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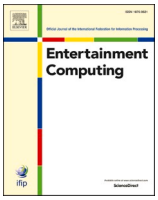

Alice Dalí augmented reality: Evaluating a cultural outdoors game for intergenerational play

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ABSTRACT

Serious Games have been shown to have many uses, such as for learning and cultural engagement. Furthermore, research has shown that some types of game experiences can have significant social benefits, such as a study by Wang, Taylor and Sun, which showed that playing cooperative video games can improve family satisfaction and closeness. In this article, we present the design and evaluation of *Alice Dalí AR* (2022), a locative augmented-reality smartphone game designed as a cultural experience for families to engage with art, music and storytelling. *Alice Dalí AR* features 12 illustrations produced by Dalí in 1969 for the iconic story *Alice's Adventures in Wonderland* by Lewis Carrol. We applied a multisensory design methodology based on synesthesia, where art shapes and color palettes from Dalí's paintings were "transposed" to music genre and music language. The play experience involves using a radar to find AR music art encounters through which a story of Wonderland emerges. The design offers a cultural and social play experience that can help strengthen family connections and knowledge exchange across generations, and at the same time encourage players to spend time outside in healthy walking activities. We present the results of a user study, which shows evidence of cultural engagement and increased intergenerational emotional bonding. The *Alice Dalí AR* app is available from the Google and Apple app stores.[1]

1. Introduction

Technological progress has brought many advantages to human lives but has also resulted in intergenerational gaps due to the differences in technology adoption rates across age groups [1]. Furthermore, social media technologies (e.g., social networks) often cluster individuals based on age, e.g., across different platforms [2]. Our newly developed genre of gallery games, published under the umbrella OpenAirGalleryAR, are designed to serve as interactive experiences that foster cultural education (art, music, literature), intergenerational family engagement, as well as healthy walking habits. So far, there are five games in the series,[2] which run on common smartphones (Android and iOS). The games are intended to appeal to any age and be particularly compelling as collaborative experiences across generations. As Wang, Taylor and Sun summarize it: "Families that play together stay together" [3].

This paper is concerned specifically with the potential for intergenerational play and cultural engagement using augmented reality. We begin by discussing the nature of the intergenerational gap associated with digital technologies, then review existing work on intergenerational play experiences, covering theory, design and some actual experiences, before we present the design methodology for one of our OpenAirGalleryAR experiences, *Alice Dalí AR*. Finally, we present a user study of 42 adult-child pairs, which shows evidence of cultural engagement and increased intergenerational emotional bonding.

2. Motivation and background

2.1. The intergenerational gap in the digital revolution

Research has shown that intergenerational gaps are becoming the norm, even when one does not consider digital technologies and their

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[1] Download link: https://download.hauntedplanet.com/alice-dali.

[2] The others are *Synaesthesia Gallery AR, Jack B. Yeats: Psychogeography*, *De Chirico Metaphysical Art AR* and *Yokai: Japanese Ghosts AR*.

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associated modes of communication. Zhang and Kaufman observe that, "a large number of people, including older people themselves, see social disengagement among older people with young people as a natural part of aging" and highlight that 'ageism,' which is often used to describe negative attitudes towards older people, also covers "the negative attitudes that older people hold towards young people" [4]. Communication and understanding across generations suffers in both directions, which Zhang and Kaufman describe as follows: "Older people view young people as problematic, while young people find it difficult to imagine life of being old and perceive older people as frail and vulnerable, and view communication with them as less than satisfactory and problematic" [4].

At the same time, digital technologies come with their own challenges, in particular for older adults. Writing on the topic of computer anxiety and technology acceptance in older adults, Ypsilanti et al observe:

> In recent years, older employees have been introduced to new technological advances, creating a shift from traditional paper and pen use to computerized systems. Although this technological shift has promoted technological literacy in older workers, it has also been perceived as threatening to the individual. Research on cognitive testing using computerized tasks indicated that computer anxiety is more common among older participants compared to younger adults. [5]

Today, smartphones have become the ubiquitous communications device for the vast majority of people, and estimates indicate that 6.8 billion people own smartphones in 2023, amounting to 86.4 % of the world's population.[3] Smartphones are frequently given to children at the age of 10–12, and while possessing a smartphone has obvious benefits in relation to child safety (e.g., for children playing outside), there are also examples of how smartphones can increase difficulty in family communication and reduce engagement in conversation and attention between family members.[4]

A study by Hunt focused on the use of technology as an intergenerational communication tool and showed that "grandchildren play a moderate to significant role in grandparents' learning of technological devices" [6]. Hunt also concluded that her "study confirms grandparents' high level of satisfaction in the learning process, along with interest and desire to interact with grandchildren at the technological level" [6]. Such studies show that there is a genuine potential in, and clear benefit from, intergenerational communication in relation to digital technologies.

2.2. Intergenerational play: Social studies on games

A considerable amount of research has focused on the benefits of intergenerational play and its potential to help bridge the gap between younger and older generations. One review paper by Zhang and Kaufman observes that:

> Intergenerational segregation has become a social issue as many older adults enter seniors' facilities and communities, or live alone due to the death of a partner. Researchers have recognized the potential of digital games to facilitate intergenerational connections and learning. [4]

Nevertheless, communication and interaction between young and older people should (and do) play important roles in an aging society. The study also observes that:

> Interaction with young people can provide opportunities for older people to develop intimacy and to nurture [the] younger generation. Intergenerational interaction is a crucial means of exchanging knowledge, skills, information, ideas and values. [4]

There is evidence that non-digital games can be beneficial for intergenerational play, such as Hewett et al [7], who report on an intergenerational intervention in the form of a board game based on secondary data from a priory study, and Rice et al [8] who report on the board game design activity itself as an intergenerational intervention.

Based on their study of intergenerational play using digital games, Lankes et al [9] make specific recommendations in relation to game mechanics, including that games for this type of play should not be too demanding, and that technically more demanding tasks be allocated to the younger player, while cognitively demanding tasks be allocated to the older player.

Chua et al [10] also present evidence that game design matters. They conducted a study using titles not specifically designed for intergenerational play (e.g., Wii Sports) and found that there were intergenerational benefits, but these were no larger than other shared activities, and the benefits were higher for the older than the younger players.

Zhang and Kaufman emphasise that the roles of adults and children can be reversed when playing with digital games, since children generally take control of them. This may offer a refreshing and worthwhile experience for both generations. With this in mind, play experiences can be designed to facilitate the creation and/or strengthening of intergenerational bonds. Zhang and Kaufmann describe this as follows:

> A number of design ideas have emerged from reviewing these games, but the most important design consideration is emphasizing relationship formation. Previous empirical studies have shown significant effects of intergenerational play on positive perceptions towards the other age group [4].

Other studies concur with this view, such as a qualitative study by Agate, Agate, Liechty and Cochran in which they employed visual and text analysis to explore the importance of intergenerational play, particularly between grandchildren and their grandparents. The researchers mailed a questionnaire pack to 16 grandparents, each of whom was paired with a grandchild. The questionnaire used drawings as well as textual approaches to data collection to identify the motivations, functions/benefits, mechanisms, constraints and negotiations/affordances of intergenerational play. The researchers found positive results, observing that "[l]eisure with grandchildren provides grandparents with enjoyable experiences, opportunities to develop familial relationships, a sense of purpose, and a source of personal growth or satisfaction" [11].

On the topic of the intergenerational dynamic associated with play, the authors conclude the following:

> Because play is a meaningful developmental process for children and for older adults, intergenerational play may address the needs of both and allow each to reap the benefits of playful interactions. The grandchild–grandparent relationship is believed to be an important one. In such relationships, grandchildren often receive support and guidance and grandparents find meaning and pride in the opportunities for caring and mentoring [11].

A grandfather who participated in the study commented: "By cherishing time spent in play, we anchor ourselves together … We become bonded" [11]. The researchers observed numerous social benefits of intergenerational play including having fun, bonding, expressing love and interest in the other, making memories, getting to know each other, and teaching lessons. A particularly interesting observation reported by Agate et al was the "surprising finding of […] the hint at ethic of care in children from the grandchild participants. Ethic of care is the concept describing a person placing another's needs before their own" [11]. In this fashion, the study shows that grandchildren became aware of grandparents' physical needs. Such awareness has a clear social benefit

[3] https://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide/.

[4] https://www.theguardian.com/lifeandstyle/2019/may/14/phones-smartphones-mobile-phones-family-relationships.

for both generations and will likely create and/or strengthen intergenerational bonds.

While the benefits of *intergenerational* play seem clear, there are also benefits related to play *per se*. Agate et al highlight the importance of play not only in childhood but also into adulthood: "For older adults, play promotes health and well-being, particularly as it provides opportunities to develop relationships and experience positive emotions" [11].

Beyond social benefits, researchers have also found evidence of organizational value associated with the use of games for intergenerational learning. A review by Ypsilanti, Vivas, Räisänen, Viitala, Ijäs and Ropes discusses the use of intergenerational video games to help adults acquire new knowledge and skills and concludes that "serious games may be a potential tool to decrease skills obsolesce, and loss of critical knowledge within an organization," even though not many examples of such games existed at the time of their review [5].

A study by Costa and Veloso also explores how digital games can help promote relationships between children and adults. Their motivation is based on observations about changes in society, which affect intergenerational interactions:

> Challenges to family structure in an increasingly ageing but network society, decline in multigenerational households and mobility with grandparents and grandchildren living at least some geographic distance apart tend to affect the quality of these intergenerational interactions [12].

The researchers divide the interactions into two groups: those that are mutually beneficial and those that are individually beneficial. Mutually beneficial interactions are those that break with age stereotypes or ageist attitudes; develop civic engagement and contribute to an age inclusive society; and link the learning and leisure needs of both generations. Individually beneficial interactions are those that influence children's cognitive, social, and emotional development; provide children's and older adults' care, training, and contribute to their information literacy in a digital context; help to overcome disruptions of family (e.g. divorce); and give a sense of purpose and companionship [12].

Well-designed digital game experiences have clear benefits for the older as well as the younger generations:

> For older adults, they can improve cognitive functioning (e.g., short-term capacity, attention, hand-eye coordination); overcome communication problems and social isolation; and encourage physical exercising and prevent falls […] For children, digital games can improve learning, skill building, and healthy development; can encourage learning, exploration, experiment, and construction of knowledge; and can develop imagination and creativity. [12]

In addition to the benefits particular to each generation, there are also social, intergenerational benefits that are shared between the generations. On this topic, Costa and Veloso write:

> Digital games can also have a mutual value for both generations by encouraging communication, solidarity, and social connectedness between generations tear down some stereotypes, and probably reduce the gap between generations and the disparities in authority of (grand) child –(grand) parents' relationships [12].

While some sources lament the relatively few numbers of serious games designed for intergenerational play, the literature shows considerable agreement about the potential (and in some cases, proven) benefits of serious games for intergenerational play. Furthermore, the range of benefits is perceived to be wide and includes cognitive, physical, educational, social, health-related and creative benefits.

3. Related work

3.1. Game design for intergenerational play

Costa and Veloso's review discussed in the previous section presents a set of design recommendations for game-mediated environments intended to enhance intergenerational interaction and hence help address the challenges posed by their reported changes to family structure, decline in multigenerational households and increased geographical distance between grandchildren and grandparents. The recommendations are based on a literature survey that examined the frequency of each design priority in peer-reviewed papers. The researchers found that the following recommendations for designing intergenerational digital games were the most cited: (a) prioritize physical, mixed-reality games and multimodal interaction; (b) prioritize peer-to-peer mentoring, collaboration, scaffolding, and learning; and (c) enable social interactions, shared context, and meeting place [12].

For any practical approach to game design, it is of course important to understand which interactions are desired and what their effects are. Costa and Veloso's survey is also helpful in this regard by presenting the most-cited ways in which games can foster intergenerational interactions: (a) by enhancing social interactions between different generations toward a communal activity; (b) by contributing to individual well-being, prosocial behaviors, and sharing of knowledge; and (c) by balancing both users' skills and challenges [12].

Another survey by Hera, Loos, Simons and Blom presents a review of the benefits and factors that influence the design of intergenerational digital games. The authors found that the benefits fell into four main categories: (1) reinforcing family bond, (2) enhancing reciprocal learning, (3) increasing understanding of the other generation, and (4) reducing social anxiety [13]. These findings are consistent with those otherwise reported in the literature.

Hera et al also discuss the motivations to play digital games, including player-centric and game-centric factors. In the former category, the researchers identify three groups of factors of which designers of intergenerational games should be mindful: *Old-Young Interactions* describe support for asymmetrical play that allows the players to take on different but complementary roles, e.g., one participant acting as caretaker and/or instructor; *Motivation to Play and Game Preferences* highlights that older players tend to avoid reflex-oriented and violent games and also to adopt more passive and supportive roles, whereas younger players are (perhaps surprisingly) less adaptable than their older companions, and studies therefore suggest that priority should be given to the younger players; *Differences in Abilities* suggest that simple gameplay that is easy to understand for an older person, gameplay that combines chance with skills, and gameplay that involves short sessions can be used to cater for the differences in abilities between older and younger players [13].

In relation to game-centric factors, Hera et al [13] identify two groups of factors: *Goal-Related Forms of Interaction* describes that collaborative games in which both generations share the same objective are welcomed by both generations, but that a middle-ground in the form of cooperative competition are also useful, as they allow children to satisfy their competitive streak and show off their skills; and *Space-Related Forms of Interaction* shows that virtual collaborative games can foster more engagement than co-located competitive games that require less direct interactions, and that such games are welcomed by both generations.

In addition to the work discussed above, Chiong has also presented game design principles that can be followed to achieve desirable intergenerational interactions. Their recommendations include designing games that are intended for short-duration of play; that provide learning opportunities; that practice scaffolding; that accommodate interests from different generations; that enable asymmetrical and asynchronous play; and that create socially desirable reward systems [14]. These recommendations are consistent with Costa and Veloso and with Hera

et al.

3.2. Locative augmented reality and social play

Locative media can be defined as media in which the physical location of the audience (and the deliberate changing of this location) has a significant effect on the experience. As described by Haahr, locative media has existed since the early 2000s, but it was only the widespread adoption of GPS-enabled smartphones that began in the late 2000s that allowed locative media to transition from short-lived art and media experiments or pure performance pieces to become a mass medium [15]. Hence, while locative media experiences have existed for over two decades, it is only within the last decade or so that they have become available to general audiences.

Locative games can be considered a particular type of locative media in which game mechanics based on physical location play a significant role. Within the last decade, blockbuster titles like *Ingress* (2013) and *Pokémon Go* (2016) have made locative games familiar to the mainstream, but already in 2009, de Souza e Silva and Sutko wrote in their book *Digital Cityscapes*: "The convergence of smartphones, GPS, the Internet, and social networks has given rise to a playful, educational, and social media known as location-based and hybrid reality games" [16].

It is clear from our earlier sections 3 and 4 that the locative smartphone game is a potentially promising platform for intergenerational digital games. In particular, Costa and Veloso specifically mention "physical, mixed-reality games and multimodal interaction" as the first of their design recommendations [12]. Furthermore, of the desirable game-related benefits identified by the literature and summarized at the end of section 3, a significant number (cognitive, physical, health-related benefits) seem straightforward to offer through a locative game, and the remainder (educational, social and creative) are in no way incompatible with the genre.

In a 2015 book chapter, Haahr offers an analysis of locative games, including a discussion of their game mechanics and narrative potential [15]. Analyzing four prominent titles, *Parallel Kingdom*, *Shadow Cities, Ingress* and *Haunted Planet,* the chapter shows how locative game mechanics vary considerably across titles, ranging from exploration to territorial conquest, and that the narrative potential across the different types of locative games also varies considerably in nature as well as expressive power. The chapter also shows how social and community aspects are key draws for many players of locative games.

Focusing on a single title, Mayra and Lankoski describe their experimental location-aware game *The Songs of North*, where "the players took the role of a northern wizard with the ability to interact with spirit world" [17]. The authors emphasize the significant role of soundscapes in the game's design "'so that one could play it only by listening to what is happening in the game world by using headphones or phone's built-in loudspeaker." While *The Songs of North* was not specifically designed for intergenerational play, the design recommendations observed by Mayra and Lankoski resonate with the design recommendations summarized in the previous section, such as allowing different modes of gameplay to support various player types as well as supporting free communication between players. Important for a locative game, one recommendation was to "ensure that movement will not become too much of a burden to the players" [17].

Diamantaki, Rizopoulos, Charitos and Tsianos describe their multiplayer game *LOCUNET* as a collaboration/competition game in which the participants, equipped with mobile GPS-enabled devices formed two competing teams. To win points, players of *LOCUNET* must collaborate with their team members to collect and bring a game object to the HQ (home). The game's collection mechanic allows a player who is within five meters of a game object to collect it. Collecting an object changes the player's avatar to that of suitcase-carrying emoticon in order to reflect that the game object is in the player's possession [18].. Discussing the social aspects of their design, Diamantaki, Rizopoulos, Charitos and Tsianos note that,

> the fundamentally social character of play has been hinted at by several authors… Simmel (1949) views 'sociability' as a playful activity, 'a social game' that exists for its own sake for the satisfaction drawn from the game itself [18].

While there are different approaches to locative game design, there appears to be agreement between game designers that social aspects are particularly important for this game genre. This resonates well with our findings from section 3 in which we concluded that this aspect is also important for intergenerational digital games.

4. Design methodology and implementation

4.1. Multisensory design and the synesthesia model

In informal use, "multisensory design" (MSD) is sometimes used simply to mean design that appeals to the senses, but when used scientifically, it means design based on the Interaction of Senses Theory based on a model of Synesthesia, which is a wiring of the brain that creates sensory pairings, e.g., color to pitch or taste to sound [19]. Synesthesia demonstrates enormous diversity of perceptions, and more than 80 types have been registered. Research has shown that people with Synesthesia are more aware of such sensory pairings due to stronger connections in their neural system [20]. There is evidence that the brain of a newborn baby is cross-modal and all infants have a form of synesthesia [21]. While synaesthetes only represent 4–6 % of adult humans, "a growing body of empirical research on the topic of multisensory perception now shows that even non-synaesthetic individuals experience cross-modal correspondences" [22].

The Synaesthesia model has been used in the areas of Sensory Substitution Devices (SSDs) [23] and multisensory approaches in Human Computer Interaction (HCI) [24] research. However, there is little work on how to map one sense to the other, or how to produce designs where the natural synchronisation is attractive to the majority of people. Synesthesia experiences are subjective and involuntary, but it has been shown that synaesthete-designed animations are more appealing than those designed by non-synaesthetes [21].

Lupton describes MSD as follows: "Reaching beyond design's traditional focus on vision, **multisensory design** incorporates the full range of bodily experience […] The brain combines input about taste, smell, temperature, and texture to create 'flavor'" (original emphasis) [25]. Velasco and Obrist observe that considerations of multisensory experiences as per technological advances is the future of design [24]. For example, Haverkamp has applied an MSD methodology for automotive design for the Ford car manufacturer [26]. Three books exist on multisensory approaches based on a Synesthesia model: one on industrial design [26], one on product design [27] and Velasco and Obrist's book on technology-based multisensory experiences (including AR/VR) [24], which addresses the importance of sensory input but does not present a design methodology.

There is also evidence that multisensory perception stimulates the brain. As Ramachandran and Hubbard point out: "Synesthesia causes excess communication among brain maps […] towards linking seemingly unrelated concepts and ideas—in short creativity" [28]. Research shows that synesthesia-enhanced applications have promising potential for education and mental health programs, such as Bor et al's experiment to train non-synaesthetes for color-grapheme synesthesia, which showed an IQ improvement and provisionally concluded that "cognitive training including synesthetic associations may in the future be a promising new tool for vulnerable clinical groups to enhance general mental ability" [29].

4.2. The gallery game: An experience for intergenerational play

In this section, we present the design of *Alice Dalí AR* (2022), the

third installment in our series of 'gallery games,' which are locative art and music experiences based on Augmented Reality (AR) that can be experienced outdoors, e.g., in a park or other open area. The gallery games run on modern smartphones (iOS and Android) and can be downloaded from the respective app stores.

The design of *Alice Dalí AR* is adapted from our earlier games, such as *Viking Ghost Hunt* [30] and *Bram Stoker's Vampires* [31]. While doing informal playtesting with these earlier titles, we observed frequent intergenerational play, even though these titles were not designed for such play *per se.* These anecdotal observations prompted the work on *Alice Dalí AR* and informed the design. While we retained the game mechanics of the earlier titles, we made important changes to story, art and music in order to facilitate intergenerational interaction during the shared play experience. The resulting design was intended to test our hypotheses that the games were suitable for intergenerational bonding (as we had seen anecdotally) and that they could be used to foster cultural engagement through intergenerational play. For example, if a parent and child (or grandparent and grandchild) play together in a park, the younger generation could help the older with the use of technology and game mechanics, while the latter could ensure safety and provide additional cultural context for the art, music and story that form the core of the experience. This section documents our design methodology for the experience, including its intended play scenarios and expected benefits.

The gallery games – appearing under one umbrella that we call Open Air Gallery AR – exist as a counterpoint to traditional (physical) art galleries, which are indoor spaces typically without music. Like traditional art galleries, the gallery games may be experienced individually or socially, but the experiences really shine when played with others. The concept is intended to be a novel experience for families, i.e., as a collective experience for group cultural entertainment. To our knowledge, it is the first time an art gallery has been offered as a locative game.

The gameplay is based on four core game mechanics: navigation/exploration, search/scan, capture/collection and review. The gallery games contain four corresponding game modes, one for each of these activities. A typical play experience is structured as follows: The audience (player) uses the Map Mode (an overlay on Google or Apple Maps) to orient themselves and to perform coarse-grained navigation of the terrain. They then use the Radar Mode (a digital representation of a naval radar) to locate a nearby music art encounter and approach it by navigating physically through the terrain. As the player approaches the music art encounter, a soundscape begins, featuring a music episode with narration. Once the player is very close to the music art encounter (within 10 m), they can switch to the Camera Mode (a modified camera function) in which they can see the artwork floating in the air. In the final action, the player photographs the artwork, and the resulting photo is stored in the Casebook, the final game mode in which further details about the art, music and narration is revealed. This play loop is repeated as many times are there are art music encounters in a given gallery game. For gallery games with more than 5–6 encounters, the encounters are grouped in groups of three or four, and completing one group unlocks the next. This allows the play area to remain relatively small without cluttering the Radar Mode with all the content at once and thereby overwhelming the player. On completion of the gallery game, the player can choose to have their photos and the textual descriptions from the Casebook emailed to them.

Alice Dalí AR (2022) is the third gallery game in our series. The game, shown in Fig. 1, is based on the iconic story *Alice's Adventures in Wonderland* by Lewis Carroll as well as paintings by Salvador Dalí who illustrated the famous book in 1969, producing one illustration for each of the twelve chapters. Original music was composed on the artworks (discussed in detail in the next section) and overlaid narration of extracts from Lewis Carroll's book.

The game is designed for the average family: children aged 4–12, parents and grandparents. As mentioned earlier, the story, art and music are specifically chosen for this purpose. Lewis Carroll's books about Alice are loved by children and adults alike, and through engagement with the iconic story, our digital experience evokes childhood fantasy worlds for all generations, appealing to parents' or grandparents' own memories from when they were young and the 'real' fantasy worlds experienced by children. For young players, the experience also serves as an introduction to the famous surrealist's works and thereby as a rewarding educational experience of art. The experience of outdoor play, of searching for (and finding) music, art and story is intended to be rewarding for all age groups.

We applied a multisensory design methodology based on synesthesia in which Dalí's art shapes, characters and colors were interpreted musically. The composer transferred the emotional charge of the paintings into sounding musical textures and classical music genres (e.g., march, dance and song). In our working hypothesis, multisensory synchronization of audio-visual design in digital applications, would not only magnify aesthetic appreciation, but possibly also stimulate the brain to think creatively.

For this reason, music plays a very significant role in *Alice Dalí AR*. As

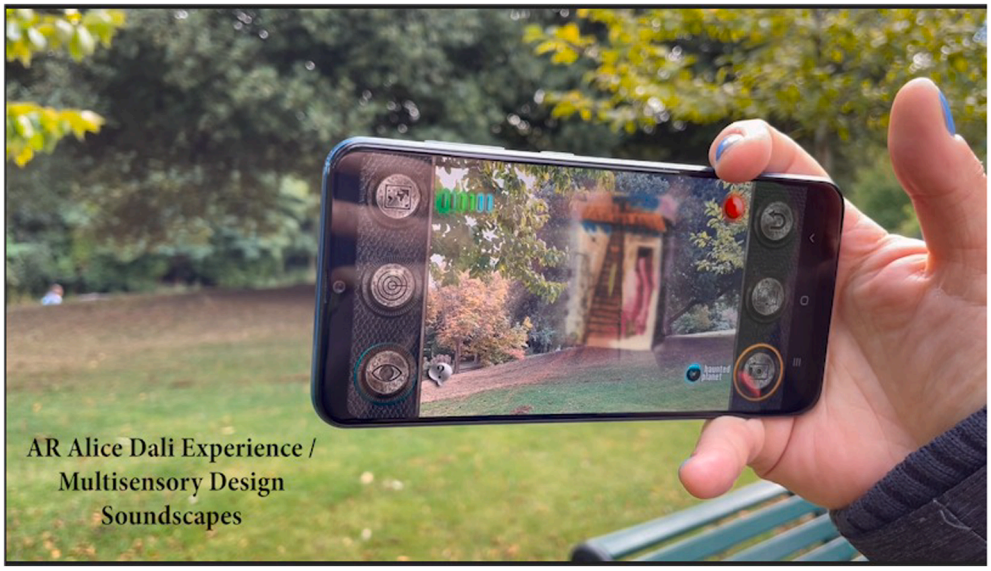

Fig. 1. Alice Dalí AR – Chapter 4 ("The Rabbit sends in a little Bill") – Action Shot.

described, the soundscape starts in the first stage of reaching the music art encounter while walking, i.e., before the artwork itself becomes visible. In this fashion, the music serves to prepare the player/audience for the atmosphere of the art image by providing emotional engagement (through music) before the encounter is seen. The idea of translating the art expression into music has further potential than we explore in this paper, such as in our other gallery game *Jack B. Yeats: Psychogeography,* which we have approached as a type of Sensory Substitution Device (SSD) in which the direct translation of art expression into music with narrative allows a new type of shared aesthetic experience for blind people when accompanied by a sighted person on a walk [23].

In designing *Alice Dalí AR* as an intergenerational game, we placed particular value on the social aspects of a family playing together and having a shared aesthetic experience of music and art. The experience is designed to offer a shared and collaborative experience during play, but the ability to share the record of the play experience (photos and text) also allows a family to save their photos on their device or print them out as a souvenir, a memory of the location and the time. This becomes particularly interesting if players (as we have seen anecdotally) pose with the art images while the photo is taken.

On the topic of play experiences, Mayra and Lankoski observe:

> In games and play, human experiences are organised in a particular way. This framing is a starting point that underlines the specificity of play experiences and is closely related to the "magic circle" – a concept first introduced in Johan Huizinga's *Homo Ludens* (1938/1955) and later established as the key concept to address the boundaries that separate games from the "ordinary life." [17].

Through its design, the gallery game creates a "magic circle" of art and music in the chosen area of play; it lets players expand their experience of a walk in the park into an augmented reality cultural experience. For the duration of the gallery game, the play area becomes an area of fantasy and imagination, of art and music, a journey into Alice's magical storyworld.

Earlier in this section, we discussed the use of *Alice Dalí AR* to introduce children to the works of the famous surrealist. In a similar way, younger players are also introduced to classical music through the piano music composed on Dalí's images. Furthermore, younger children in the age group may not yet have read Lewis Carroll's book, and while they may be familiar with Alice as a character (e.g., from the Disney film), the game may also motivate them to read the book later on. To teach children to appreciate culture, music and art is the goal of many families, e.g., to teach emotional intelligence through art and music. Writing from the perspective of Psychology and Consciousness studies, Carroll E. Izard expresses this as follows: "Emotions play a critical role in the evolution of consciousness and the operations of all mental processes" [32].

4.3. Composing for augmented reality: A multisensory approach

In *Alice Dalí AR*, the Augmented Reality view is used to show an additional fantasy world – the source of learning, entertainment, and fun – on top of the real world. While many people associate Augmented Reality primarily with visuals, we prioritize audio as highly as visuals, and we are augmenting the soundscape of the real world with music and narration in the same way that we are augmenting the visual backdrop of the real world with art. Paterson et al have written on this hybrid approach to AR sound design, and (using a design based on sound effects rather than music) found that the audio played an important role in immersing the player within the game space as well as fostered emotional engagement with the virtual world [33].

In *Alice Dalí AR,* short music soundscapes on art (around 2.30 min each) are composed to be a summary with distinctive music genre (march, dance or song) to give a grasp of the art's essence and emotional charge. The narration (voice) creates dialogue with the piano part. In the following, we describe the composition process. Due to space constraints, we will focus on three chapters: CH 1 (Down the Rabbit-Hole), CH 7 (A Mad Tea-Party), and CH 8 (The Queen's Croquet-Ground). We will discuss the general structure of leitmotifs/characters with symbolics of Dalí.

In his 12 illustrations for *Alice's Adventures in Wonderland,* Salvador Dalí created the stylistics and art composition in his characteristic surrealist style. The composer (Svetlana Rudenko) perceived Dalí's art emotionally, in an attempt to hear what he saw in Alice's story, reflecting not only on verbal content of Lewis Carroll's book, but also on the atmosphere of Dalí's paintings and the perception of the characters musically – to transpose the experience of one sense (in this case, visual) into another (audio, music). This is the main principle of multisensory design: to be able to view information through/with another sense. It is also the main principle of creativity: the ability to see new combinations, hitherto unknown and out-of-the-box solutions.

Louise Harris, audiovisual composer, University of Glasgow, describes process of "thinking audiovisually" [34] for digital music. She points to elements of audiovisual composition:

> […] consideration of the elements of the composition process as it exists within music, visual art, film, photography and dance. It will then look to find ways to reconcile these elements into single set of characteristics for consideration in audiovisual composition [34].

CH 1 ("Down the Rabbit-Hole") is a waltz in E-flat major ¾ time, influenced by Alice's encounter with the Rabbit in a suit (as described in the novel). As shown in Fig. 2, Dalí's Rabbit is not wearing a suit (and hence is more 'real'), but the music evokes the idea of a dance and therefore a Rabbit that can speak and dance. Dalí places Alice on a mushroom, making us wonder if the Rabbit's dance is real or hallucinogenic. The waltz becomes Alice's leitmotif for the whole cycle and appears in CH 5, CH 6 and CH 8 fragmentarily as a reminder of the CH 1 encounter with the Rabbit. The melody, Alice's melody, is not consistent, with some notes 'out of tune,' imitating a child's manner of speaking with jumping from one subject to another and mixing extracts of conversations. Alice's second theme appears in CH 2 ("The Pool of Tears"), but it is in A minor, also in ¾ time but not a waltz. (See Fig. 3.).

CH 7 ("A Mad Tea-Party") is in the Habanera genre, 4/4 time and D-minor key. The absence of a developed melody in the first four bars symbolizes the surreal 'tea- party' with soft clusters as a shadow of voices. Dalí's iconic depiction of Alice with a skipping rope is present in all 12 illustrations. (See Fig. 4.) It is characteristic that Dalí's Alice is a young girl on the verge of becoming a woman, whereas in Lewis Carroll's book, she is only seven years old. Perhaps Bizet's Carmen is another female archetype which influenced the choice of Habanera, as well as a metric pace matching with a melting clock of Dalí. Time is a subject of Dalí's investigations in many of his works. Here in music, it is presented by metric ticking quarter notes with triplets in the accompaniment, which are in a higher register – some reminiscences with butterflies, as to give the feeling that Time is always running, always fluid. The theme in the lower register is repetitive suspension, nearly warning: Time cannot go back!

CH 8 ("The Queen's Croquet-Ground") features the Queen's threatening theme, which is in 4/4 and E-minor ('Off with their heads!') and reflects on the characters' pace, walking in procession. In Dalí's painting, two cards have long shadows with feathers as a reminder of the Greek mythical creature the sphinx (interpretation of author) and two other shadows in the position of 'gossiping.' The Alice and Rabbit waltz theme appears again in F-major, manifesting to the Alice Nocturne in D-minor/A-minor and empathy to such a 'terror.' The music scene finishes with the game of croquet in D-major. In Dalí's painting, he left an enormous field desert with dominating shadows of the play.

The whole music album of *Alice Dalí AR* is available on Bandcamp and during the game experience.

Fig. 2. Alice Dalí AR – Chapter 1 (“Down the Rabbit-Hole”) – Player Photo (Central Park, NYC, USA) (Played in “Random Mode”).

Fig. 3. Alice Dalí AR – Chapter 2 (“The Pool of Tears”) – Player Photo (Botanic Garden, Durham) (Played in “Staged Mode”).

5. Results and discussion

We designed a user study to test our hypothesis that using *Alice Dalí AR* for intergenerational play would have beneficial effects on cultural engagement, interaction, and familial bonds. The game was staged in the Botanic Garden at Durham University, and data was collected over a period of two days, 24–25 February 2024. Ethical approval was granted prior to data collection by Durham University Music Department’s Ethics Committee. Each of the 12 art music encounters was staged in a chosen location that resonated visually with the chapter material. For example, a small pond was chosen as the location for Chapter 2 (“The Pool of Tears”); giant ant sculptures were chosen as the location for Chapter 3 (“A Caucus-Race and a Long Tail”) due to the presence of fantastic animals; and the location for Chapter 5 (“Advice from a Caterpillar”) was chosen such that the Botanic Garden’s iconic mushroom sculpture would appear in the AR view along with the painting.[5]

A total of 42 adult-child pairs were recruited for the study. To manage data collection more efficiently, each pair signed up online for a designated time slot in advance of participation and were asked to download the app to their own smartphone prior to arrival at the Garden. Each pair played the game together on a single smartphone. Upon arrival, adults gave informed consent on behalf of themselves and their associated child. Each pair were given two sets of wired headphones and a cable splitter to allow them to hear the music clearly and in sync. They

[5] A full list of sample photos is available here: https://api.hauntedplanet.com/casebook/show?uuid=4392a428-c7a6-456d-801c-7d033fc50796.

Fig. 4. Alice Dalí AR – Chapter 7 ("A Mad Tea-Party") – Augmented Reality View (Botanic Garden, Durham) (Played in "Staged Mode").

then received instructions (see Appendix B) on how to use the app and were shown how to navigate by the app's Radar Mode and how to find the first art music encounter. They were then sent on the path to explore the Botanic Garden and find the remaining 11 encounters on their own. After completing the game, each pair completed a questionnaire (see Appendix A) and were rewarded with a drink in the Botanic Garden café. An additional handful of visitors to the Garden also tried the game without having signed up to the study; they did not complete the questionnaire and were not included in the dataset reported here.

5.1. Questionnaire design

Basic demographic information was collected, specifically the age and gender of both the child and adult and their relationship (e.g. parent–child), and both the adult and child rated their previous amount of experience in playing outdoor AR games (with *Pokémon Go* provided as an example). Subsequent questions probed their previous knowledge of the Dalí paintings, whether they would like to see the actual paintings, and their enjoyment of the game (including which specific aspect they enjoyed most, with separate sub-questions directed toward the adult and child). Both the adult and child were asked if they helped their partner, and if so, an open-ended question probed for more detail on the specific helping behaviors. They were asked if they would play the game again as is, as well as using a different story on a subsequent trip to the Garden. The Inclusion of Other in the Self (IOS) scale was used as a validated measure of interpersonal closeness [35]. Specifically, we asked adults to rate how connected they felt to the child when they arrived at the Botanic Garden, and then how connected they felt to the child after playing the game on a 7-point pictorial scale. Finally, we examined the degree of interaction between the pairs in relation to the story, art, and music via rating scales, and the questionnaire ended with an open-ended question where participants could leave any further comments about their experience of the game. The questionnaire was completed via Qualtrics online survey platform on a tablet by the adult from each pair, with input from the child for the relevant questions. The median completion time for the questionnaire was 14 min.

5.2. Quantitative results

Table 1 shows a summary of the demographic characteristics of the sample and a comparison of key results across the two groups (children and carers). Carers were primarily parents (93 %); the remaining three carers were one grandparent and two parents of a child's friend.

From the questions related to Dalí's paintings, 71 % (30 pairs) did not know Salvador Dalí had painted *Alice's Adventures in Wonderland,*

Table 1
Group level demographic and descriptive statistics.

	Children	Carers
Mean age in years (range)	7.8 (4–12)	43.5 (34–68)
Gender	18 female, 23 male, 1 other	29 female, 13 male
Experienced in playing outdoor AR games	79 %	55 %
Most enjoyed game aspects	1. navigating by radar (43 %) 2. seeing the paintings (29 %)	1. seeing the paintings (38 %) 2. navigating by radar (33 %)
Helped their partner	83 %	71 %
Most common helping behaviors	1. navigating by radar (83 %) 2. taking photos (20 %)	1. navigating by radar (20 %) 2. using/holding phone (12 %)

and 69 % (29 pairs) responded they would like to see the original paintings. These results suggest that that the experience was **educational** and that it supported **continuing cultural engagement** by fostering interest in Dalí's paintings.

In relation to the **interactivity and design** of the experience, children's most enjoyed aspects of the game were navigating by radar and seeing the paintings, whereas carers showed the reverse pattern (see Table 1). Pairs were also asked to rate how much they talked about the art, music, and story during the experience. The modal response to all three questions was "a little" (2 on a 5-point scale), but paired-samples t-tests showed the participants talked significantly more about the music than the art or story (ps $>$ 0.03), with no significant difference in how much they talked about the art versus the story (see Fig. 5). In addition, 62 % (26 pairs) reported that they liked the AR game more than a typical walk in the Botanic Garden, while 17 % (7 pairs) liked it about the same. 69 % of the pairs would play the same AR game again in the same location, and 90 % would play again with a different story.

These results show that the children as well as the adults enjoyed interacting with the AR experience, and that there is considerable interest in interacting with similar (and even the same) experiences. While this study did not attempt to measure the health benefits of walking, gallery games seem promising in that they can retain players' interest and perhaps that way can help encourage healthy walking habits.

1. In relation to **intergenerational play**, the majority of partners helped one another, and most often this occurred in relation to navigation via the radar (see Table 1), although several of these comments suggested the children took a leading role while the adults

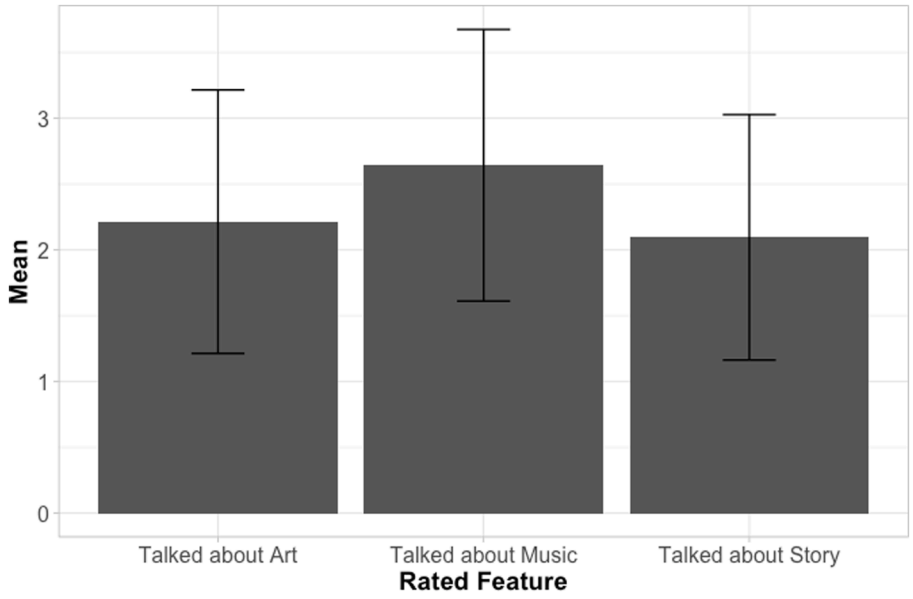

Fig. 5. Mean ratings of how much each pair talked about the different game elements (error bars represent +/-1 standard deviation).

provided support for this task (e.g., "Helped them understand how to use radar to look for art pieces," "corrected navigation"). In addition, adults felt significantly more connected to the child after playing (M=5.45) as compared to before (M=4.79), $t(41) = 2.47$, $p = 0.02$, as indicated by their ratings on the Inclusion of other in the Self scale.

These are perhaps the most encouraging results of the study. It is clear that the game supports intergenerational play as hypothesized. The numbers show that role-switching took place, supporting Zhang and Kaufman's observations [4]. It is particularly encouraging that such a high proportion of the children helped their adult and vice versa, which supports Costa and Veloso's observations that digital games can encourage communication, solidary, and social connectedness and also reduce disparities in authority [12]. The finding that the adults felt more connected to their child after the shared experience supports the hypothesis that emotional bonding took place.

5.3. Qualitative results

The following comments were made by the participants in the user study:

2. "My 6 year old really liked it and could do it on his own."
3. "Really enjoyed the experience. It was great and very interactive. I'd highly recommend this to anyone. Wireless headsets would be beneficial."
4. "We really enjoyed it. We found the music really helped to set the scene. The images could have been a little larger and clearer but other than that it was great."
5. "Thought the idea was great, a few issues with overlapping over stories and finding some of the latter paintings, but really enjoyed it. Lovely to see the art work and hear the literature and in such lovely surroundings. Would love to see more things like this at the botanic Gardens."
6. "My child said that he enjoyed this activity a lot and would do it again. He said that he enjoyed it more than a normal walk. He loves anything to do with tech so I thought he would enjoy this experience. Thank you"
7. "The best hunt ever, quote from child"
8. "We really liked the music. We had a lot of fun and we enjoyed working things out together."

The comments show support for the hypothesis that the game encouraged **cultural engagement** with art, literature and music, as well as **interaction/cooperation** between the pairs.

It is worth noting that comment 2 indicates that *Alice Dalí AR* can also work as a single-player experience. As discussed in section 4.2, the story, art and music for *Alice Dalí AR* were specifically chosen to support intergenerational play, but the game mechanics were taken from our earlier titles for which we had observed intergenerational play anecdotally, but which were not specifically designed for this purpose. Hence, while the *Alice Dalí AR* does have benefits as a result of intergenerational play, we can only expect such benefits if the game is played in a collaborative fashion.

There were, as one might expect, also a few critical comments, primarily in relation to technical problems as a result of people using their own smartphones. For example, the Android version of *Alice Dalí AR* did not work equally well on all Android phones. The issue of "platform fragmentation," i.e., the differences between the many thousands of different types of Android phones makes this a well-known challenge for software developers on this platform.

6. Conclusions and future perspectives

In this paper, we have presented the design and evaluation of the gallery game *Alice Dalí AR,* an outdoor interactive art/music experience for intergenerational play. Our study showed that the experience is conducive to intergenerational bonding through the sharing of music, art and story; and it clearly stimulated interest in all three. Our study focused on the game's use in a collaborative context and did not consider its potential benefit as a single-player experience.

Many games exist that are not primarily designed for intergenerational play, but which may nevertheless have such potential. As discussed earlier, research exists on gameplay that can support this type of play, but there is not yet a classification system to help analyze a given game to assess its potential for intergenerational play. This could be a useful area for future work, especially since not all games, as shown by Chua et al [10], have this potential.

The vast majority of digital experiences available today encourage interaction in (and with) virtual spaces, but *Alice Dalí AR* uses a real environment to serve as the game's magic circle, merging the real and the virtual. A large source of inspiration for our work was the many walks taken during pandemic and a feeling of nostalgia for cultural

activities that were closed due to the lockdown, such as galleries, concerts, and museums. While we did not evaluate the game's potential benefits in relation to healthy walking habits, it seems reasonable to believe that the app also has some potential in that regard, which we will explore in future work.

As discussed, multisensory design plays a key role in the design methodology of *Alice Dalí AR,* and also in the other experiences in the OpenAirGalleryAR series. In this paper, we focused on intergenerational play, but in the future, we will focus on evaluating the specific effect of this design methodology in providing a stimulating environment for entertainment and learning as well as a pleasing aesthetic experience to support interest and engagement. In addition, we think there is potential in relation to multisensory stimulation and the role it has been shown to play in relation to creativity. For example, such activities directed to multisensory stimulation of the brain could form more established neuronal pathways to "cross-talks" and creative minds.

Augmented Reality experiences allow a hybrid reality of imaginative and real experiences to merge, to extend a fantasy world into the real, training the brain to "see" more. In this sense, digital technologies may facilitate creativity training, in our case augmenting your walk into a cultural gallery excursion. The result is an experience that integrates multisensory design into an engaging game experience. When the emotional response is shared between adult and child, it strengthens a bond.

CRediT authorship contribution statement

Mads Haahr: Writing – review & editing, Writing – original draft, Supervision, Software, Methodology, Conceptualization. **Svetlana Rudenko:** Writing – review & editing, Writing – original draft, Investigation, Conceptualization. **Kelly Jakubowski:** Writing – review & editing, Supervision, Methodology, Investigation, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.entcom.2024.100865.

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