowledging these complexities, in this work we explore two things: if and how non-expert users can provide characterizations for animated motion-captured dance segments, and how can we motivate this process through a game-like experience. Naturally, we do not expect that the non-expert users would be trained through an online interface within some hours of engagement with it. Movement Analysis frameworks need years of cognitive, embodied training, and practice for their users to deeply understand and perceive the concepts through observing movement and moving. Consequently, our research objectives aim to explore: (a) how naive users receive the process of annotation, i.e., qualitatively characterizing movement, a process that most people, even experienced dance educators and performers are not familiar with and (b) whether collecting knowledge from the wider audience, in the philosophy of motivating a form of crowd-sourcing, offers any potential advantages for dance annotation and for its users. The work we present here does not aim at proposing a complete system that can be used to collect ground-truth data or substitute the work of trained CMAs. Clearly, movement analysis requires embodied practice and material experimentation possessed by expert CMAs. The motivation, however, behind integrating such activity within a web-based game application is to explore the potential of involving non-expert users in the dance annotation process and to understand the opportunities and limitations of transferring this process within a game-like context. We hope that this will allow non-experts to become annotators from a distance and trigger their curiosity about movement annotation.

For this purpose, we designed and developed Motion Hollow, a story-driven playful experience which uses the Laban Movement Analysis framework to create metaphorical descriptions used for the annotation of movement qualities in dance segments performed by 3D animated models. The goal of Motion Hollow is to provide users with a simplified playful expression of the Laban Movement Analysis framework as a tool during the annotation of dance segments, thus making the process of contributing qualitative characterizations easier and less complicated for all users. Game mechanics, archetypal characters, and movement metaphors are used to transform the annotation process into an engaging and pleasant experience, motivating users to participate in the annotation tasks. Although gameful approaches have been applied in music annotation, this is the first such playful application for dance movement annotation. In this paper, we present the design of the experience as well as the results of a user study carried out with 25 participants with varying expertise in dance and movement. The results offer insights on the effectiveness of the experience to promote user engagement as well as a deeper understanding of the proposed annotation framework by users with or without dancing experience.

Section 2 presents a brief overview of related work in serious games and gameful annotation applications as well as the theoretical framework of our work. Section 3 focuses on our approach to mapping LMA Effort Actions to natural elements and metaphors. Section 4 presents the application of this mapping in our playful experience design. Section 5 describes the design of our study, followed by the results in Section 6. Section 7 further discusses these results and Section 8 concludes the paper.

2. Related work and theoretical background

In this section, we present the related work and theoretical background informing the design of the Motion Hollow experience. Specifically, in Section 2.1 we explore the different ways gamification and serious games are used for various purposes in different fields. In Section 2.2 we provide a brief presentation of Laban Movement Analysis and the 8 Basic Effort Actions, which form the basis of the annotation framework created and used in our experience.

2.1. User engagement in serious games and games with a purpose (GWAPs)

2.1.1. Serious games

In the field of Human Computer Interaction, the term "gamification" is often used to describe the use of game elements and mechanics toward motivating user engagement in non-game contexts and enhancing user experience (Deterding et al., 2011). Over the past decades, gamification of applications has been used in many fields for multiple purposes. Serious games are often introduced in the field of health, both mental and physical, as tools for motivating users into taking care of themselves and being mindful toward others. Examples of such games are Merlynne (Chan et al., 2021), a game designed to encourage users to participate in peer-to-peer Cognitive Behavioral Therapy through an RPG (Role-Playing Game) environment, or exergames created to motivate users into exercising such as Nintendo's Ring Fit Adventure (Lu et al., 2021).

Serious games can also be used to educate people and raise awareness around social issues. Geo-Colonizing Mars (Arroyo-Cruz et al., 2021) for example, is an immersive game aimed at helping students understand and learn geometry through a narrative which also encourages them to care about the environment. Another example of a game purposed to investigate user behavior and raise awareness is Point of Contact (Hill et al., 2021), a serious game created to examine how a game can affect the way people think and behave in regards to others during the global pandemic of COVID-19. Games designed to motivate learning and skill practicing subscribe to the educational scope of serious games as well, with one example being ZenSketch (Williford et al., 2019), a game developed to encourage users to practice line work.

2.1.2. Games with a purpose (GWAPs) and annotation games

Games with a purpose (GWAPs), otherwise referred to as Human-based computation games (HCGs), form a special category of gamified applications and serious games, which aims to assist in the solution of computational problems by outsourcing tasks to the players, while simultaneously offering them an enjoyable experience (Von Ahn and Dabbish, 2008). Games for annotation are a very common type of GWAP, since crowd-sourced annotation is a challenge present in many different fields.

One category of annotation GWAPs are games aimed for musical annotation. For example, games like TagATune (Law et al., 2007) and MoodSwings (Kim et al., 2008) are multiplayer collaborative games for assigning descriptions to sound and music segments; in games like ListenGame (Turnbull et al., 2007), users simultaneously assign descriptions to the same segments and they afterwards get feedback on what other players selected. MajorMiner (Mandel and Ellis, 2008) is a single-player web-based game where the player tags clips and scores points when their descriptions match the ones assigned by other players. GWAPs can also be powerful tools for gathering language resources (Phrase Detectives, Poesio et al., 2013), or labeling images (ESP Game, von Ahn and Dabbish, 2004). HCGs are used in numerous fields to solve complex problems through crowd-sourced free labor (Burgoyne et al., 2013; Madge et al., 2019; Ponnada et al., 2019); the applications mentioned in this section are only a few of them.

2.2. Laban movement analysis

Laban Movement Analysis (LMA) is a system developed by Rudolf Laban, a Hungarian dance artist and theorist, as a tool to observe and analyze movement toward providing a form of knowledge regarding the way people interpret and describe the different elements of human movement expression (Laban and Lawrence, 1947; Groff, 1995). Laban, along with his collaborators, identified and distinguished movement patterns, which resulted in the creation of the rich and complex movement framework of specific terminology that is the LMA (Bartenieff and Lewis, 2013; Wahl, 2019).

LMA has many applications and it is widely used in various fields of research studying movement computation and expressivity. It is often used as a practical tool for teaching dance to children (Davis, 1995) and adults (Hankin, 1984), for actors to practice expressive movement (Shampain, 2014), and for choreography (Nahrstedt et al., 2008). In these practical contexts, a variety of rich examples of metaphors, situations, behaviors or even characters are used to convey the meaning of qualitative aspects. In this work, we create and utilize metaphors and analogies based on the LMA framework, in order to make the process of qualitative movement characterization simpler for the wider audience, and thus easier to use in the context of our playful experience. It is important to note here that the notion of character itself can be arbitrary. In movement-based practices and performing arts where LMA usually applies in

a physical context, the character evolves through material and embodied aspects (movement, voice, posture, gaze, articulation, etc.). In the field of digital interactive games and character animation (Lankoski, 2011), depending on the type of the game, character development can evolve through similar aspects, e.g., appearance, facial expression, and movement of the character. Some researchers also propose the use of LMA in character animation (Bishko, 2014). Sometimes in digital games that are designed as digital card-board games, the character might be more simple: a background, image and description that trigger the player's imagination. This is the approach that we follow here.

2.2.1. The LMA framework

Laban Movement Analysis differentiates four categories of movement components: Body, Effort, Space, and Shape. These categories contain movement terminology and they form Laban's BESS system (Alaoui et al., 2015). Body provides vocabulary related to the body parts actively involved in movement and how these body parts are affecting each other. Effort focuses on terminology related to the qualitative characterization of movement using four motion factors—*weight, time, space* and *flow*. Space approaches aspects of movement related to direction and location, as well as the way the body uses the space it is surrounded by. Shape provides terminology associated with the way different body parts are arranged in order to express and adapt to actions and movement generated internally, as well as the way the body adapts to the environment. The components of BESS are completely intertwined with each other when it comes to processing and analyzing movement and its functional elements (Bartenieff and Lewis, 2013). However, they can all be used individually as valid lenses through which we can try and simplify the amazing complexity of human movement (Groff, 1995). Recently the component of Time has been suggested as a new addition to the BESS System, establishing the BESST System. The need for this addition has emerged from time-related issues present in machine-induced motion, which has great qualitative differences compared to human motion (Laviers and Maguire, 2022). Several HCI projects have used the Effort category to characterize movement in various fields with a computational setting (Chi et al., 2000; Chen et al., 2011), some examples being the field of robotics and artificial intelligence (Knight and Simmons, 2014; Barakova et al., 2015; Bacula and LaViers, 2021) or character animation (Bishko, 2014), etc. Since this work approaches movement annotation from the perspective of qualitative aspects, we will be focusing on the Effort category as well.

In the Effort category the motion factors of *weight, time, space* and *flow* are used to describe the qualitative aspects of movement. Each factor has two polar opposite elements, two Efforts, each one catering to qualitative characterizations which present slight differences regarding their dynamic (Wodehouse and Sheridan, 2014). The four motion factors are the following: (i) *weight*, taking values of either Strong or Light, is used to describe the body's attitude toward having an impact on its surrounding environment; (ii) *space* or *direction*, taking values of Direct or Indirect, describes the body's attention to its surrounding space, as well as its tendency, or lack thereof, to follow a clear direction while moving in it; (iii) *time* or *speed*, taking values of Sudden or Sustained, is used to describe the movement's level of urgency, whether or not movement is brief or "gives in" to time; and (iv) *flow*, taking values of Bound or Free, is used to describe the level of control and restriction present in movement, and how difficult or easy it is to stop moving all at once (Newlove and Dalby, 2004; Alaoui et al., 2015). The combination of the aforementioned 6 Efforts generates Laban's 8 Basic Effort Actions (BEAs) which describe the unique dynamic qualities of movement, as well as describe possible ways in which an action can be made.

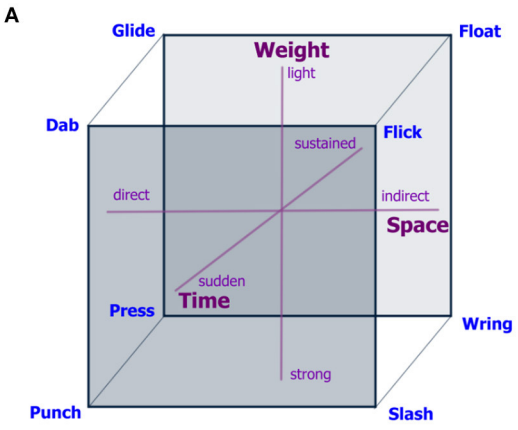
2.2.2. Laban's 8 Basic Effort Actions

The human body is capable of moving in numerous ways which are associated mostly with the environment (Bartenieff and Lewis, 2013), as well as with one's personality traits and mannerisms (Newlove and Dalby, 2004). Having broadly studied bodily movement, Laban was able to provide one movement example for each specific combination of Efforts, creating the following eight Effort Actions: Punch, Slash, Dab, Flick, Press, Wring, Glide, Float (Newlove and Dalby, 2004; Wodehouse and Sheridan, 2014).

As mentioned in Section 2.2.1, each of these Effort Actions is derived from combining the Efforts of the three motion factors-weight, space (or direction) and time (or speed). These combinations are presented in Figure 1B. In this section, we present the eight Basic Effort Actions using metaphors and actions from everyday life,. In what follows, we present the Effort Actions that work as metaphors for specific qualities. E.g., the Punching movement does not refer to actually punching someone but describes the qualities in which a punch usually is done (direct, strong, and sudden).

Punching is a direct and violent movement, the most common form of which is thrusting our closed fist at a target during a fight. **Slashing** is a movement commonly seen in combat or sports that require the use of some sort of racquet or handheld equipment, like tennis. **Dabbing** is a movement commonly seen in everyday activities like dabbing computer keys while typing, painting by dabbing a brush on a canvas. **Flicking** is a brief movement that can be seen when people flick a swarm of bees away from their body, or hair out of their sight. **Pressing** can be associated with actions performed by people on a daily basis, such as pressing door-bells or elevator buttons. **Wringing** makes us think of a wet towel that we wring out until all the liquid is squeezed out of it. **Gliding** brings to

A



B

	Direction	Time	Weight
Punch	Direct	Sudden	Strong
Slash	Indirect	Sudden	Strong
Dab	Direct	Sudden	Light
Flick	Indirect	Sudden	Light
Press	Direct	Sustained	Strong
Wring	Indirect	Sustained	Strong
Glide	Direct	Sustained	Light
Float	Indirect	Sustained	Light

FIGURE 1
Different presentations of Laban's Basic Effort Actions. Panel **(A)** visualizes Laban's Effort dynamosphere (Newlove and Dalby, 2004) and panel **(B)** lists Laban's Eight Basic Effort Actions.

mind activities such as figure-skating, or coming down a snow-covered mountain on a sleigh. **Floating** is a movement with a light feeling and it can be associated with activities such as flying or swimming on a surface (Newlove and Dalby, 2004).

2.3. Natural elements used as movement metaphors

Metaphors, symbols and imagery are often used in dance as tools for enhancing the movement experience, as well as communicating the experience to the space and people around them. Dance metaphors create images which dancers use to motivate the way they move. Instead of just moving around in space, they imagine moving in the context set by the metaphorical image, thus forming a deeper connection to the movement itself (Samaritter, 2009). When it comes to the field of dance education, studies have shown (Overby, 1990; Sawada et al., 2002) that the majority of dance students have been taught or guided through the process of movement using metaphors and imagery, working toward augmenting a particular qualitative aspect of movement. In some cases, such educational methods have been proven more effective and enjoyable for students than literal movement instructions and models, often helping students reach a deeper level of understanding and perception of movement and its qualities (Nordin and Cumming, 2006).

Movement metaphors can take multiple forms. They could either stem from our cultural background and be more familiar to certain groups of people, or have a more archetypal character, leading to people understanding them regardless of their background. Natural phenomena such as the sea or the wind have a strong element of movement and can thus be used as movement metaphors as well (Samaritter, 2009). In the field of video games and animation, natural elements seem to be a very popular archetypal trope (The Pokemon Company, 1995; IGN, 2002; Nickelodeon, 2008; Tropes, 2014), each of them representing different types of powers and dynamics of characters or actions performed by characters. In our approach we utilize the natural elements of fire, water, wind and earth as images and visual metaphors to create a set of metaphorical descriptions, one for each Laban Basic Effort Action, to be used as a guide during the annotation process of the experience. Our goal is to attempt to make the qualitative aspects of LMA simpler for non-expert users to understand, as well as to enable the creation of an engaging gameplay. The elemental metaphors are presented in the following section.

3. Mapping the natural elements to LMA Effort Actions

In this section, we present our approach of assigning natural elements such as fire, water, wind and earth to Laban's 8 Basic Effort Actions by mapping the qualities present in the movement of each element to Laban's motion factors. It is important to note that the mapping presented below does not, by any means, indicate an ultimate truth or a systematic conceptual model. It consists of a set of metaphorical descriptions that serve as a foundation to design our experience around and invite users to participate in it. This set of metaphorical descriptions is based on the intuitive and practical embodied experience of the authors and works as an initiation mapping for exploring the understanding of non-experts when seeing movement (without having necessarily the embodied experience of this movement). The complex problem of applying verbal descriptions for

embodied and perceptual experiences raises the question of subjectivity vs. objectivity of the descriptions; it could be further investigated through the lens of embodied cognition and the notion of conceptual metaphors and image schemas (Johnson, 1987, 2007; Lakoff and Johnson, 2008). We are aware that some of the descriptions might be subject to cultural interpretations, however this is not a systematic approach and we make sure to clarify which form of the element our descriptions are based on in each case. We also acknowledge that if this were a conceptual systematic approach, there would be a need for an expert Certified Movement Analyst to assist with this process, as well as a practical workshop that involves more movement practitioners and dancers to explore together the potential of these mappings in a material and embodied manner.

A blowing wind can be a "gust" or a "breeze". In terms of the motion factor of Space, wind can be considered to be Direct, since it usually follows a clear path. In regards to Time, wind is classified as Sudden, since wind by definition "occurs because of horizontal and vertical differences (gradients) in atmospheric pressure" (Encyclopedia Britannica, 2022).

Earth is the substance of land we live on. It can be associated with little to no movement, unlike the movement of any of the other elements. Movement associated with earth can be considered to be quite "grounded" and "resistant to change". In terms of Space, earth can be classified as Direct since movement generated from the ground is usually caused by natural phenomena (e.g., earthquake) which create a clear path for the involved parties to follow. Regarding the Time motion factor, earth can be considered Sustained, since "earthy" movement is quite resistant to time, starting at a point in time and moving steadily toward a climax.

Qualities such as "intensity" and "passion" can often be associated with the element of Fire. In terms of the motion factor of Space, fire can be classified as Indirect, since it can expand very easily without following a clear direction, covering its surroundings. Regarding the motion factor of Time, fire classifies as Sudden, since it moves unpredictably and quickly and it can transform from spark to conflagration in a matter of seconds.

For Motion Hollow, water is visualized as a lake or an ocean. Water often symbolizes "life" and "amplitude". When it comes to the motion factor of Space, water can be classified as Indirect, since it expands and covers its surrounding space provided that there are no obstacles restricting its flow, such as dams or barriers. As for the motion factor of Time, water can be classified as Sustained in this case, since any movement or current created in an ocean or lake would show some resistance to time.

In all of the aforementioned natural elements, the Weight motion factor can be classified either as Light or Strong, depending on the way the element is visualized. This results in two Laban Effort Actions being grouped under each natural element, one for when the movement is characterized as strong and one in the presence of light movement. Having established the relationship of the natural element metaphors with the LMA motion factors of Space and Time, we can now group the 8 Basic Effort Actions as presented in Figure 2. The Laban Effort Action visualizations used in the figure are from a Drama movement educational source (Shampain, 2014), and they are utilized as visual aids in the experience as well.

4. Experience design

Motion Hollow is a story-driven playful experience designed to motivate users into contributing movement annotations. It employs a playful expression of LMA through metaphors, cards and archetypal characters. In this section, we briefly present the experience gameplay, design choices and mechanics.

Before starting the experience, the users have to read and agree with the Terms of Use, which state that there are no right or wrong answers. They are then presented with a starting screen which offers two playing modes to choose from. The Story mode immerses the players in a narrative where they need to complete quests to reach the ultimate objective: break the neutrality spell and help the Empresses and Motion Hollow restore their identity (Section 4.1). These quests involve annotation of dance segments. The Free mode invites users to perform the same annotation tasks without the story concept (Section 4.2). A short description of each mode is provided to help the users make their choice (Figure 3). A short informational video overview of the experience can be found here.

4.1. Story mode

In this mode, the user navigates through the experience while following a storyline and advancing their quest by annotating dance segments.

4.1.1. The story of the experience

The experience begins with the user being introduced to a character named Celestine who is a resident of the small mystical town called Motion Hollow. Celestine serves as the narrator of the story, the "insider" who guides the user. After welcoming the user, Celestine shares information about Motion Hollow (Figure 4). There are four districts in total, each corresponding to one of the following natural elements: Water, Earth, Fire, and Wind. Motion Hollow is ruled by the Empresses of Nature, each of whom reigns over one of the districts. Every empress possesses the power of the natural element associated with her district, and that power affects the way they move. Celestine then informs the user about a neutrality spell cast on the village by a mysterious villain, which has caused all the districts to lose their elemental identity, color and texture

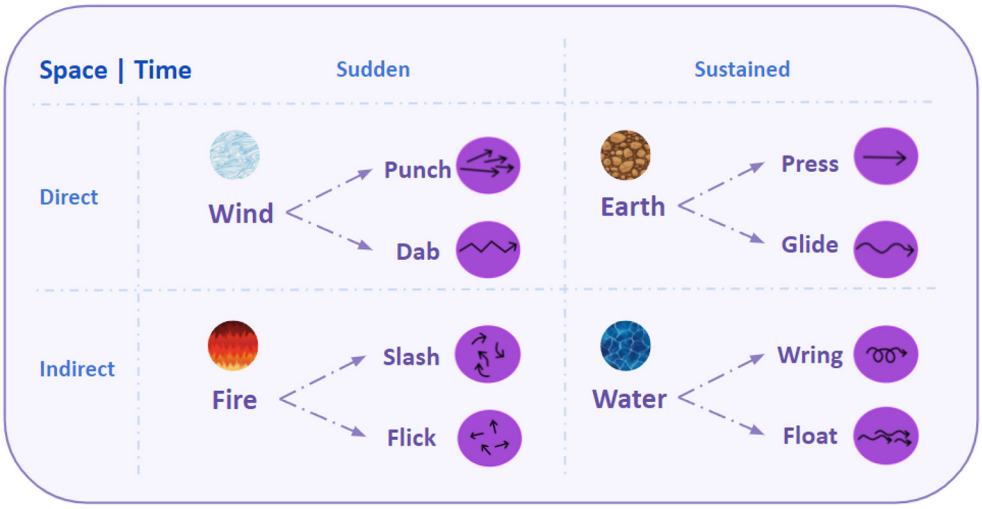


FIGURE 2
Our grouping of Laban's 8 Basic Effort Actions under the natural elements of wind, earth, fire, and water.

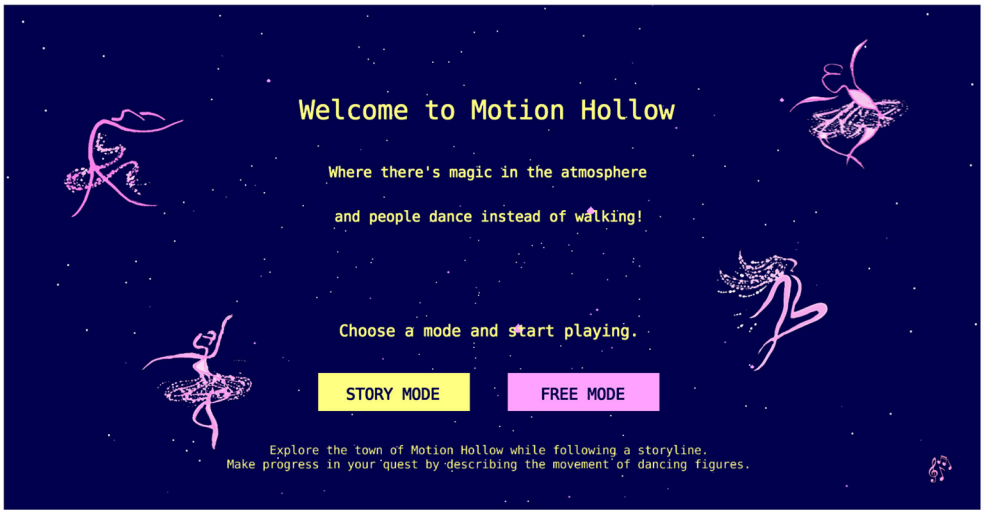


FIGURE 3
The intro screen of the experience.

and the empresses to lose all parts of identity, except their will and ability to dance. She then asks the user for their help in breaking the spell and restoring Motion Hollow back to its natural state, while offering her help throughout the quest. Consequently, the player's mission is to travel around the districts, watch each empress perform a dance and try to identify her by the way she moves in order to break the neutrality spell.

4.1.2. Game mechanics and playful elements

4.1.2.1. From natural movement metaphors to character cards

The storyline was carefully designed to accommodate our LMA approach. The eight Basic Effort Actions are grouped under the four natural elements, to support annotation through movement metaphors (Figure 2). The users are also given tools to support them in their quest. These are essentially the basis

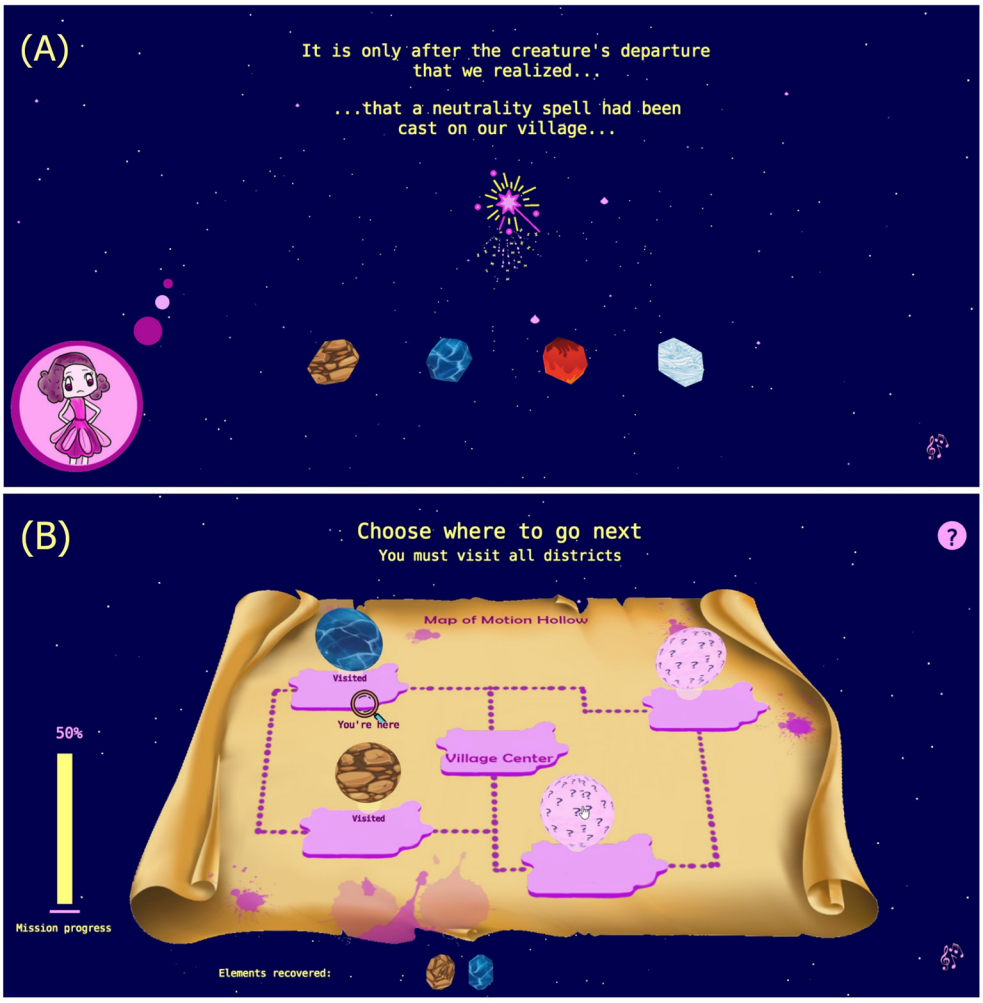


FIGURE 4
Panel **(A)** depicts a screen from the storytelling part of the experience and panel **(B)** depicts the Motion Hollow map and progress elements.

of the annotation framework, which consists of four elemental archetypes—Fire, Water, Wind, Earth, each represented by an Empress. We have grouped two Laban Effort Actions under each element, as detailed in Section 3. The Effort Actions of each element share the same efforts when it comes to the Space and Time factors and different ones when it comes to the Weight factor. In order to make the Laban terminology more accessible to the user, we created the following metaphorical explanatory descriptions, which link the Effort Actions to the element and empress they represent:

Wind: Silia is an expression of the element of wind, her moves are **direct** and **sudden** like a wind current with a clear **direction** and **quick** temperament. When she is happy she moves **lightly** like a breeze ***dabbing*** the flowers, when she is angry she moves like a **strong** wind storm ***punching*** the trees around her.

Fire: Nyla represents fire. Her moves are **sudden**, she moves unpredictably **without** following a clear **direction**, **exploring the space** around her. On her carefree days, she moves **lightly** like a spark ***flicking*** away from a flame. When she is upset, she transforms into a blazing fire ***slashing*** everything on her path.

Earth: Thalia is the expression of the element of earth, her moves are **direct** and **sustained**, like sand falling from the edge of a cliff with a clear **direction** and a **steady pace**. When she is happy she moves in a **lighter** manner, like a lily-pad ***gliding*** on the surface of a pond. But if you anger her, she gets **stronger** like Earth's tectonic plates ***pressing*** against each other during an earthquake.

Water: Aria represents the element of water. Her moves are **indirect** and **sustained**, continuous and **flexible in space** around her. When she is in a pleasant mood, she moves **lightly** like a leaf ***floating*** on a lake. But when she is down, her moves

get **heavier** like a ***wringing*** whirlpool cast on the ocean, slow, twisting, and powerful.

Visual aids have also been created for the aforementioned metaphors. The Empresses, along with their natural elements and the corresponding Laban Effort Actions, are presented in the form of character cards (Figure 5). These are available as inventory items, to be assigned to the dancing figures of each district.

4.1.2.2. Navigation and progress elements

After the narrative part is over and the user is assigned their mission, they are presented with a map of all the districts of Motion Hollow. The user has to visit all the districts in any order they wish, observe the dancing avatar, and characterize its movement. The annotation process is presented in detail in Section 4.1.3. Apart from the map, on screen there is a progress bar for the mission, as well as a collection of badges for the elements that have been successfully recovered from the neutrality spell. There is also a Help button with details about the framework terminology.

4.1.3. The annotation process

At every district the user is presented with an avatar performing a dance segment. They are required to observe the avatar's movement and assign qualitative characterizations to it. At first, the user has to match one of the four empress character cards from their inventory, to the dance segment. The descriptions and movement metaphors for each card are available to the user upon clicking the corresponding card. They can go back and forth among the available cards and read the descriptions as many times as they feel like until they reach a decision, in which case they choose the card and click on the button to move on (Figure 6A). It is worth mentioning that a "HELP" button is present on the screen at all times providing information regarding the LMA-related terminology used in the experience, while specific information for each card and its corresponding Effort Actions are available to the user during the annotation process through hint icons.

By choosing a card, the players assign values for both Space and Time Laban factors. Next, they have to identify the way the avatar moves according to Laban's Weight motion factor, choosing either, both or none of the given Effort Actions. They then watch the spell being broken for this district, the chosen element being recovered and the district's environment returning to its natural state. It is important to note that the player would have broken the spell at every district no matter which element card they had assigned to the local avatar's movement. This design decision offers an "illusion of success" and its purpose is to motivate the player while advancing in their quest. We realize that the "no right or wrong answers" approach might not seem appropriate for achieving accurate results, however the goal of this work is not to train the users to give the right answers, given that it would be impossible to expect any training of the users within 1 h. What we aim at is triggering the participants' curiosity and engagement and analyzing their answers so as to explore the potential of the proposed model. If the results of this exploration are positive, we can then proceed to thoroughly researching and carefully designing a process to train the users into annotating correctly.

After completing the district, the player then returns to the Motion Hollow map, where the progress bar, the badge collection and the newly recovered district's appearance have been updated. They choose a district they have not visited yet and they go through the aforementioned process for a new dance segment. At every new district, the element cards that have already been matched to another district are excluded from the pool of options and the user can only view them but not assign them to a new segment. This, however, results in only one element card being available to be assigned to the last remaining district, eliminating the element of challenge and motivation to characterize the movement of the local avatar. In order to address this issue, a plot-twist is positioned right after the user returns to the map from the third district: The Mysterious Creature who cast the spell in the first place returns to stir things up again, by making all the cards look like the remaining element card. However, the Effort action visualization icons of each card remain unchanged. Movement metaphors are still included in the card descriptions, but there are no references to the corresponding empresses and their elements. This way the user still faces a challenge: Even though they know which element is to be unlocked, they have to observe the dancing avatar and assign the card and descriptions that match the movement. This design choice, even though it assists the story and narrative of the experience, it certainly creates limitations, since users have a different pool of options at every dance segment they have to annotate. However, regardless of the limitations, the evaluation of the system as a GWAP is a very important step toward achieving a balance between a more reliable process of annotation in the future, while keeping game mechanics that might improve the engagement levels.

4.2. Free mode

In Free mode, there is no storyline. The user is able to proceed through a series of dance moves and sequences performed by an avatar. Essentially, the user is provided with a series of 13 dance segments, as well as a set of descriptions to match the movement to. Each description is a Laban Effort Action along with its corresponding Efforts in the Space, Time and Weight factors, as well as a visualization of said Effort Action with an icon. The user can move back and forth among the segments and choose which ones they want to describe by observing the movement for as long as they want and check the boxes of the descriptions that they think match what they are

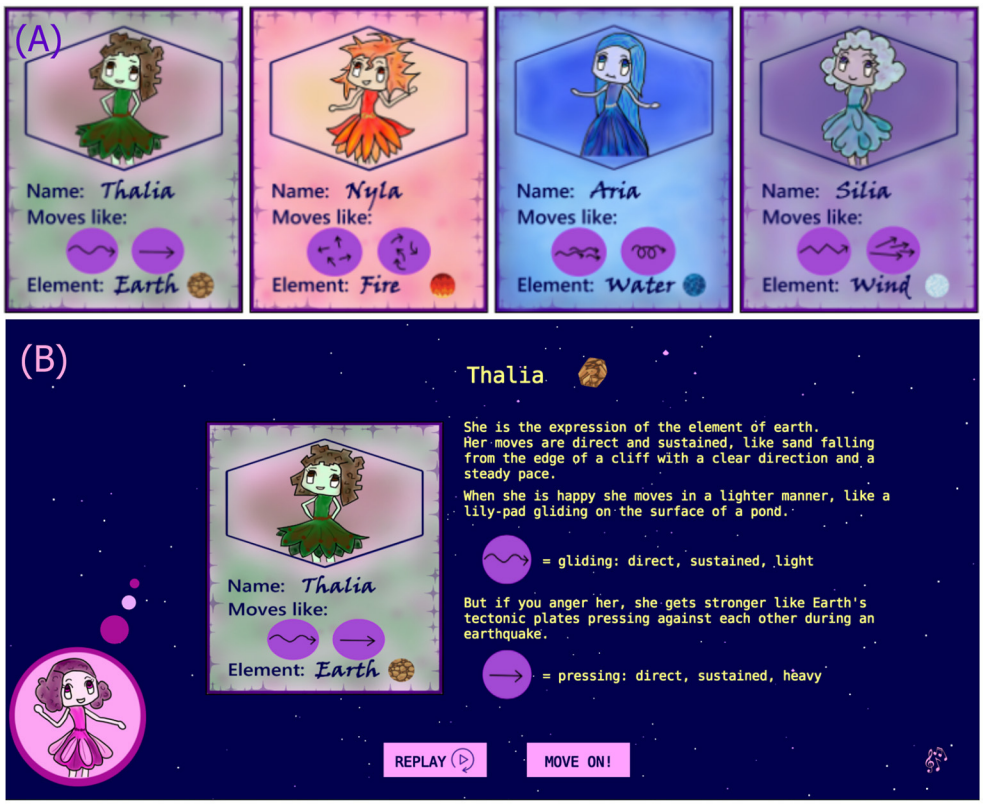


FIGURE 5
Empress character cards and their in-game presentation. Panel **(A)** depicts all the Empress character cards together and panel **(B)** depicts an example of how each individual card presents movement metaphors during the game.

seeing. They are free to revisit any segment and change their answers before submitting them and exiting the free-play mode (Figure 6B).

4.3. Look and feel

When it comes to the "Look and Feel", we aimed for a design which motivates the player to complete the quest while simultaneously creating a pleasant and relaxing experience that does not overwhelm. According to Sutcliffe's "Designing for User Engagement: Aesthetic and Attractive Interfaces" (Sutcliffe, 2009), there are various design principles to achieve different types of user engagement.

To make an aesthetically pleasing interface, it is crucial to define a color palette. To this end we consulted a tentative circumplex model for color scripting in video games proposed by Geslin et al. (Geslin et al., 2016). According to the model's axes of emotions, our pool of options is the range between the axis of Excitement and the axis of Serenity/Zen, so as to achieve the desirable balance between stimulation and relaxation. All the colors in this range induce Positive valence, while the level of arousal varies between mid-low and mid-high values. Choosing from this range, we opted for dark blue for the experience's background color which is closer to the axis of Serenity/Zen and is also reported to be effective on backgrounds (Sutcliffe, 2009). We used different variations of pink and light purple for graphic elements, since these colors are located approximately in the middle of the acceptable range. For text elements, we used a bright yellow which, according to the model, is estimated to induce higher values of arousal than blue, pink and purple and thus attracting the user's attention. We also used a combination of accelerating and steady-paced animations for the movements of the graphic elements on the screen, in order to maintain the desirable balance since, according to the circumplex model, rapid movements result in higher levels of arousal and valence while slow movement low arousal and negative valence.

With a palette of dark blue, yellow and variations of pink and light purple, we opted for fantasy/galaxy aesthetics for the interface. So, we added stars on the dark blue background to make it similar to a night sky and animated the graphic elements to resemble a "floating" effect. To further enhance the relaxing element and the desired fantasy theme, we created a lullaby-like tune as background music for the experience.

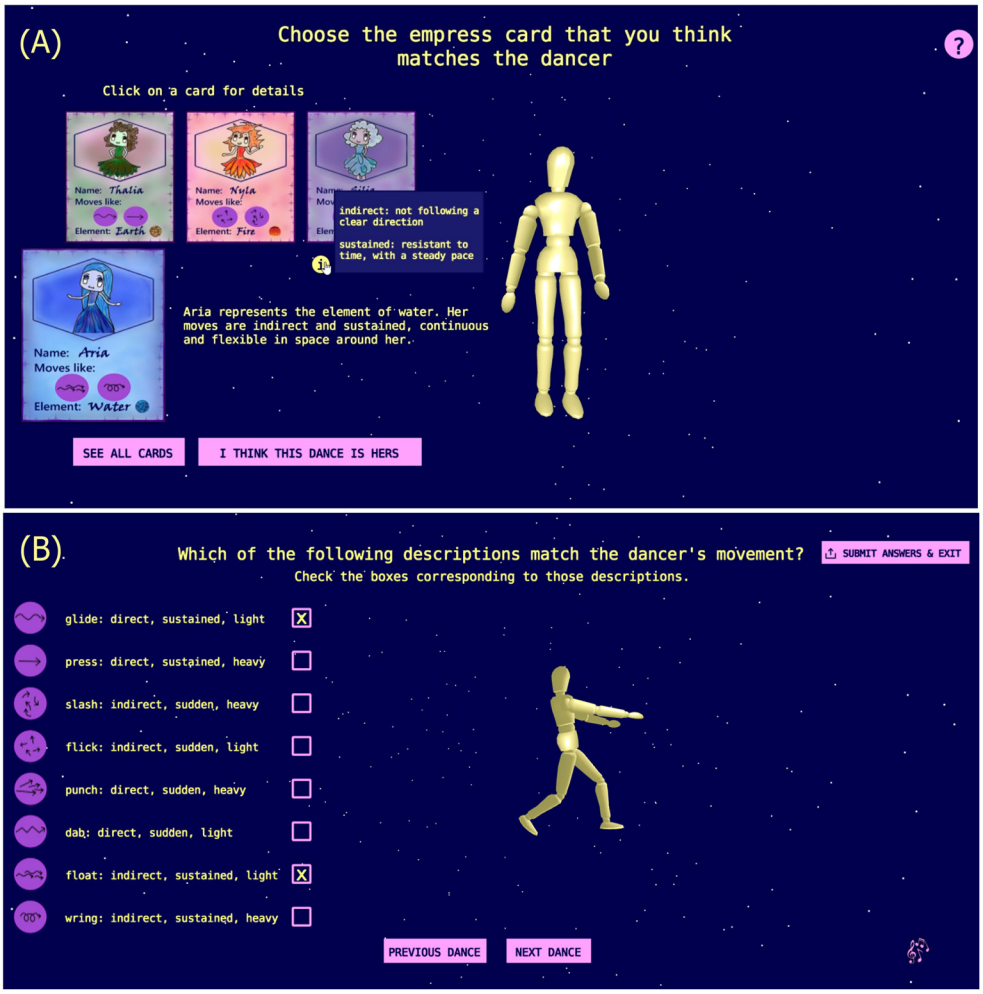


FIGURE 6
Screens from the annotation processes in Story mode and Free mode. Panel **(A)** shows the process of assigning an empress card to the dance segment in Story mode and panel **(B)** shows the process of assigning matching Effort Actions to dance segment in Free mode.

Since Motion Hollow is a playful experience, we decided to give it a retro arcade-like feel by designing all the navigation buttons to be rectangles with upper-case text, so that it bears some resemblance to games that might be familiar to the user. In order to better visualize all the aforementioned ideas and capture the desirable "Look and feel", we created a mood board (Figure 7) which brings together the aesthetic elements and the color palette of Motion Hollow. Mood boards are essentially arrangements of visual and physical elements such as pictures, materials and text created to visualize the aesthetics and style during the conceptualization or design phase of an application.

For the selection of the avatar, the priority was to use a neutral design allowing a clear representation of the movement to support the annotation process. To this end, the avatar used for the performance of the dance segments both in story mode and free mode is a simple wooden mannequin. The avatar was animated in Autodesk Maya (Autosdesk, 2022) with motion-captured dance data from segments performed by professional dancers of each genre. All Motion Capture Animation data used for animating the 3D models were taken from the WhoLoDancE Motion Capture Library and they were created using Qualisys (Qualysis, 2022) and Vicon (Vicon, 2022) motion capture devices. WhoLoDancE (Whole-body Interaction Learning for Dance Education) is a Research and Innovation Action funded under the European Union's Horizon 2020 programme (2016-2018) under Grant Agreement No 688865. The segmentation of the sequences has been both during and after the motion capture process and consists of another complex interdisciplinary problem on its own that falls out of the scope of this work. More information can be found in El Raheb et al. (2018, 2022), Rizzo et al. (2018), and El Raheb and Ioannidis (2021).

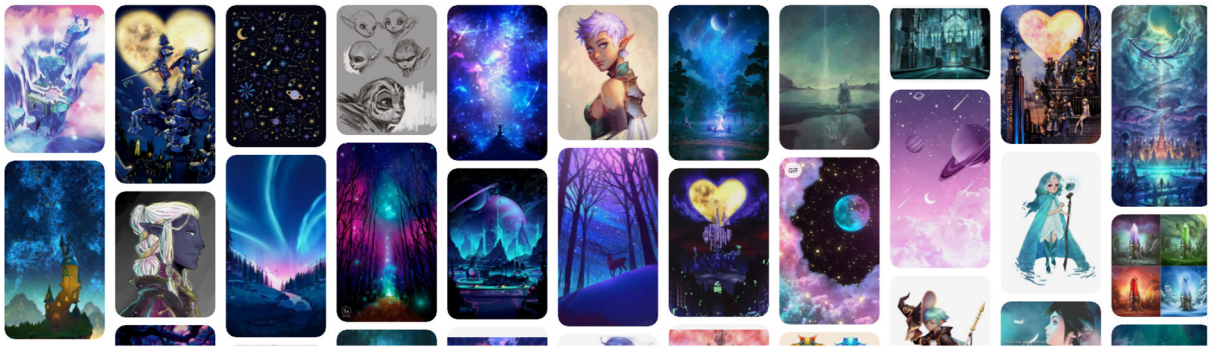


FIGURE 7
Part of the moodboard created for the Motion Hollow experience. The inspirational moodboard was created on Pinterest, and its full version can be found at https://pin.it/4gwn2oH.

5. Evaluation

5.1. Objectives of the study

Our goal for this playful experience design was to guide users through a complex movement analysis framework using playful elements and metaphors and to motivate them to contribute with movement annotations in a story-driven environment. Consequently, this work focuses on the following research questions:

RQ1: Can we transform the process of movement annotation into an enjoyable, engaging experience? And how?
RQ2: Can the wider audience become more familiar with the process/concept of qualitative annotation through playful elements and metaphors? Are patterns identified in the annotations related to LMA and the metaphors used?
Having the aforementioned in mind, the purpose of this research is two-fold: (a) to observe the effects of the story-driven, playful experience on user engagement (RQ1), and (b) to reflect on the efficacy of a movement annotation framework based on LMA, which uses playful elements and metaphors (RQ2). In this section, we present the details, methodology and process of the user evaluation of Motion Hollow.

5.2. Evaluation methodology

5.2.1. Participants

The Motion Hollow experience aims at collecting movement annotations from the wider public regardless of their level of familiarity with movement practices and dance, from complete novices to experts. Therefore, for our experiment we invited participants who belong in either of the aforementioned familiarity levels, so as to maintain the group of users as inclusive as possible. A total of 25 users participated in our experiment, 12% (3) of whom were between the ages of 18–24, 72% (18) were 25–44 and 16% (4) were 45–64 years old. Seventy-two percent (18) were female, while 28% (7) were male.

Participants were informed about the experiment through an open invitation sent out via e-mail and discord servers by the authors. The authors with professional dance expertise communicated the invitation to dance experts of different levels of expertise in various movement practices. We proceeded to schedule the evaluation using an online scheduling tool. Considering the ongoing pandemic of COVID-19, the majority of the user evaluations were carried out via online meeting software.

Apart from the basic participant demographics, we also recorded the participants' expertise in gaming and movement practices, including dance and also experience with the LMA annotation framework, since such information could prove useful in the process of contextualizing the feedback received during the evaluation. We also thought that it might be worth investigating whether there are any interesting correlations among the different levels of familiarity and expertise. Figure 8 presents an overview of the participants' expertise in digital gaming and experience with movement practices in general, their familiarity with the qualitative movement characterization, as well as their level of experience in movement practices and their dance and movement styles.

5.2.2. Process

At the beginning of the evaluation process, the participants were handed a document which contained basic information about the project and the study, including its purpose, procedure and duration. They were then asked to sign a consent form, where they were asked to confirm that they had read the provided information and understood that their participation

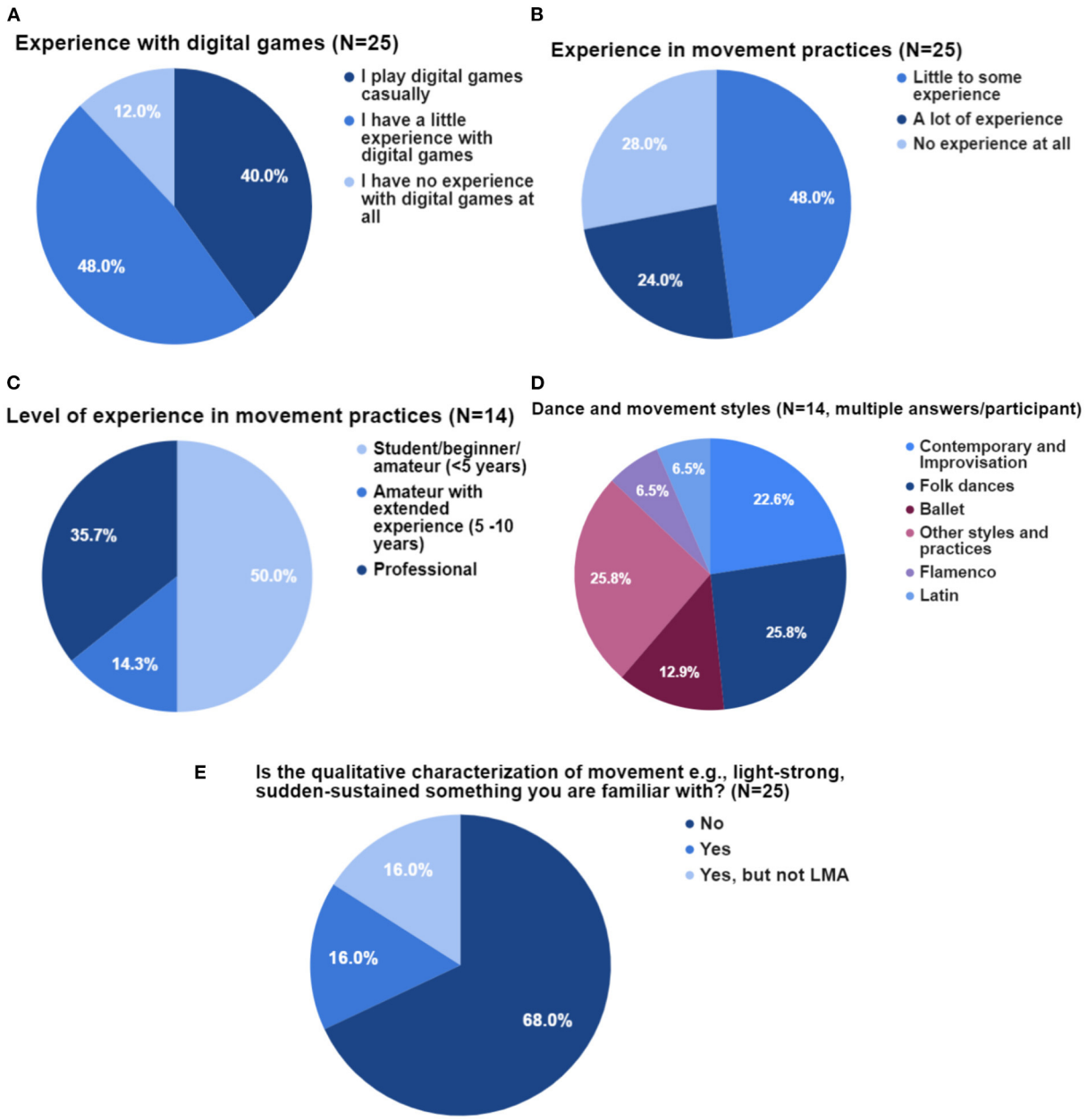


FIGURE 8
Participants' background. Panel **(A)** shows their experience with digital games, **(B)** experience with movement practices, **(C)** level of experience in movement practices, **(D)** dance and movement styles they are familiar with and **(E)** the level of familiarity with movement characterization.

was voluntary and could be withdrawn at any time, as well as give consent for the use of their personal data.

The participants were then asked to start the web application. In the case of evaluations carried out via online meeting software, the participants were asked to share their screen so as to let the evaluators observe their activity. In all cases they were instructed to freely comment and express their thoughts and questions to the evaluators while proceeding ("think aloud" protocol). They were first presented with the selection menu for either the story mode or the free mode (see Section 4 for the description of the experience) and could see the description for both. They were then instructed to choose the story mode first and asked to complete the playful experience while being observed by the evaluators.

After completing the story mode, they had the option to either move on to the questionnaire or try the free mode as well. The users who voluntarily chose to play through the free mode, were informed by the evaluators that they could skip movements and exit the application whenever they felt like it.

At the end, they were asked to complete an on-line questionnaire (see Section 5.3.1) consisting of 4 parts: basic profiling and demographic information, general user experience, the GEQ (Game Experience Questionnaire) Core Module (IJsselsteijn et al., 2013), and selected sections from PLEXQ (Playful Experiences Questionnaire) (Boberg et al., 2015). After completing the questionnaire, the users were interviewed (see Section 5.3 for details).

5.3. Evaluation instruments

5.3.1. Questionnaire

The design of the questionnaire was an important step of our methodology. It includes questions aimed to record the participant profile, general user experience aspects and more specific aspects to the game experience. For the latter, we employed relevant parts from two standard questionnaires, the Game Experience Questionnaire (GEQ) (IJsselsteijn et al., 2013) and the Playful Experiences Questionnaire (PLEXQ) (Boberg et al., 2015). It is divided in the following sections.

5.3.1.1. Participant profile

Six questions related to general demographic information of the participant, such as age, background in movement and level of experience in digital games, as well as their familiarity with movement analysis and dance.

5.3.1.2. Overall user experience

Questions regarding the user experience and overall usability of the application, such as whether or not they thought the experience was too long or tiring, the simplicity of the instructions, story and narration, etc.

5.3.1.3. GEQ core module

The Game Experience Questionnaire (GEQ) (IJsselsteijn et al., 2013) is a widely used questionnaire for the evaluation of games and playful applications in general, applied in many relevant studies. It consists of 3 modules: the Core Module, the Social Presence Module and the Post-game Module. In our case we opted to use the Core Module. It contains 33 statements which the user is asked to evaluate in a 5-point Likert scale from 0 to 4. The user responses are then used to calculate the 7 GEQ scores, Competence, Sensory and Imaginative Immersion, Flow, Tension/Annoyance, Challenge, Negative affect, Positive affect. The questionnaire statements and score calculation method are detailed in (IJsselsteijn et al., 2013).

5.3.1.4. PLEXQ questionnaire

The Playful Experiences Questionnaire (PLEXQ) (Boberg et al., 2015) is a questionnaire created to measure various facets of playful experiences. It consists of statements on a 5-point likert scale, from 0 to 4, which are then used to calculate scores for its 17 categories. We included 7 categories, Captivation, Completion, Relaxation, Sensation, Suffering, Challenge, and Humor, which are relevant to our study, resulting in 24 statements. Categories such as Competition, Cruelty and Fellowship were excluded due to the fact that the application is single-user, whereas categories such as Control, Expression and Subversion are not relevant to the nature of the application and our experiment objectives.

The full evaluation questionnaire is provided as Supplementary material to this article.

5.3.2. Interview

The purpose of the interview was to record in greater detail feedback about the more qualitative aspects of the experience, as well as more details regarding the users' background in movement, so as to deepen our understanding of their own perception of the experience. Therefore, the interview consisted of 15 questions focusing on the qualitative characterization of movement and the chosen annotation framework, such as the participant level of familiarity with the LMA framework and terminology, the effects of the 3D graphics and the characteristics of the avatars, how easy or complicated it was for them to describe the movement etc. The full interview questionnaire is provided as Supplementary material to this article.

5.3.3. Collected data

Our study produced both quantitative and qualitative data from the questionnaire, the interview, as well as data-logging and user observation during the experiment. More specifically, the questionnaire results include: (a) calculated scores for the 7 categories of PLEXQ used in our experiment; (b) calculated scores for the 7 categories of the GEQ Core Module; (c) scores for the individual statements both from PLEXQ and GEQ; (d) scores of four additional 5-point Likert-scale statements related to specific elements of the experience; and (e) answers to open-ended questions. The logged data include: (a) the annotations made by the user both on story mode and free mode; and (b) the duration of the user's experience in free mode. Observation data include: (a) if the user used the provided help and hints during gameplay; (b) whether or not the objective of the experience seemed to be clear to the user; (c) if the user replayed any storytelling parts; and (d) possible issues the users encountered in relation to the usability of the application. Interview data include: (a) detailed feedback regarding the user experience and engagement; and (b) detailed feedback

regarding the way the annotation process was designed and delivered, as well as the way the LMA framework was applied in the experience.

6. Analysis and results

As discussed in Section 5.1, this research focuses on two main objectives: (a) observe the effects of the playful experience on user engagement (RQ1); and (b) to reflect on the efficacy of an LMA movement annotation framework presented through playful elements and metaphors (RQ2). In this section, we briefly present our approach to analyzing the results of the study and then focus on the results, structured around the two main research questions.

For the analysis of the open ended questionnaire and interview questions, two evaluators separately identified and recorded themes for each one. They then consolidated their findings, leading to common themes and topics as well as a set of representative user quotes used to substantiate our more quantitative findings.

In relation to the analysis of the questionnaire data, we proceeded with calculating for each participant the PLEXQ and GEQ scores for each of their corresponding categories. We also opted to examine the questionnaire statements individually, as they provide concrete insight for certain aspects of the experience. For all quantitative results we calculated the average and standard deviation across users.

The open-ended questionnaire questions and the interview data have been analyzed through a thematic analysis approach. Two evaluators independently went through the data and identified themes and concepts that were prominent and consistent throughout. They then compared their findings and, with the rest of the team, reached a consensus as to the themes that would be used for coding of the data. This coding scheme was then used at the second round of analysis again individually by two evaluators. They compared and discussed their results to reach consensus. The results are included in this section.

6.1. Examining the effects of participant expertise on the users' experience

To examine the possible effect of the participants' expertise in gaming and in dance or move on any of the collected data, we performed an analysis looking for possible correlations. Participant scores and ratings were handled as ordered random variables, making no assumption about their distribution. Our first step was to examine the possible effect of the participants' experience in gaming and in dance or any other movement practices, on the collected data. To this end, we performed a statistical analysis using the SPSS software.

The 7 PLEXQ categories, the 7 GEQ categories and the experience duration were treated as continuous interval variables. We performed Kolmogorov-Smirnov and Shapiro-Wilk tests to examine their distribution for normality. The categories that follow the normal distribution according to both tests were:

PLEXQ Challenge: $D(25) = 0.139$, $p = 0.2$ for Kolmogorov-Smirnov and $D(25) = 0.929$, $p = 0.08$ for Shapiro-Wilk
GEQ Competence: $D(25) = 0.162$, $p = 0.88$ for Kolmogorov-Smirnov and $D(25) = 0.959$, $p = 0.403$ for Shapiro-Wilk
GEQ Flow: $D(25) = 0.127$, $p = 0.2$ for Kolmogorov-Smirnov and $D(25) = 0.960$, $p = 0.406$ for Shapiro-Wilk
GEQ Challenge: $D(25) = 0.137$, $p = 0.2$ for Kolmogorov-Smirnov and $D(25) = 0.942$, $p = 0.165$ for Shapiro-Wilk
GEQ Positive affect: $D(25) = 0.128$, $p = 0.2$ for Kolmogorov-Smirnov and $D(25) = 0.932$, $p = 0.096$ for Shapiro-Wilk

For those categories that follow the normal distribution, we performed the one-way ANOVA test with both Bonferroni and Hochberg's GT2 *post-hoc* correction. None of the categories produced significant results across, neither in experience in dance nor in experience in gaming.

For the rest of the categories as well as the experience duration that do not follow the normal distribution, we performed Kruskal-Wallis non-parametric tests, which, similarly, did not produce significant results. Although the results of the statistical analysis did not detect a significant effect of the dance and gaming experience on the PLEXQ and GEQ categories, to further confirm this result, we proceeded to examine possible correlations of these two participant profile variables to the individual PLEXQ and GEQ questionnaire statements, as well as on the X individual "Overall user experience" statements. More specifically, we calculated the bivariate correlation coefficients Pearson r and Spearman rho (non-parametric tests used to measure the degree of association between two variables). The control rejects the "No correlation" hypothesis with a significance level of $p = 5\%$ (when the p-value of the sample is less than 0.05), on which Bonferroni correction has been applied. The value of the Pearson and Spearman coefficients shows whether the variables are proportional (0,1] or inversely proportional [−1,0).

This analysis revealed no significant correlations between participant expertise in dance and any of the quantitative results, suggesting that dance expertise is not a factor affecting engagement with the experience. In the case of gaming expertise, the following correlation have been detected with one item of the "Overall user experience" part of the questionnaire:

"The story of the experience was simple and easy to understand" ($r = 0.550$ with $p = 0.004$ and rho = 0.635 with $p = 0.001$).

Looking closer, however, at the average score for each gaming expertise level, we can note that in all cases the relevant score is indeed high, as those with no expertise (1) had an average score of 3.6 (STD = 1.52), those with medium expertise 4.9 (STD = 0.32) while the game experts 5 (STD = 0). These results imply that although there may be a difference in how the more expert gamers perceive the game in terms of ease of grasping its narrative aspects, the relevant average scores remain high for all users, regardless of expertise, further confirming that the participant profile in terms of experience in gaming or movement practices did not affect user experience. More details about the study results (in relation to user engagement) are presented in the next section.

6.2. User engagement

Overall the application ran smoothly during all the evaluations and there were no usability issues reported by any of the users nor observed during the sessions. For this reason, this section will be focusing mainly on the results regarding the UX (User Experience) aspects related to user engagement.

A strong evidence of user engagement are the average scores derived from the questionnaires, PLEXQ and GEQ. As seen in Figure 9, the scores related to categories regarding positive influence achieved relatively high scores in both questionnaires, with the highest being Positive affect with an average score of 3.36 (STD = 0.49) in GEQ and Sensation with a score of 3.47 (STD = 0.55) in PLEXQ. On the other hand, the categories related to negative influence scored pretty low numbers, with the lowest point being Tension/Annoyance with a score of 0.09 (STD = 0.25) in GEQ and Suffering with a score of 0.08 (STD = 0.20) in PLEXQ.

Another result confirming the basis of our research question regarding user engagement (RQ1) is the participants' willingness to voluntarily play through the Free mode of the experience and the time they spent doing so. According to the experience logs, 96% (24) of the participants chose to voluntarily experience the free mode after completing the story mode, instead of immediately moving on to the questionnaire. The minimum number of dance segments characterized is 3 out of the 13 available, the maximum is all 13, while the average number of segments characterized is 8.71 (STD = 3.85). The maximum play duration is 17 min 35 s with the minimum being 1 min 20 s. and the average 7 min (STD = 4 min 35 s). When it comes to the preferences of 96% (24) of participants who experienced both play modes, Figures 9C,D present an overview of the participants' favorite play mode, as well as the mode they would most likely choose to experience in their free time.

The aforementioned quantitative results are confirmed through the interview and user observation data. All participants reported that the experience was "interesting", "fun", and "not boring at all". In many cases, participants described the overall experience as "very relaxing" and "chill", stating that the look and feel along with the background music created an aesthetically pleasing, "atmospheric" experience. This result is also reflected in the fact that the Relaxation and Sensation categories of PLEXQ achieved pretty high scores, with Relaxation calculated at 3.16 (STD = 0.67) and Sensation at 3.47 (STD = 0.55). More specifically, in GEQ the statement "I thought it was fun" scored 3.44 (STD = 0.65) while the statement "I felt good" scored 3.56 (STD = 0.58). Similarly, in PLEXQ the "I had fun" statement achieved a score of 3.40 (STD = 0.65), while "I felt relaxed" scored 3.52 (STD = 0.77).

Overall, it seems that the experience was successful in motivating the users to complete the task. As one of the participants commented, *"the addition of a story, characters and other playful elements has successfully transformed an otherwise mundane task, such as annotation, into a very good experience"*. Another participant shared: *"For me the concept of natural elements was super familiar from other games that I have played. Although I was completely unfamiliar with the characterization of movement, I got so invested in this imaginary world, the atmosphere, the aesthetics, the story, that I was motivated to move forward and complete the quest."*

6.3. Playful elements and annotation

All participants reported that the playful elements such as the empress character cards, the Laban Effort Action visualization icons and the element metaphors used to enhance the process, proved to be quite helpful to support the annotation of dance segments. 88% (22) of participants said that they had no trouble understanding the descriptions/metaphors accompanying the character cards, while 12% (3) said they experienced some difficulties. Moreover, as seen in Figure 10B, 72% (18) of participants found the available descriptions to be enough to characterize the segments. Specific details regarding the difficulties users had during the annotation process in general are presented in Figure 10A. Regarding the avatar used to visualize the dance segments, Figures 10C,D present participants' feedback on whether it was helpful, as well as their suggestions for changes.

In relation to help and hints, 32% (8) of participants used the resources available to them throughout the experience, while the remaining 68% (17) did not even notice the corresponding icons on the screen. None of the players replayed any of the storytelling parts.

During the user interviews, several suggestions were made by participants regarding the design of the annotation process. Twenty-eight percent (7) of participants felt that it would be helpful to be able to revisit districts and re-assign cards/Effort Actions to the dance segments, or be able to see all the dance segments first and then assign the cards/Effort Actions to each of them. Some participants were

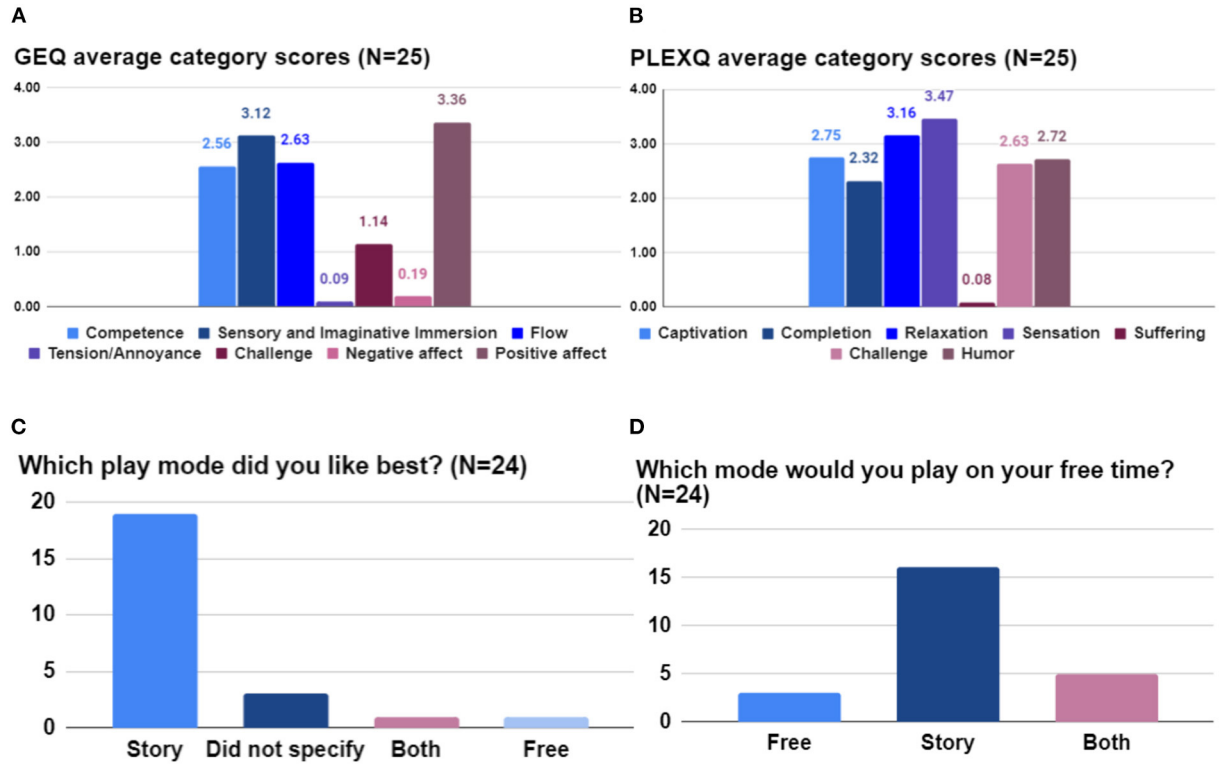


FIGURE 9
Participants' scores and preferences. Panel **(A)** shows the GEQ average category scores, panel **(B)** shows the PLEXQ average category scores, panel **(C)** shows participants' favorite playing modes and panel **(D)** shows participants' preferred mode to play in their free time.

not sure about how they were supposed to proceed at the last district where all the cards looked like the remaining element card. They had memorized the pair of Laban Effort Action visualization icons and they were torn between either immediately choosing the card with the Effort Actions they had memorized, or observing the movement and choosing based on the descriptions provided. Thirty-six percent (9) of participants would like to be able to receive feedback for their submitted answers. Alternatively, if feedback is not possible due to the fact that there are no right or wrong answers, they would like to be provided with a visualization of other users' annotations.

One participant thought that not being able to match dance segments with element cards that have already been assigned to another segment was really restrictive and limiting. As the user may not be able to choose their first choice, they have to compromise with the next available one that seems most relevant. Twenty percent (5) of participants, including 2 dance experts, reported that the experience gave them a chance to learn new things about dance, or appreciate what they already knew in different ways. More specifically, the ones with dance or movement practice expertise commented that the experience promoted reflection on movement, with one expert suggesting that this kind of experience might have an educational added value especially for young students. These results are also reflected in the Challenge category of PLEXQ, which includes the statements "It stimulated me to learn new things", "It was a true learning experience", and "I enjoyed learning new things", scoring an average of 2.63 (STD = 0.91).

When it comes to the annotations participants contributed while playing the story mode, Figure 11 presents the participants' element card assignments during the first stage of the annotation process, while Figure 12 includes the counts of Laban Effort Actions assigned by the participants during the second stage of the annotation process for all the segments. Figure 13 presents a visualization of the participants' contributed Effort Action annotations on Laban's dynamosphere of Efforts (Figure 1A). As the results pictured in these figures show, there has not been agreement among participants' answers neither when it comes to the natural element assignment, nor to the annotation of Basic Effort Actions on the segments. To this end, we analyzed the collected Basic Effort Action annotations into their corresponding combinations of Efforts for the motion

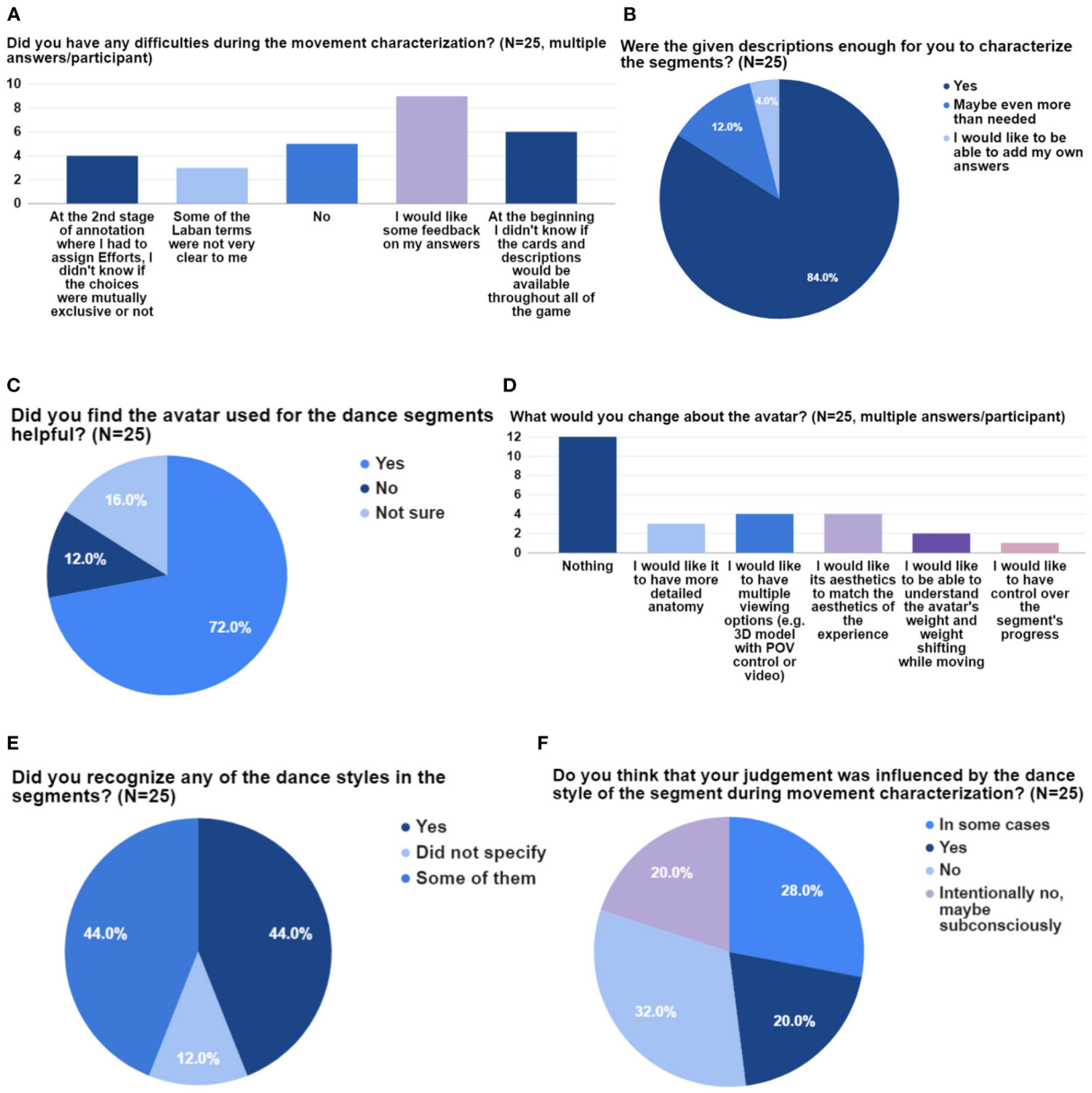


FIGURE 10
Participants' feedback on aspects of the annotation process. Panel **(A)** presents feedback on difficulties during annotation, panel **(B)** shows feedback on card descriptions, panel **(C)** shows participants' feedback on whether the avatar was helpful **(D)** shows some of participants' change suggestions about the avatar, panel **(E)** presents the participants' feedback on whether they recognized the dance styles included in the segments and panel **(F)** shows their feedback on the influence of the different dance styles on their judgment during movement characterization.

factors of time, space and weight, in order to check for possible consensus, patterns or even tendencies in the users' answers. The results of this analysis, which are presented in Figure 14, suggest that there is no agreement among participants' assigned Efforts either, however we can certainly identify tendencies, in some cases stronger and in others less apparent. A more elaborate discussion regarding these results can be found in Section 7.

7. Discussion

The results from the statistical analysis presented in Section 6.1 imply that expert gamers tended to become more absorbed in the experience and it was easier for them to understand the story concept. For participants more proficient in gaming it was maybe easier to feel more comfortable and able to focus on the game. Similarly, they

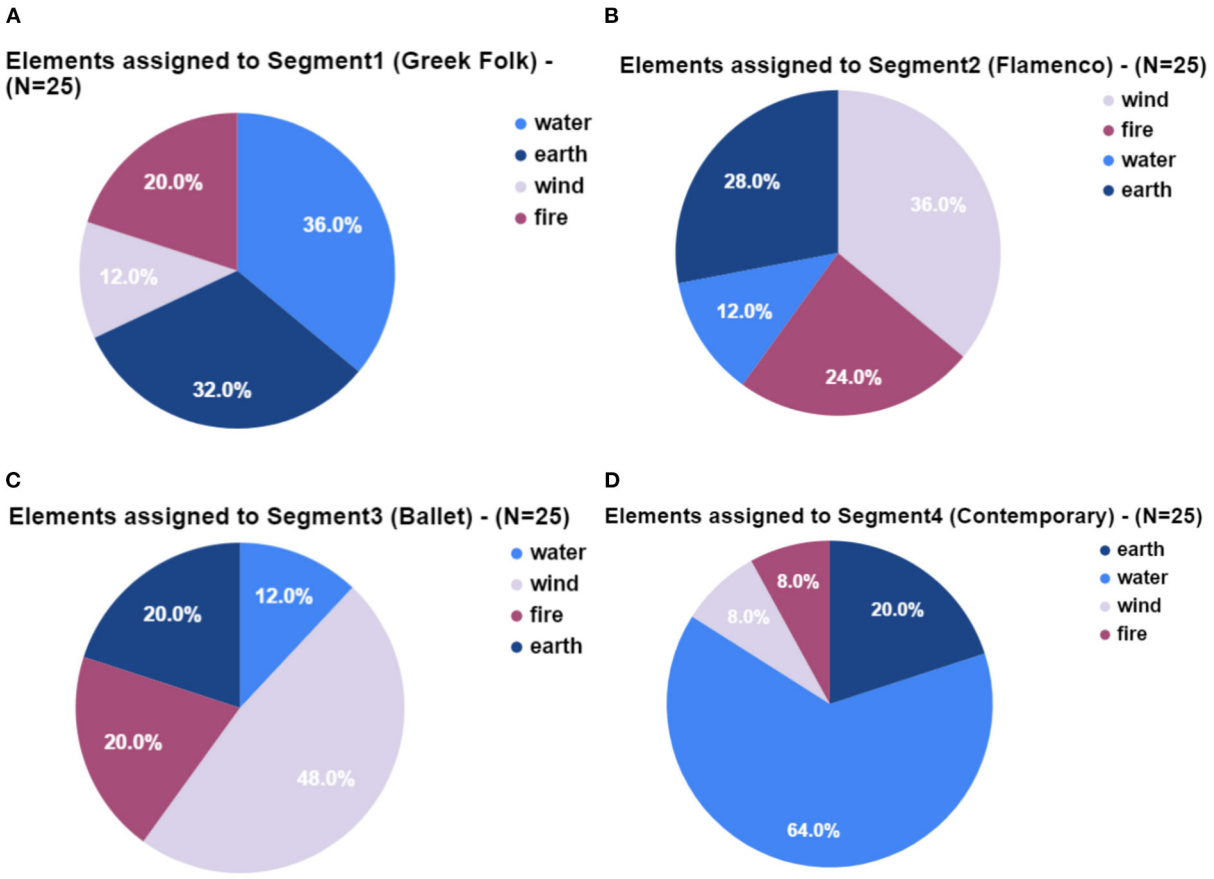


FIGURE 11
Participants' assigned element card annotations. Panel **(A)** shows the annotations of Segment1 (Greek folk), panel **(B)** shows the annotations of Segment2 (Flamenco), panel **(C)** shows the annotations of Segment3 (Ballet) and panel **(D)** shows the annotations of Segment4 (Contemporary).

considered the game narrative easier to understand, probably due to being more used to considering such narratives in a gaming context.

Our study results confirm that the incorporation of dance segment annotation tasks within a playful story-based experience can make the process of movement characterization engaging and attractive to both dancers and non-dancers (RQ1). However, such an approach by itself cannot resolve all the complexities of qualitative characterization of motion-captured dance segments (RQ2). While the natural elements helped the participants understand the notion of qualitative aspects as well as the nature of the annotation task, it was not always easy to select the right element. As they reported in their interviews, there were several moments when they felt undecided or wanted to change their mind. As mentioned in Section 6.3, even though the collected annotation data shows that there has not been agreement among users on matching segments with elements, emerging patterns can be identified, especially when analyzing the natural elements (fire, wind, water, earth) in relation to the LMA Effort Actions (punch, dab, wring, glide, float, flick,...) and the LMA Efforts of each factors (light/strong weight, direct/indirect space, sudden/sustained time). For example, participants might not agree that segment 4 can be associated with one particular natural element (see Figure 11D) or even particular Effort Actions (see Figure 12D), however if we take a look at the individual Efforts, we can see that the majority of people somehow identifies this dance segment to be indirect in terms of space (Figure 14J), strong in terms of weight (Figure 14K) and sustained in terms of time (Figure 14L). More specifically, in terms of space 78.6% (22) of the answers were indirect, in terms of weight 85.7% (24) were light, while in terms of time 85.7% (24) were sustained. As we can see, segment 4 is one of the cases where strong tendencies are identified in the users' answers, there are however other segments, such as segment 3, were the Effort distribution shows smaller differences. Although the segment is mostly identified as direct (Figure 14G), strong (Figure 14H), and sudden in terms of time (Figure 14I), the numbers backing up these results are less significant, with 65.7% (23) for direct, 54.3% (19) for strong and 68.6% (24) for sudden.

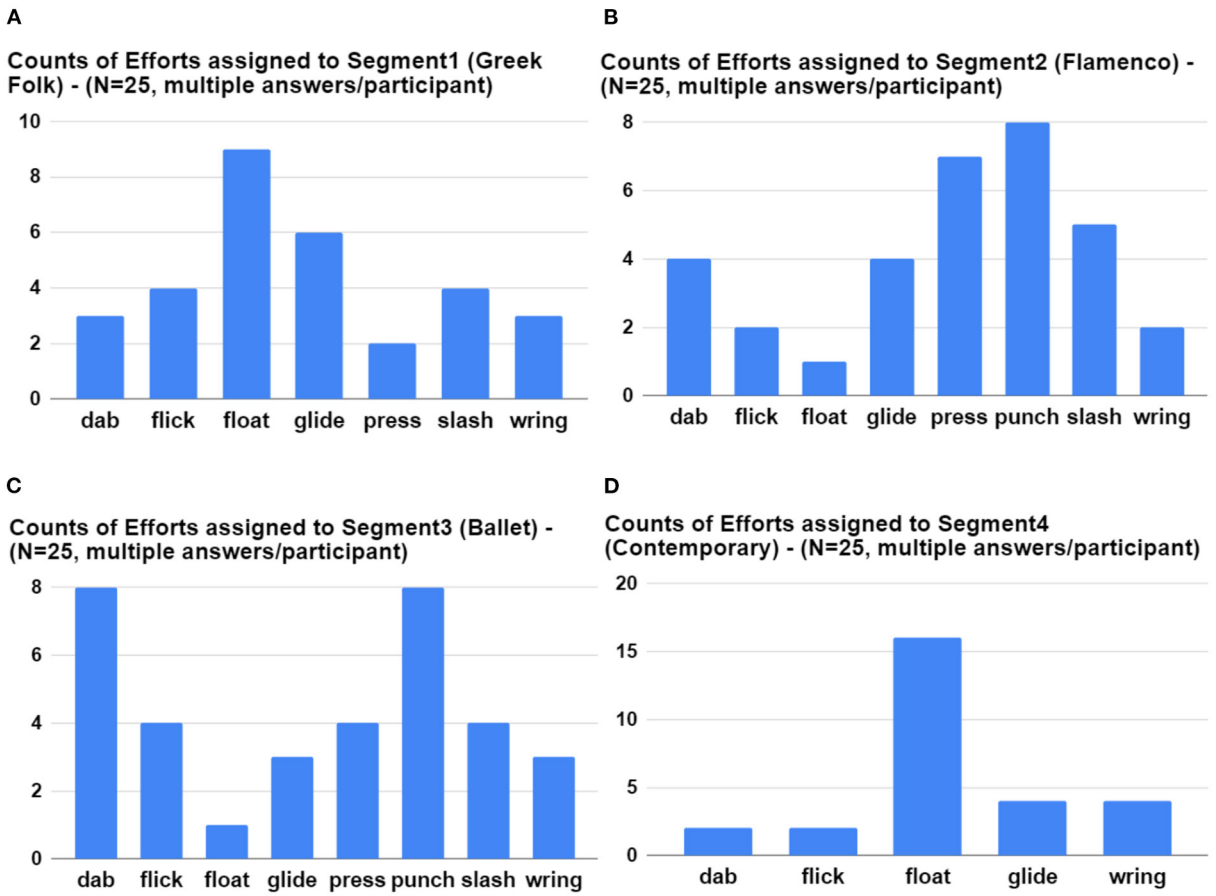


FIGURE 12
Participants' Laban Effort Action annotations. Panel **(A)** shows the annotations of Segment1 (Greek folk), panel **(B)** shows the annotations of Segment2 (Flamenco), panel **(C)** shows the annotations of Segment3 (Ballet) and panel **(D)** shows the annotations of Segment4 (Contemporary).

Interestingly, the type of dance seems to have affected the answers in various ways. Some participants admitted that the dance style might have created a bias about the element e.g, "flamenco is a flaming, passionate dance, therefore this segment should be fire" (see Figures 10E,F). At least one participant commented that it might be more interesting to try these experiments using only contemporary dance segments which are considered less stylized and more neutral in terms of contextual connotations. On the other hand, some dance experts reported that it was interesting how the annotation process and the experience made them rethink these biases, inviting them to look carefully at the movement rather than answering based on what their first guess was according to the dance style. This point also highlights a trade-off between making the characterization of movement and LMA easier to grasp by applying elements like a storyline, archetypes and natural elements and participants enjoying a playful experience without paying actual attention to movement and its qualitative aspects, or being over-guided by the explanations.

In addition, while it is a known issue that annotating movement comes always with some subjectivity, even among professionals trained in the same framework (Alaoui et al., 2015; El Raheb et al., 2018; El Raheb and Ioannidis, 2021), in the context of a playful experience with game mechanics such as rewarding elements, participants expect to know whether their answer is right or wrong. Motion hollow could not offer this type of reward: participants were not given any feedback regarding their answers, since the system's objective is to introduce the public to qualitative movement annotation, rather than collect accurate annotations. The scope of this work was shared with and understood by the users during the evaluation interview, who suggested that the lack of scores could be partially addressed by showing statistics relating their answers to those of other participants.

As the study results suggest, the segment itself can make it easier or harder to characterize. Some segments that have been initially created with the performers following qualitative instructions (e.g., move lightly) were easier to characterize and

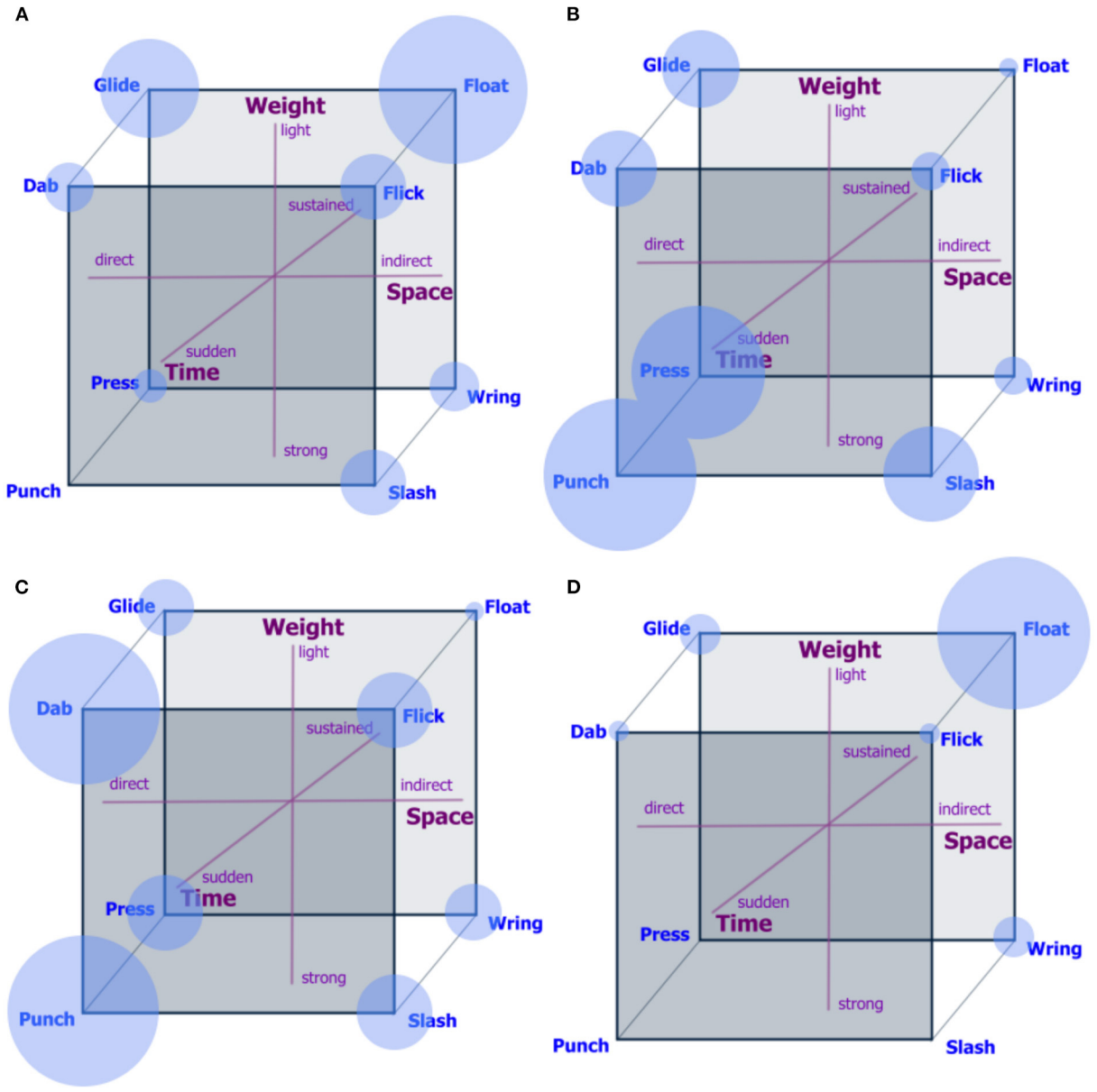


FIGURE 13
Visualizations of participants' Effort annotations on Laban dynamosphere. Panel **(A)** shows a visualization of annotations of Segment1 (Greek folk), panel **(B)** shows a visualization the annotations of Segment2 (Flamenco), panel **(C)** shows a visualization of the annotations of Segment3 (Ballet) and panel **(D)** shows a visualization of the annotations of Segment4 (Contemporary).

reached higher agreement both in natural elements (Figure 11) and LMA Effort Actions/and factors (Figures 12, 13). On the other hand, in segments that belonged to flamenco, where the kinesiology is specific and more multilayered (i.e., the arms move in different qualities than the feet), it was more difficult for the participants to agree. This is aligned with previous results suggesting that movement segmentation is not independent from how easy an annotation is for the user. Dance movement is a continuous activity and selecting part of the movement for the user to characterize removes it from its original context, what happens before and after the segment, that might affect their annotation. As reported also in previous work, not only revisiting but comparing segments is useful when it comes to qualitative aspects of movement (El Raheb et al., 2022), during the interviews 7 participants said that they would like to change their answers

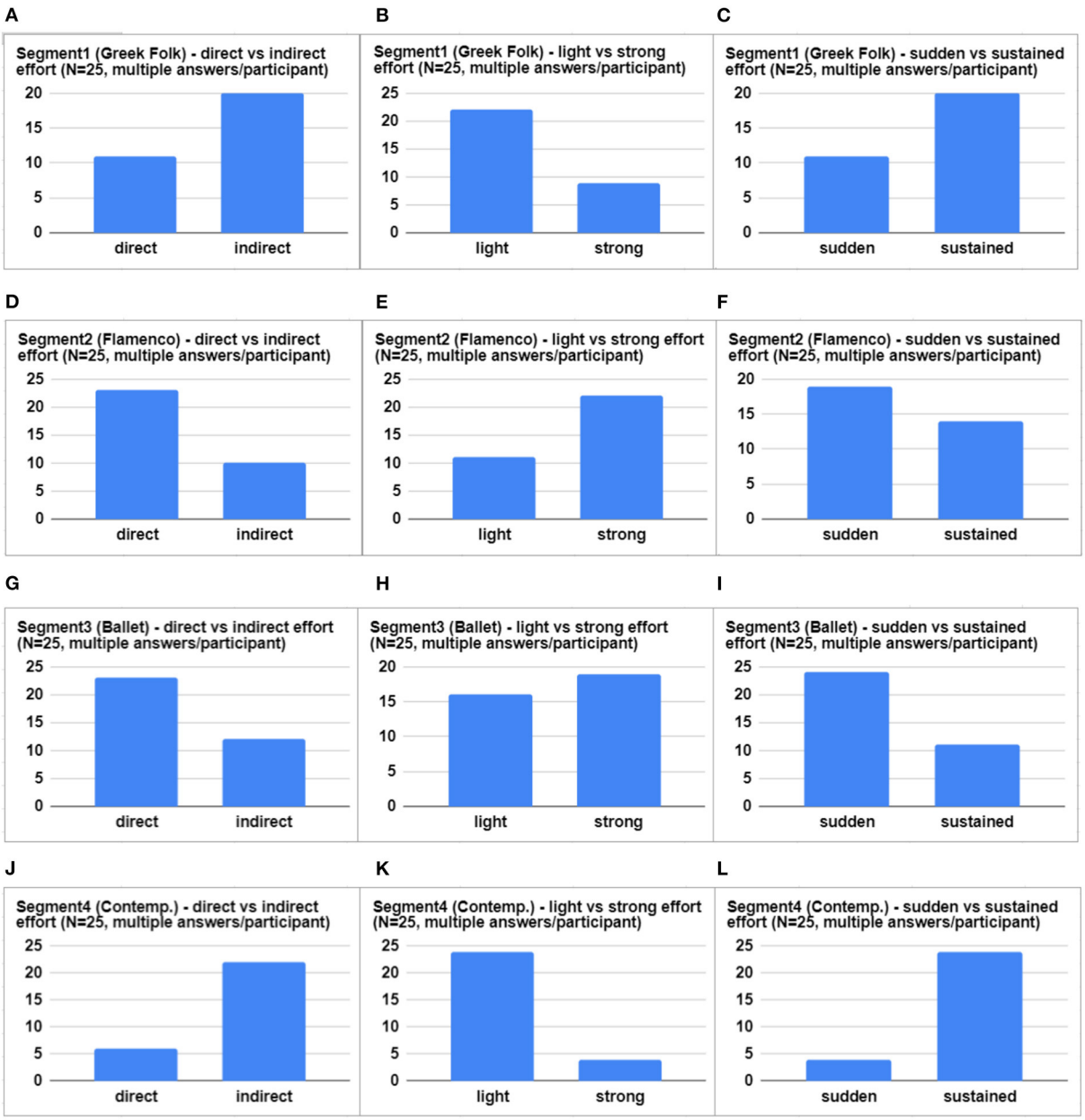


FIGURE 14
Comparisons of participants' Laban Effort annotations for each motion factor. Panel **(A)** shows the annotations of the motion factor of Space for Segment1 (Greek folk), panel **(B)** shows the annotations of the motion factor of Weight for Segment1 (Greek folk), panel **(C)** shows the annotations of the motion factor of Time for Segment1 (Greek folk), **(D)** shows the annotations of the motion factor of Space for Segment2 (Flamenco), panel **(E)** shows the annotations of the motion factor of Weight for Segment2 (Flamenco), panel **(F)** shows the annotations of the motion factor of Time for Segment2 (Flamenco), panel **(G)** shows the annotations of the motion factor of Space for Segment3 (Ballet), panel **(H)** shows the annotations of the motion factor of Weight for Segment3 (Ballet), panel **(I)** shows the annotations of the motion factor of Time for Segment3 (Ballet), panel **(J)** shows the annotations of the motion factor of Space for Segment4 (Contemporary), panel **(K)** shows the annotations of the motion factor of Weight for Segment4 (Contemporary) and panel **(L)** shows the annotations of the motion factor of Time for Segment4 (Contemporary).

after seeing another segment that seemed to be a closer match, comparing between them as to which was, for example, more airy.

All these points suggest that in future versions, a possible combination between the story mode and free mode, providing more flexibility on revisiting annotations

that allows comparisons among the different segments should be considered.

7.1. Limitations

Motion Hollow, as a GWAP, has been designed with the intention to balance and reconciliate promoting engagement and producing annotations that reflect as closely as possibly the user's perception of the movement in relation to the LMA framework. To this end, certain design choices were bound to favor one or the other of these two objectives. For example, as already mentioned in Section 4.1.3, not being able to assign cards already assigned to other districts was a decision made to support the story narrative and game quest. However, it may have hindered the user from characterizing the movement the way they wanted to. In the next version of the experience, a new approach should be implemented and assessed, so as to allow the user to assign all cards to all segments regardless of if a card is already assigned.

Some researchers have pointed out the value of movement annotation for teaching (dos Santos et al., 2018; El Raheb et al., 2018) or "training the analytical eye" (Stancliffe, 2019) in the context of dance practice during the creative process (Blades, 2015; Ribeiro et al., 2016; deLahunta and Jenett, 2017). These are different contexts of use than the one we propose here. However, it seems that this potential of combining digital playfulness and dance annotation in formal or informal learning that targets improving movement literacy and observational analytical skills on movement is something that was reported by the participants of this study (both those with and without any dance experience).

Similarly, grouping the Basic Effort Actions under natural movement metaphors might have helped the users progress quickly with the quest, however only 4 elements can be quite limiting. Expanding the number of metaphors and cards should be explored as a design choice to offer the user a wider selection of more specific options. Lastly, a concrete need identified during the evaluation was for the users to be able to go back and change the characterization of a movement segment.

8. Conclusion and future work

In this paper, we presented Motion Hollow, a story-driven playful experience for dance segment annotation, using descriptions and metaphors based on the LMA framework. Movement annotation is a challenging multifaceted issue, especially when it comes to the qualitative aspects. The complexity of human movement, the lack of intuitive annotation frameworks combined with the lack of approaches able to motivate users to contribute their annotations are the main reasons behind the absence of a successful solution implemented so far for dance, in contrast to other fields such as the annotation of manuscripts or music. We evaluated the experience with 25 users and confirmed its potential to transform the annotation of dance movement segments into an engaging and enjoyable experience. It has also showcased its ability to foster a deeper understanding of the the process of annotation of movement qualities, revealing its educational aspect.

One possible direction of this research is exploring the capabilities and limitations presented by the combination of different types of story and annotation models. Pairing the more flexible annotation approach implemented in free mode with the playfulness and mechanics used in the story mode could result in a more open experience design with a less definitive storyline and a wider set of options provided during the annotation process, which supports the addition of a valuable feature: reusability of characterizations and the ability to change given answers at any time mid-game without affecting the progress of the story or creating plot-holes. This way the experience focuses on providing the user with maximum freedom during annotation, while still offering an engaging experience.

An important next step is to proceed with collecting more annotations from a larger number of participants. The first indications of patterns concerning the annotations are promising, however more data is needed to be able to fine-tune issues like the optimum movement segment size, the avatar style or the number and type of offered metaphors or elements representing the movement Effort Actions. Motion Hollow offers a gameful and engaging test-bed for experimentation with dance annotation by both experts and non-experts, paving the way for creating user-generated annotation content in the field of dance movement.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethics Committee of the Department of Informatics and Telecommunications and the Research Ethics Committee (E.H.D.E.) of the National and Kapodistrian University of Athens. The patients/participants provided their written informed consent to participate in this study.

Author contributions

LK in collaboration with KE focused on the design of the conceptual framework, as well as the definition of the application's specifications. LK designed the UI/UX (User

Interface/User Experience) of the experience and developed the application. MR and KE supervised the design process. LK, KE, and AK designed the evaluation process. LK and KE conducted the user evaluations. AK performed the statistical analysis. MR supervised the overall research. The paper authoring was divided amongst all authors. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcomp.2022.957274/full#supplementary-material

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