IT IS MORE THAN WHAT MEETS THE EYE

Exploring Immersion & Co-Experience in Holographic Art

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Abstract

With the growing interest in digital ways to experience art exhibitions, HCI and especially experience-centred design research have in recent years begun to show promising results when implementing holograms into the social dynamics found in art exhibitions. However, as to why holograms can enhance engagement and immersion, more research can be done. This thesis seeks to explore holograms’ unique characteristics through an iterative experience-centred approach through the theoretical lens of Flow and its ability to prompt for co-experience. In two studies with eight participants, a design workshop and a mini-exhibition, we uncovered four unique characteristics and two takeaways regarding its potential to design for co-experience. The results indicated that holograms were perceived as immersive and presented properties related not only to the hologram but also the environment, as to why. It was concluded that even though holograms can benefit art exhibitions, the social aspects could be explored further.

Keywords: hologram; art exhibition; co-experience; experience-centred design; immersion; affective affordance; Flow; HCI; digital arts.

1. Introduction

British artist and also the first to employ holography as a medium to communicate art, Margaret Benyon, stated that "Too much of the true creativity of our time has gone into science and technology. It is up to the artist to change these state of affairs" (Benyon, 1973, p. 8). While this bold claim was written 47 years ago, as from when this thesis was published, it still applies to today’s issues between the art world and the technological world. As of late, plenty of advancements have happened ever since then in favour of art and expressive means; it addresses desires, demands and voices about how artists, exhibition facilities and visitors seek new ways of consuming and visualising art. We entered the new digital age several years ago, and whilst the means for creating digital art has expanded dramatically, with tools such as Clip Studio Paint, Autodesk Maya and advanced video cameras, the measure to visualise them has remained relatively dormant. The development of high definition screens is in constant improvement, but the basis for using them is the same; a flat, two-dimensional surface on which to view various media. With augmented reality (AR) and virtual reality (VR), we have progressed towards new and creative ways of displaying creations, though we are still bound to a screen, often small, that shows us the work or, with VR, to an enclosed virtual world. They act as windows that restrict us from viewing the artwork freely, an imaginative layer atop our world rather than a part of it (Hornecker & Buur, 2006). Rather than us being bound with means to see, let the art present itself to us.

Like a sister to AR and VR and an alternative to a two-dimensional screen, holograms can allow us to experience art in a new light. As with the quote presented initially, Benyon (1973) had explored the exceptional qualities with the medium for artistic purposes. However, since
it is such an old article and with versions of holograms that, as compared to our current state, were unexplored and not optimised for said purpose, she merely expressed the technological opportunities and artistic desires; “...a powerful way of affecting human sensory response” (Benyon 1973, p. 4). While reflecting on the artistic value of the technology, she also makes connections to how it would benefit the future of HCI, meaning now, due to the rise of computing systems and the need to understand its usage. With this, she explains how important it is for technology to grow alongside art in more than just one direction. “The work of art is complete only as it works in the experience of others than the one who created it... the product of art is the connecting link between artist and audience.” (Dewey, 1934).

In art exhibitions, likewise, technological measures have been used for many years now and are desired by the visitors as well effective regarding its experiential and engaging properties. Several examples are presented in this thesis, but they collectively state that integrating visualisation technologies has enhanced the experience amongst visitors in positive ways since it utilises natural “interactions” (Ryong Kim et al., 2019). This is due to our constant interaction with technology in everyday life, and it is believed that in exhibitional contexts; controlled environments that act as pockets of contemporary experiences of art, holograms can act as a familiar breath of fresh air; our reality becomes an augmented reality (Pietroni et al., 2019). Subsequently, they have also shown that holograms in art enrich visual expression and figuration as well as it enlarges the limitation of many branches of new digital art (İşik, 2014), meaning that whilst the focus has been on the exhibitions and the museology, it had provoked secondary aspects regarding this.

1.1 Purpose & Research Questions

Many attempts have been made to visualize art using technology in exhibitions, many of which have been successful. However, making these technologies perform in favour of art is challenging in terms of the experiences to be achieved and the visitors’ expectations. AR and VR have proven to be very useful but somewhat niche and with properties that can clash regarding what one wants to achieve experience-wise. With the complexity but desirability of technological usages, exhibitions will need to explore new ways of visualising digital art; to create entirely new experiences for people to have (Bell, 2002; Song et al., 2015; Huang & Tsau, 2018). The method of doing so can be intricate, with technology being accessible and developed yet limited. One could be inspired by the results from AR and VR techniques, as we enquire with this thesis, and proceed from there with what we want to understand. By combining the knowledge about these technologies with the desire to know more about the experience and appreciation when interacting with them (Poretski et al., 2019) in social environments, such as exhibitions, we can provide holistic knowledge about the properties of holograms and direct the usage of it towards successful implementations. We hope to contribute with knowledge through contextually informed theories to broaden the desired experiential understanding of holograms and their social usage in the exhibition; to shorten the gap between the arts and HCI (Blythe et al., 2006).
Then, our thesis seeks to study the unique characteristics of holograms from an experiential standpoint and how it then can be applied in the social context of art exhibitions. To explore this, we aim to answer these two research questions:

*What are the experiential characteristics of holographic art?*

*How can we inform the design of holographic art exhibitions?*

To answer these questions, this thesis takes an explorative, iterative, experience-centred design approach to explore how holography can be understood in the context of exhibitions. The aim is to provide an in-depth understanding of holograms' unique characteristics for future designers and artists to utilise. Based on the findings, we discuss how holograms can inform future technological exhibitions.

### 1.2 Holography & “Holograms”

This section will present a brief overview of the history of holography, its technological complexity, alternatives of the technology and an example of modern development.

According to Ambs et al. (2005), holography is the scientific practice for optical technology, to put it simply, for making holograms. The word comes from the two Greek words of *holos* and *grafè*, which roughly translates to “whole picture” and has been a part of visualisation and optical technology since 1948, when it was theoretically discovered by the Nobel prize-winning Hungarian physicist Denis Gabor.

To briefly summarise, excluding complicated physiological terms, holography is a real-time recording visualisation technique that uses coherent laser light for “wavefront reconstruction” of an interference pattern to reproduce a three-dimensional light field. To reconstruct this, one needs a laser beam projecting the desired object through a recording medium (e.g. a semi-transparent mirror) onto a photographic plate (a glass or plastic plate) through which the viewer can observe the reconstructed image.

Ever since, the advancement of holography has been expanding, theoretically, within that field, though the technology itself is rather underdeveloped and inaccessible regarding its applicability to modern-day usages, such as in exhibitional contexts. However, a similar optical technological method has been used to replace “actual holograms” in such or similar contexts to achieve holography generates; lenticular display technology (LDT). Unlike holography, this technique uses simple lenses, which holography emerged from by eliminating that specific factor, portraying an image; moving and static (Pietroni et al., 2019). Since the results of both technologies are essentially equal, actors outside the physicist practice have been able to produce “holograms” to the extent that has exceeded the actual limitation of the original usage thanks to the accessibility of LDT. It is, however, crucially important that one does not perceive them as synonyms even though they produce a similar outcome. For our thesis, we will use LDT techniques during our data gatherings, as many other studies also have done (Pietroni et al., 2019; Ryong Kim et al., 2019; Caggianese et al., 2020; Pollalis et al., 2017), but our focus will be on the experiential qualities and how it can be applied in exhibitions. As stated above, since holography is such a complex technique to manage, LDT has been an optimal
replacement to study the desired outcome in a more accessible way with just as a satisfactory result, if not even better (Pietroni et al., 2019). We will refer to any images as a hologram for ease whilst reading.

To give some examples on techniques as well as some of the latest developments within LDT, Pepper’s Ghost is the oldest, the most common and the most explored manner of hologram production due to its accessibility, the time it has been in use and its creative freedom and efficiency in especially performance art (Song et al. 2015). In short, Pepper’s Ghost was invented by the British scientist John Henry Pepper in 1868 though the ideas derived from an even older concept of camera obscura in 1584. This optical illusion is a reasonably simple contraption that aims to project an object onto a scene in a theatrical sense. A powerful light source illuminates this object, and the light that bounces off the object reflects onto a vertically positioned (45°) transparent film from which the audience sees the show, giving the impression that the illuminated object is a part of the actual play. Such an object is often positioned underneath and in front of the stage, making it a part of the play while remaining separate from the actual physical location, thus providing unique opportunities for creativity and experience. Two examples of such a technique in modern times are the 2012 Coachella Live Concert with the rapper Snoop Dogg and the deceased rap legend 2Pac where they used a current configuration of the Pepper’s Ghost to give the illusion that they were performing together (2Pac-King, 2014). In addition, Vocaloid concerts, which are singing, virtual, Japanese pop-idols, are displayed in a slightly different, technological manner yet with the same result as 2Pac (xtokashx, 2016).

To further exemplify with a new development of holograms, there is No-logram, an extraordinarily sophisticated yet young “hologram” technique that exploits motion-tracking and a fine mist of microscopical water droplets to display two-dimensional projections in the air, that together create the illusion of a three-dimensional hologram (Lemercier, 2017). No-logram, in contrast to the previously mentioned, allows the user to engage more with the content since they can use their bodies to navigate the interaction rather than just getting an illusion through a transparent screen from a two-dimensional image. Even though this holographic display technology is in the early development stages, research would benefit from exploring them regardless, since the role of technology is to widen and enrich experiences (Song et al., 2015).

2. Related Research

This section introduces current scientific research on the issues that our research addresses.

2.1 The Sisters of Presence-Based 3D Visualisation

Regarding previous research on this topic, we found ourselves in a sea of studies done with augmented reality (AR) and virtual reality (VR) with only a few examples of cases done with “holograms”. Being aware of the complex nature of holograms and AR and VR, being more affordable and flexible for tailored intentions, this was to no surprise. However, with holograms being underdeveloped, there has been a considerable rise in exploration, mainly
experiential, educational or technological purposes, with these other technologies (Radu & Schneider, 2019). With Radu and Schneiders’ (2019) study showing how AR affects self-efficacy in education due to its way of contextualising the content; Poretskis’ et al. (2019) paper on the sense of relatedness and ownership in AR due to its engaging “physicality”; or Carrozzi et al. (2019) where they demonstrated that shared experiences with users lead to individual perspectives on psychological ownership; they all guide us towards the increased interest within HCI and the importance of exploring the possibilities of these technologies.

To further exemplify, Ryong Kim’s et al. (2019) did a case study where they explored the user experience of a novel interactive “holographic” retail shopping station. They acknowledged the increase of online shopping and why top online retailers such as Amazon have ventured to provide physical stores and explore the middle ground with this “kiosk”. Moreover, they saw the importance of creating a seamless shopping experience for users by integrating the immersive aspects of visualisation technology like AR or VR, thereby proving the effectiveness of said technology.

Examples such as the Microsoft HoloLens include a pair of glasses for hands-free AR navigation, which has been a popular tool for researchers to evaluate either the technology itself or the interaction with it in various aspects. As previously mentioned, Radu and Scheider (2019) used HoloLens to evaluate their research activity by making an application that the participants used throughout their study, showing valuable results thanks to its well-developed technological system. Bach et al. (2018) used it to evaluate human perceptual and interaction capabilities to see if the technology will suffice as an optimal tool for understanding and navigating 3D visualisations. By comparing the HoloLens with two other technologies and a desktop setup, they examined the significant properties of each medium to see where the others lack, which generated a conclusive understanding for all of them. Tangibility, visual perception, and immersiveness were among the examined factors; through a process that informed us in our research process.

Moreover, Pollalis et al. (2018) used the HoloLens in a museum to engage visitors with the exhibition to heighten the educational factors of the displays. They discovered that AR has proven helpful for educational reasons and is now extensively employed in museums and similar venues, even though they had with their study intentions to focus on the physical artefacts in the displays. In contrast, AR was mainly used to increase the surrounding experience. Therefore, the application they designed for the HoloLens provided the user auditory and visual information when looking at an artefact. The application would recognise the interaction with said artefact and provide additional information about it. This study is a work-in-progress at the time of writing and does not provide the case study results. However, another study by Pollalis et al. (2017), which is also a work-in-progress, made a similar approach to enhance engagement amongst visitors where they designed yet another application for the HoloLens. While still having the same factors to examine, this application was made to visualise detailed renderings of existing artefacts in an exhibition that does not allow for touching, enabling users to inspect old, brittle objects in otherwise impossible ways.

Decisively, however, Ryong Kim et al. (2019) pointed out the clumsiness of using a headset, whether it be VR or HoloLens, in experiences that derive from something as “naturally”
integrated with our perception like being in a store, physical or digital (taken from their study of the shopping kiosk); a concern that others have addressed as well. Franz et al. (2019) are amongst them where they recognised that, even if VR and AR is an effective way of engaging the user with the content, it does not suffice for exhibition environments due to the social situation that such spaces encourage; the settings are made for shared experiences. Pietroni et al. (2019) acknowledged this as well, mentioning that whilst visitors appreciate such technologies, facilitators tend to dissociate the usage of the technology from the interplay with the exhibition, making the visitors feel abandoned or frustrated. Therefore, they conducted a case study on using the technology of Pepper’s Ghost, as handsfree as possible, to examine the interaction of the visitors by means of understanding their experiences through concepts such as storytelling, engagement and user experience.

Caggianese et al. (2020) arranged a similar case study where they also made a holography installation though equipped with an artificial intelligence-powered, interactive system aimed to describe the art of Leonardo da Vinci, enabling the user to manipulate da Vinci’s work with touchless interfaces. Whilst being more sophisticated and advanced than Pietroni et al. (2019), it presents concerns, insights and assumptions about the behaviours and thoughts of the users. During the interaction, they came across instances where the participants expressed increased engagement with the content, disregarding age and background due to the technology’s fascinating properties, which deepened involvement.

As shown above, we have mainly found studies on AR since we believe that it is the closest one can get to holograms. Nonetheless, this has given us valuable insights into previous research and informed us on approaching our research subject.

2.2 Co-Experience in Social Situations
Understanding experience when interacting with technology has been a primary field to explore within HCI (Poretski et al. 2019) and has gained many advancements during the past 15 years (as of 2021). Commonly, experience has been away for companies to sell products, to market them as “real experiences”, whereas, in the scientific world, it is a delicate sensation that should be seen as something more due to its way of spreading positive and worthwhile results (Wright et al. 2003). This differs between studies and aims, but their collective premises have been to inform design for better technology and more successful implementation in a users’ life (Forlizzi & Battarbee, 2004). Since one’s life includes plenty of social situations, we as designers must adhere to it accordingly. Co-experience has therefore been a valuable theoretical perspective to use when approaching such situations.

Bründl et al. (2017) examined this phenomenon by studying the influences of the perceived co-experience on enjoyment when users engaged in social live streaming services. Using a hedonic version of the Technology Acceptance Model, they measured various parameters of enjoyment during the interaction on 127 participants, providing exciting results. Their findings imply that the perceived co-experience had a strong link with the level of enjoyment the users felt both in their passive and active involvement of the live stream, showing that, disregarding one’s involvement, the anticipated co-experience can significantly benefit the level of enjoyment nonetheless.
When going to an exhibition, one enters a space filled with carefully orchestrated installations to be experienced and explored. Nowadays, implementations and general approaches with technology are not uncommon, and the general public has very much appreciated it. It is, however, somewhat tricky to make these implementations work as smoothly as one would have wanted; there are several aspects to consider. Pietroni et al. (2019), as written previously, conducted a case study where they examined the experiences of museum visitors with a holographic showcase, which resulted in them thoroughly reflecting upon the responses. Whilst being based on museology, they conducted their study to further the knowledge about holographic implementations so that, if one decides to do so, they are considering some crucial aspects before doing so. They presented multiple parameters to adhere to when designing such an installation whilst regarding the museum’s exhibitions. These parameters advised factors such as acknowledging interactive accessibility, the target group, the environmental conditions, and the general expectations from visitors, all of which have proven to be essential to respect.

Similarly, Forrest (2013) also found essential factors when designing for an experiential exhibition, especially environmental conditions and applications to enhance visitors’ experiences. Together with Ivey and Sanders (2006) and Kocsis (2009), these principles have proven to be helpful to prompt design choices for social environments, as they viewed this from the perspective of co-experience. To date, there has been limited research about environments that prompt for co-experience since the focus has primarily been on products where the users are the ones who create co-experience. Therefore, Ivey and Sanders (2006) designed an exhibition space aimed to prompt co-experience that informed approaches in which to do so. The main take from their study was the context of the installation concerning the environment and the sense of interactivity because commonly, when visiting a museum or an exhibition, it is usually not allowed to touch anything, which emphasises the sense of invitation. To further affirm, Kocsis (2009) found with their digital, interactive installation that it was through the collective, social interactions with the exhibition that generated the sense of co-experience, hence being a vital factor to consider.

To conclude, Kesner (2014) explored how one perceives and experiences what an artwork shows with a neurological and subjective, phenomenological account. His approach was based on previously done studies on similar subjects, stating that how one perceives and interprets an artwork, we as humans are cognitively wired to read the environment and the objects within it as the first thing we do before continuing to evaluate further. Kesner (2014) continues to develop upon this with the context of “art-viewing” and interpretation; that of, if the viewer arrives at the solution, the end of this naturally occurring reading, more often than not, one does not feel obliged to continue to go beyond the recognition of the content. He tested these theories with a participant looking at artwork with clear and unclear elements of direct interpretation. This resulted in him finding pleasure in indirect recognition due to dopamine release when achieving something but with elements in the artwork that were not easy to decipher, the enjoyment of exploring continued, thereby prolonging the experience. What caused these recognitions and the experiences resulting from them are what Kesner (2014) calls affective affordances; properties of objects that afford to be interpreted but with affective
attributes make us react and reflect. Conclusively, one is given a clearer view of how one might perceive and “read” an artwork and what, in that process, is incorporated that makes up one’s experience. This information has provided us with great insight into how we should proceed when analysing our data.

2.3 The Instance of Immersion

Engagement is a broad term that describes the general drive of involvement of a person and something else, like another person, a film, a technological device or a community; depending on the perspective in which to view it, the description differs. In HCI (though it is a highly multidisciplinary field), the primary focus has been the act of a user engaging with technology in various ways. Ways that look at the user’s perspective, the perspective of the technology in question or the situation surrounding it; all are ways one could address the study object. The objects differ, but also what kind of engagement, immersion is one of them.

To be immersed, according to Douglas and Hargadon, 2000 (cited in Doherty & Doherty, 2018), one of many explanations as to “…being completely absorbed within the ebb and flow of a familiar narrative schema. The pleasures of engagement tend to come from our ability to recognise a work's overturning or conjoining conflicting schemas for a perspective outside the text, our perspective removed from any single schema”. This then means that the familiarity of an aspect of an environment or situation makes one feel immersed, which is consistent with a remark made by Dewey (1934) about art. He expresses that no matter how manipulated an artwork is, the substance with which it is created is what one should interact with, immerse in, and pair with the artist’s speech in the way they executed it. This suggests that the "nature" or substance of the art influences us because its visualisation is made of something that naturally affects us, taking us into an engaged state and creating immersion.

The phenomena of immersion have been studied immensely within HCI with the aim of, e.g. getting a better understanding of what a user experiences when interacting with technology. As presented previously, Bach et al. (2018) explored how a user experienced the interaction when using immersive technology and found that whilst the technology was proven valuable and desirable, they also found that the sense of immersion varied. This was due to the different individuals’ past experiences and preferences, which they found necessary to acknowledge. On another note, they also found that, since the technology generated a sense of immersion (in varying capacities), the participants preferred to include their whole body when performing the given tasks; a phenomenon which could be linked to the fact that a sense of familiarity was kindled by the nature of the technology (AR). These principles were used as a basis for Dinet and Kitajimas’ (2018) study by acknowledging the fact that if one would like to study the sense of immersion, one must recognise the fact that if technology were to be designed to generate immersion, the environment it is used in must correlate with what is done with it. To exemplify, a virtual environment is exposed to extraneous distractions; the sense of immersion fades since the world one is presented in does not correlate with what is happening. If an immersive factor were to be presented in “our world”, the circumstances must align with our surroundings to be seen as immersive.
Arguably, other layers of atmospheric elements may play a role in making one feel immersed. Mörtsell (2018) studied what one needs to consider when designing a game to achieve a sense of immersion. She followed an existing model called the *Narrative Model* to make the user stay interested in a game. With this model, she used the theory of Flow to examine if the feeling of immersion was achieved, which was confirmed to be the case. Based on Ermi and Mäyrä (2005) statements, immersion is vital to consider when designing a game and, depending on platform and genre, can be generated through different factors and their interplay; their insights correlate with Harvey et al. (1998) theories regarding immersion. Their focus being museums, the considered factors for immersion are very similar to the ones for games; it is crucial for effective execution from immersion, that there are different parts required to gain it, and the importance of them interacting well together. For a game to be experienced as immersive, one could see similarities with the different environments; a game is its own world as well as a museum being its own, carefully orchestrated space (Harvey et al. 1998). By basing these statements on the fact that an individual seems to seek immersive situations to gain pleasure/positive feelings (Turner, 2010), places such as museums must adhere to this and grant the visitors with experiences and to maintain engagement by, e.g. providing interesting and stimulating interactions and installations with effective, atmospheric elements (Hart et al., 2012).

### 3. Theoretical Lenses

Here we address the theoretical lenses that guided us in understanding how to conduct our research. The general premises are briefly presented regarding experience and engagement in HCI, where we highlight *co-experience* (Forlizzi & Battarbee, 2004) and the theory of *Flow* (Csikszentmihalyi, 1990; Biasutti, 2017) by using the concept of *affective affordance*.

#### 3.1 Co-Experience with Technology in Social Interactions

“Understanding experience is a critical issue for a variety of professions” Forlizzi and Battarbee (2004, p. 261) states and for a case such as ours, which concerns art and exhibitions, areas which in its core revolves purely around experience, it is even more crucial to acknowledge it. As presented previously in this thesis and something which will be discussed further in later sections, exhibitional facilities have been trying to incorporate digital implementations to enhance the engagement and experience of the visitors (Franz et al. 2019; Pollalis et al. 2017; Song et al. 2015; Pietroni et al. 2019; Ryong Kim et al. 2019; Caggianese et al. 2020). This then demonstrates a growing interest in experience-centred topics related to artistic background, with researchers varying in how they have chosen to address this specific issue, from how to why and with what.

According to American philosopher John Dewey’s (1934) theory about the experience in relation to art invokes a totality that reflects the engagement of oneself in the relationship with the object at hand in the situation. Many researchers have built upon this theory to suit better their practice, where Forlizzi and Battarbee (2004) have targeted HCI, distributing the knowledge amongst the specifics within this multidisciplinary field. They proposed, amongst
two others, the interaction-centred perspective, a perspective that collectively emphasises the new theories which originated from Dewey in HCI. They have also created a framework situated within social contexts, explaining the dimensions of experience in which one could study experience related to the design of interaction systems (Forlizzi & Battarbee 2004). Within their framework exists co-experience, a theory adopted from Dewey (1934) and symbolic interactionism, which we will adopt in this thesis.

Co-experience is the concept of when experiences are created with others through technology in a social context; it helps us theorise on how experiences unfold and evoke; a seamless blend of experiences in social interactions, direct or indirect (Battarbee, 2003; Forlizzi & Battarbee, 2004). Technology plays a massive role in supporting co-experience through providing mediated means of communication which generates the possibility to share and view the content with others, in whichever way possible. With technology, the concept of co-experience elevates the means of expressive and shared attention, where they become part of a social interpretation process that can influence what the experience comes to indicate. The same experience created by the viewer would not be possible without the presence of the technology and the possibilities it provides in that specific social context.

Battarbee (2003) explored this phenomenon in a case study where telecommunication was studied in MMS conversations. The study generated insightful knowledge on creativity and interpretation to how the participants make experiences relevant and meaningful to each other, both creation- and content-wise. To elaborate, creative use finds new possibilities for existing functionality where interpretation is required in the interaction process. This means that the addition of sensory inputs significantly improved the richness of the MMS over SMS, allowing for more sophisticated interpretations such as emotions or mood. This approach stresses the importance of these experiences in the context of social interactions in which people interpret particular events and create meaning from them.

3.2 Immersion: on the Spectrum of Engagement

Engagement can be approached in several ways depending on its intention and from what field they study. Ontologically speaking, from the perspective of information science and (user) experience, engagement is our direct involvement globally, grounding our encounter with technology in broader contexts of our purposes (Turner, 2010). It is simply one’s act of cognitively and physically approaching something.

Whilst being a stable explanatory basis of engagement, it lacks discussions regarding affect, claims Turner (2010). He states that since engagement and interaction, which is the “step after” the sense of engagement, lacks a centrality, the middle ground between these two must be the sense of affect. This means that technology must have some affective properties that make an individual engage with it, resulting in some sort of direct or indirect interaction; these properties are affective affordances. This approach on how to view engagement can be compared to O’Brien and Toms (2008, cited in Doherty & Doherty, 2018) description of engagement, characterised by qualities of user experience such as aesthetic, sensory appeal, affect and perceived control. Affective affordance comes from the general understanding of psychologist James J. Gibson’s definition of affordance, a term that describes properties of the
environment or object taken regarding the individual (Heft, 1989). Typically, the concept of affordance has been associated with product usability but can likewise be seen as a way people undertake cognition and action in the world to express and explore (Forlizzi & Battarbee, 2004). Hence why the concept of affective affordance becomes more convenient regarding engagement since it refers to the narrowed-down concept of how specific properties affect us on a more experiential basis.

With the knowledge on how to approach an object of study efficiently now comes the means of selecting an appropriate lens for engagement through which to study artistic holograms in exhibitional contexts. To identify what means to use when investigating holograms, we approached this using the theory of Flow; a theory advanced by Csikszentmihalyi (1990) and Biasutti (2017), which refers to the state of mind where one is so entirely captivated by the performing task or medium which makes one disregard everything else surrounding them. The nine components of Flow consists of:

- being confronted with tasks to be completed (challenging);
- effortless involvement that removes one’s awareness of surroundings (immersion);
- has clear goals and purposes (clarity);
- gives immediate feedback (feedback);
- the level of concentration it requires (control);
- a sense of self-control (freedom);
- concerns of the self disappear yet intensifies when removed from the matter (reflection);
- one’s sense of time is altered during an activity (temporal insensitivity) and;
- curiosity and intent encourage one to participate and find enjoyment in the activity without expecting an external reward (autotelic experience).

Depending on the context and the medium in question, the levels of validity for “flow” vary in terms of how many components it fulfils (Csikszentmihalyi, 1990). With the context being art exhibitions, Flow theory suits accordingly since it correlates to desirable factors regarding museology, which we need to consider when approaching this research.

Flow has been widely referred to in the sense of immersion; essentially, a subset of engagement that often has been used to study circumstances close to ours, such as games (Mörtsell, 2018) and websites (Hart et al., 2012). For example, Hart et al. (2012) used Flow to capture the sense of immersion when a user interacted with museums’ websites, identifying what aspects of each website generated the sense of immersion. Using Flow, alongside other approaches, even the smallest aspects could be identified and acknowledged to grasp what factors caused what emotion/sense thoroughly. Likewise, Mörtsell (2018) had done a study using GameFlow, her model based on the Narrative Model (which is based on Flow) that aimed to measure how users feel when playing a game to identify elements that triggered immersion. With the data, her model could if followed when designing games, generate a more genuine sense of GameFlow, resulting in a more immersive outcome.

Both of these show valuable ways to use Flow theory to measure characteristics of an object/subject of interest, making it a suitable theory to be supported by, which we use by identifying and studying affective affordances.
3.3 Understanding Co-Experience & Immersion Together
“The more we understand social behaviour in terms of its experiential (material) context, the better can design efforts be focused on relevant attributes.” (Gaver, 1996); a quote which briefly explains how we view our experience-centred approach. To more elaborately compare, the MMS study done by Battarbee (2003) illustrates similar factors in our research, which makes us perceive that co-experience is suitable for our research. An exhibition facilitates a particular form of social interaction, whether it is a dialogue between the artist and the lone viewer through the art or a dialogue between several viewers in the presence of others, the art, and the setting in which it all takes place. This reflects how the possibilities with holograms can generate knowledge from a co-experience perspective since, compared with 2D images, in a similar way, posing that hologram can contribute to new ways of experience.

“...the richness of the message content was much increased with the inclusion of sound and image, but not only because they provide a multisensory description of reality, but because the elements together provided more possibilities for interpretation: emotion, mood and humour” (Battarbee, 2003). This quote further proves the possibility of co-experience being suitable when analysing holograms since it looks at the subject as being an enhancement from something else that serves a similar purpose; them being SMS to MMS, and us being screens to holograms. In addition, from solely an art perspective, art is as close to the definition of a pure experience as one can come to, and if placed in an environment where social interactions are being intertwined with means of interpretation and expression, co-experience is being “created” (Battarbee, 2003). “A work of art is what the product does with and in the experience” (Dewey, 1934).

While often being used in context for experience, the theory of Flow can equally be used for immersion. Due to its strong links to experience, we also believe that it will benefit us even more during our analysis since we believe that these senses are strongly linked and are based on each other yet need to be considered individually to get a sense of totality. Since our study object takes place in exhibitional contexts, places where people often go to with some intention, it would be more desirable if the setting optimised for a better general experience. Kesner (2014) states that the phenomena of the whole viewing experience are that of affective reactions that unfold throughout the entirety of seeing. Our interpretation of this is that if one strives for the true experience, considering means that more broadly affects one will generate the most success. Thus, we will be given a more precise understanding of how holograms make one immersed by using the Flow-scale. The term affective affordance will be a component that will help us explore factors that determine whether or not the studied characteristics of hologram suits the theory of Flow. Because what one cognitively experiences in space are the affordances of the whole, and we engage with something and continue to do so because we enjoy doing so – thus proving that affect has an essential role in engagement (Turner, 2010).

4. Methodology
This section presents the methods in practice that we have employed to approach our research questions. To explore what experiential qualities holograms have and how they can be
successfully used in art exhibitions, we embraced an iterative experience-centred design approach, equaling two studies; a design workshop and a mini-exhibition. This approach was chosen because we intend to ask our participants about their experiences when exposed to the hologram, ask them to reflect on their feelings and then, for us, to analyse the relations between the technology, experience, and situation (Wright et al., 2003).

Exploratory in nature, the design workshop was chosen for its potential of generating informed decisions about a design through a series of group exercises. The design workshop combined a design-oriented method, an inspirational design kit, semi-structured individual interviews, and semi-structured group discussions to effectively collect data (Corbin and Strauss, 2008). The workshop was repeated three times, once for each group of participants. Our second study brought the results from the first study “outside the lab” and informed the design of a physical exhibition termed mini-exhibition. Our mini-exhibition was the culmination of our research efforts and the final results of this iterative design process. By addressing the features of this design process, we can validate the process itself if the elements of the process and the verification of design qualities are documented and their values justified by a design process description (Ståhl & Höök, 2008), resulting in us getting material for our final takeaways.

There will be images of the data gathering sessions in Appendix 6, Figures 1-5.

4.1 Participants & Ethical Considerations
A request was made over Facebook Messenger to a total of twelve potential participants with information regarding our study (see Appendix 1). In sending out the request, we had chosen to use purposive sampling to select participants from our acquaintance list; classmates (current and former), family, and friends. We wanted participants with the characteristics of having prior experiences of art exhibitions or museums and overall interest in creative practices. The flexibility of purposive sampling allowed us to choose the best-suited candidates with the time and resources we had, mainly when time and resources already were scarce because of the restrictions posed by the pandemic. Conversely, selecting participants from a specific group based on their potential for providing an experienced point of view may implicate the possibilities of generalising and validating our discoveries.

Nine recipients of the request responded and agreed to participate in our studies. However, one participant requested to cancel their participation right before their workshop, thus leaving our first study with six students and two currently working, eight participants in total. This group of people comprised a diverse range of creative talents, each of whom contributed unique perspectives and values of importance and were between the ages 23 and 41. Furthermore, the participants hold essential to our thesis as they have previous experiences from art, exhibitions and design knowledge through personal interests and prior studies in the field of digital media (to view their extended presentations, see Appendix 2).

The identities of our participants have been anonymised in the study, and aliases were allocated based on their interests. We also informed our participants early in the thesis process that they are free to quit participating whenever, just as one did. This is not to hold the participation against them and force them to stay until we are done with the studies.
4.2 Data Gathering
The first study comprehends a set of three design workshops, which included deploying two inspirational design kits to our eight participants across these sessions. The kits consisted of questions, a physical component, and videos (see Appendix 3). Our participants acted upon the physical parts and other topics in each session, which lasted one evening and one afternoon, all of which will be detailed in the next section.

The second study consisted of the mini-exhibition, a physical rendition of how a digital art exhibition using holographic technology could look based on the findings from our first study combined with previous literature from our related research. The description of the said exhibition is presented in section 4.2.2.

4.2.1 Design Workshop
Two inspirational kits were introduced for the workshop sessions. The first kit included a couple of questions (see Appendix 1) in preparation for the workshop, a physical component; a transparent plastic sheet cutout with premade ridges that would allow the participant, when instructed in the workshop, to bend the plastic to form a pyramid design similar to that of a traditional DIY Pepper’s Ghost (BealsScience, 2020; Vasanth, 2015). They received either a small plastic pyramid – fit for a smartphone – or a larger one fit for tablets depending on what device they had at their disposal.

The second kit included a checklist of prerequisites that we recommended our participants arrange before the workshop and a description of other materials to be used and referenced in the workshop. These were links to six videos that would provide inspiration and help our participants to think creatively. The first video gave a general idea of art exhibitions in a technological manner (Rachel & Jun’s Adventures!, 2019), the second and third video presented Pepper’s Ghost in use today (xtokashx, 2016; 2Pac-King, 2014), which gave a more relevant idea of the technique and its potential explored in our study. Finally, the last three videos presented some of the latest developments and usage in holographic technologies (Lemercier, 2017; Ikinamo, 2014; Looking Glass Factory, 2020) to give them insight into how it is progressing (see Appendix 3).

The following were the workshops’ official start and when we met the participants over the virtual-communication app Zoom for the first time. Here, we first interviewed our participants one at a time, separate from the remaining participants, where a set of four semi-structured questions were asked (see Appendix 4). These individual interviews transpired parallel to what we refer to as the Lounge. After each participant completed their interview, they were transferred to the Lounge and switched places with someone else.

In the meantime, the remaining participants currently not interviewed were placed in the Lounge and tasked to discuss two questions about the videos included in the second inspirational kit: “Did you know about these videos or concepts about them before we sent out the videos?” and “Have you experienced something similar?” If they finished talking about these topics, they could talk freely, but not about the individual interviews. Additionally, the Lounge was recorded through a second Zoom account, which was given the name Lounge Bot fittingly. Lounge Bot was always present in the Lounge sessions but was, however, always
non-interactive. When all the participants had been interviewed, the next phase, the Activity, would begin.

In this phase, we gathered all participants into a single virtual room and demonstrated how to assemble the plastic pyramid component from the kit and attach it to their devices. Following, each participant would receive an image depicting four sides of a 3D model. Each was designed to show the front, back, left, and right sides of the 3D model when displayed on a device fitted with a plastic pyramid; the image would reflect the 3D model, creating the illusion of floating in the air like a hologram. This setup allowed for a simple yet convincing holographic illusion and allowed participants to discuss the experience while it was happening (a picture of how the setup looked is provided in Appendix 6, Figure 2). They would then receive a GIF of the same 3D model on their computers; however, this version was more dynamic and showed the model slowly spinning around its y-axis. The GIF allowed them to compare and discuss the two techniques, which began the Discussion phase. Finally, this phase was for them to reflect on a set of semi-structured questions (see Appendix 4) on the experiences of holography as a medium for art, the different experiences of the 3D model using a flat computer screen and the hologram and general thoughts about the topic.

4.2.2 Mini-Exhibition
The second study was a mini-exhibition hosted in one of the researchers’ homes. Wistfully, this was not the original course of action; our initial approach was to compose a small art exhibition at Umeå University where the participants could interact with the display to answer a few questions later. Unfortunately, the pandemic caused these limitations, which restricted us from making our initial approach; it also restrained us from having any physical interaction with others and acquiring a space with optimal tools to host it.

The exhibition featured a large glass panel (85cm x 60cm x 0.5cm), a large computer monitor, a pair of speakers and an animated 3D model of a sea angel (Cheung, 2020). The glass panel functioned similarly to the plastic pyramid by reflecting the projected image from a monitor onto itself, making it appear like the image "floats mid-air". The speakers played ambient underwater music to provide a more immersive experience while the 3D model was projected on the glass. The 3D model of the sea angel was chosen based on the initial nautical theme we wished the exhibition to have, which stemmed from the fact that those themes tend to be very immersive, and we found many relevant 3D models on the site where it was purchased. The model included a looping animation that made it appear to be swimming on the spot, but it was further animated using a Dualshock 4 controller to give it more life and to mimic the implementation of direct manipulation by the viewer; another factor that we wanted to do in real life but sadly could not. Because the design workshop informed the design choice of how the hologram should be “developed,” the sea angel was animated; the participants wanted to engage with the hologram, and the use of the controller allowed us to apply this factor as a first draft of how an interaction may resemble.

Since we did not want to promote physical gatherings, we sent out a 48-second video to our participants showcasing the exhibition and how it would look if they were present, and four open-ended questions (see Appendix 5) similar structure to the ones from the workshop. For
easy and quick communication, this video and questions were sent over the Facebook Messenger application. We requested them to respond to the questions and justify their answers as thoroughly as possible in text format. Appendix 6 - Figure 5 shows a screenshot from the video.

4.3 Data Analysis
To analyse the data from our first study, we used an inductive approach based on a thematic analysis; an analysis which goals are to break down the number of themes to explore and develop an overarching theme from the data, or an integrative theme that weaves various more minor themes together into a coherent narrative (Saldaña, 2016). We chose a thematic analysis with inductive reasoning to provide us with relevant insights for our two research questions. Since both of them refer to the study object (RQ 1) and how to situate it (RQ 2) correctly, a thematic analysis was regarded as suitable due to its ability to summarise the participant’s words to identify appropriate statements to formulate context (Saldaña, 2016).

Our analysis started with the initial extraction of relevant data that in various ways provided feedback, thoughts or criticism that would help us answer our research questions. These extractions were then further extracted in the form of codes that we found relevant to our research questions. Then, we categorised these codes with an inductive lens, meaning that the information drawn from the raw data was interpreted and categorised to formulate either a theory, a model, a method or something similar (Saldaña, 2016).

The second study, our mini-exhibition, was also evaluated using inductive thematic analysis. The difference between this and the previous one was that an open-ended survey enabled the collection of data. In this second study, thematic analysis was an appropriate approach because it allowed for discovering patterns in participant communication that were not constrained by response limitations (Swart, 2019). The approach we took in analysing it was close to how it was done in the first analysis, making the process easier.

Our analytical processes were done over the digital platform Miro, a platform made for easy online design-, analytical- or workshopping processes with an interface being similar to how a dashboard or a brainstorming table would look like, thereby providing ease and familiarity during this process. The themes found in both of the studies will be presented in chapter 6 and 7 as the titles of each section in their respective chapter.

4.4 Method Discussion
Design workshops are one of many subcategories of User Experience (UX) workshops enabling an environment where cross-disciplinary participants or team members may in an intense session of activities collaborate to solve a problem, develop a plan or decide on a design (Nielsen Norman Group, 2019; Nielsen Norman Group, 2020). However, our design workshops included an activity that generated meaningful data, though not in a teamwork setting, but rather a setting similar to a focus group. Because the way our participants expressed themselves was more distinct than what could be captured through their interactions with the hologram, the data we obtained from the workshops were more
attitudinal than behavioural. One reason for this could be the primitive interaction and the limited experience brought upon the social construct of the virtual meeting environment.

Furthermore, alternative ways of conducting the significant parts of this study were adopted due to the pandemic. For instance, our mini-exhibition was modified to still provide our participants with the opportunity to experience their collected thoughts and desires on what features such an exhibition would have while under regulations set by the Public Health Agency of Sweden (Folkhälsomyndigheten, 2021). Our original intention was to invite the participants to see the exhibition physically, but this would not have been easy to do given the circumstances. As a result, the video recording and survey seemed, at this time, to be the only possible method of collecting responses to the mini-exhibition.

We developed an understanding through our thesis about the current perspectives of holographic usage in art exhibition through an iterative design process. Even though such processes may generate different outcomes depending on the purpose in mind, they are generally distinguished by the idea of continuously refining a concept or prototype; the cycle of research evaluation and modification of a prototype or concept is to excel where the first iteration falls short. For us, this was done through two studies to allow for specific knowledge to emerge in each, contributing to a more comprehensive and conclusive perspective for our final takeaways, thus not resulting in a prototype.

5. Results - Design Workshop

The findings from the data obtained during the workshop sessions are shown below. As noted in the section on data analysis, we discovered a set of seven themes in total. Equally, as the object of study consists of likewise factors, the themes while being based on each other, will be presented separately. The participants are referred to the numbers we have given them (for more information, see Appendix 2) with the pronouns they/them to keep them anonymous. The mentioned quotes below are translated to English since the data gathering sessions were all in Swedish, ours and the participant’s native language.

5.1 Holograms Add to Spatiality

All eight participants positively expressed to an extensive degree that holograms added to the sense of spatiality, a factor in which seven out of eight collectively agreed on being an important factor when visiting an exhibition. Among the responses on why they felt like it added to this sense, two instances stood out the most in both depths of discussion and how often that specific subject occurred as a factor of describing it, bodily navigation and perception of realness.

The earliest mentioned one was how it allows for natural bodily navigation. What they meant with this was that, while the object is virtual, its three-dimensional properties allowed them to use their body to navigate their viewing exploration.

“...especially if you aim to create environments, I believe you definitely can benefit from this type of technology!” – P4
"It becomes something that's “in the room” that you can explore. You can, like, walk around it and experience it from different angles..." – P8

These two comments are but a few expressing how the hologram afforded for bodily navigation. Even if the hologram given to the participants were relatively small, a factor in which six out of eight commented on being mildly unsatisfactory, they all still expressed how they could envision how that experience would be.

To further add to this phenomena, seven out of eight participants expressed that the hologram “penetrated into their world” in a way that made them feel a sense of immersion and that they experienced “realness” towards the hologram. This was the most outspoken aspect of the hologram throughout all of the workshops, resulting in 38 unique mentions in total. While the object being projected as a hologram does not exist, participant 7 stated that the technology allowed the object to be shown in a way that created intriguing experiences and allowed the object to pop out.

“3D is like... it replicates the world we live in. We know how to act... it's like, depending on how I position myself... it becomes more like a real movement experience. Because we're in the real world, and so is this (points towards their pen holder), but this (the hologram), which isn't really in the real world, still becomes a part of it. With this (the technology), it just makes it feel... real and more immersive. It’s like magic!” – P7

“So cool! It's just floating there! This really gives it (the hologram) the sense of popping out of there... I like it!” – P3

5.1.1 Technology Allows for Inclusive Participation

When the participants answered and discussed our questions about whether this technology would attract new viewers or speculations around the impression this would have on the general public, all participants agreed that this technology would increase the number of visitors due to several aspects.

One of the mentioned aspects was the technology itself possibly being of interest amongst individuals who are generally interested in new technological usages or even the general public. For example, five participants stated that to some degree, whilst the focus might be the most on the art, the other aspects like the technology and the theme might attract other people in ways that were not “as possible before”. Equally, participant 4 expressed that with technology, one is not only expanding for more viewers but also creators. However, they believed that the current state of exhibitions still favours the analogue art medium as the centrepiece, excluding digital artists from this culture.

“This (hologram) may be more engaging for non-art interests. It feels like everything that is just slightly more interactive automatically becomes more interesting...” - P3
“...you kind of perceive that you need to adhere to a specific culture and that you need to understand it in a specific way and that can feel very exclusionary...” - P4

Participants 2 and 3 pointed out that due to the “spectacle” of the technology and the possibilities that could be applied, holograms could be a valuable and fun technology that might appeal to children well; thoughts that were influenced by the inspirational kit (videos) we sent them before the workshop showing interactive technological exhibitions.

“This’ll engage and attract a younger audience, I think. Maybe it’s enough with just the hologram... it would communicate well with them but since children use all their senses, like touch, when exploring... they kind of need that for understanding things better.” - P2

5.1.2 New Technology Heightens Engagement
Another aspect, similar to what was previously mentioned, is that all eight participants strongly agreed that technology overall is always exciting, curiosity-provoking and engaging regardless of who one might be. The general assumption was that five out of eight participants claimed that new things generally make one interested, especially technology, in one way or another whilst the remaining three, participants 3, 4 and 5, furthered their claim. They pointed out that due to the rapid advancements in general with technology, it is not solely for explorative manners but instead as an appreciation towards this expansion within the art field.

“...definitely better when you mix technological practises with artistic ones... it kind of bridges everything together... because I believe that technology can be used in so many better ways than what we do now. Often, nowadays, it’s only used in simple manners, like a video or a poorly done VR solution. It’s about damn time we do something else!” - P5

However, four out of eight participants stated that even if the technology might be intriguing, the art and the context itself were still the main factors that contemplated the engagement and interest duration. Furthermore, they also said that even if the current technology works and is more advanced than the hologram, they expressed that it is slightly primitive and boring since they are used to that type of technology (referring specifically to films and screens).

“People will most likely be intrigued by this because it’s new and exciting. But in the long run, it will always depend on the content, and it will affect everybody differently regarding how they engage and interact.” - P1

“A video or the GIF is just “there” on the screen... we're used to that... I believe that holograms can contribute so much, especially for those of us who grew up with technology.” - P3
5.2 Multiple Sensory Stimulations Create Stronger Experience
To further the topic regarding appreciation towards spatiality, all participants expressed in various degrees how they received stronger experiences when, not only regarding hologram, multiple technological sources are intentionally added to the sense of spatiality.

To begin with, seven out of eight participants experienced that holograms added: “more to the object” compared with the GIF that they were given during the workshop. When they spoke about it, they mentioned, for instance, that the hologram felt real, as presented in section 6.1, and that factor made them get a stronger experience.

“*It feels so real somehow. Like, it’s in my physical space even if it’s from the screen originally and it being here gives me, like, an understanding of it, oddly enough...*” - P2

“This (hologram) makes it feel more faithful to reality. We discussed it earlier that we all agreed on this being more of an experience than what this (GIF) can do.” - P4

Together with this, they also collectively discussed how the hologram would be even more admirable if it moved around or was animated. Participant 1 especially mentioned that they wanted to add it because it would enhance the overall experience.

“If the hologram was animated or moved in some way, then it would definitely enhance the experience. Then the experience would be more “real” compared to it if it was still...” - P1

During the discussion regarding the potentials of holograms, six out of eight participants emphasised the relevance of the interaction between the various added technologies and the hologram. They compared the hologram from the workshop with the videos from before the workshop and past experiences, where participant 3 expressed positivity towards it. However, participant 8, while still agreeing, mentioned that too much visual impression could be a bit overwhelming or exhausting.

“This (hologram) is like an extra layer on our reality. Think of it like a digital art constellation where you can, with this (hologram), add depth. Like to build with layers using this because it can add depth by placing it in the mid-ground or foreground.” - P3

“(referring to a past experience) Of course it was very rad to experience all that, but it almost made me super dizzy because of all of the constant impressions.” - P8

5.2.1 Seamless Technology Allows for Immersion
The properties of the hologram being “seamless”, as the participants proclaimed, was a word they discussed plenty. However, the two most prominent topics, through which it occurred generously, were 1) when they compared it with past experiences with technological usage in exhibitions and 2) how they believed this “seamlessness” could benefit exhibitions towards the goal of spatiality and immersion.
When they discussed the first standpoint, five out of eight recalled some of their past experiences with unsatisfactory technology in exhibitions; it, for example, is how a movie has a noticeable beginning and an end, and if one comes in during the middle, one has to wait until it loops (P8) or if some technology does not add actual value with its usage concerning the exhibition (P1, P3 & P7).

“When you enter a room with a movie, you’re kind of “walking in on something”. I mean, it’s effective in some cases, but in this social space... it doesn’t really fit in. It doesn’t give the same baked-in experience.” - P8

“The thing was... you didn’t feel like using it because it wasn’t worth the while. It said the same thing as the description-plate of the art, and it felt unnecessary... for me at least.” - P1

Regarding spatiality, five out of eight participants acknowledged the hologram in relation to what they discussed earlier concerning spatiality and immersion and expressed some suggestive proposals. Participants 4 and 6 specifically spoke about how holograms help the viewer be a part of the installation in a way that allows them to feel immersed.

“If we talk about making an environment, you’ll probably want to achieve something that’ll fit into that theme. Then I would absolutely say that holograms can help to achieve that strife because it kind of helps the viewer to visualise what the artist wants to say, and it also kind of places the viewer in the art piece. Just in general, this can be used to include the viewer in the experience that the artist wants them to feel. Because this (hologram), I feel like, allows you and others with you to interact with the art in a new and unique way.” - P4

“To feel like I’m a part of or closer to the artwork is important to me. To really show that and to allow all of the viewers there to be active participants instead of passive in any way can bring so much. This (hologram) can make you feel closer to the art for real. This makes it more exciting, and it can really boost everyone’s experience.” - P6

5.2.2 Interactive Opportunities Heightens Experience
Lastly, all eight participants stated that technology, especially when exposed to the hologram, should have interactivity, direct or indirect, a highly explicitly requested factor from participants 5, 6 and 8. The collective reason they wanted interactivity was because of the “realness” they felt the hologram emitted. In general, their rationale was based on the videos sent to them before the workshop, which prompted ideas on how holograms may be used, such as adhering to the hologram’s 3D-properties and allowing the spectator to treat it as a physical item (P5), or as participant 8 expressed:

“This is a pretty smart and cool way of generating things like this (3D objects). Because this type of visualisation IS more like a REAL experience! I really think that it would be super interesting to let people participate in the art together; it’ll make it so interesting!” - P8
5.3 Spatiality Increases the Sense of Immersion

Our final and most prominent theme regarding data volume contains how the participants experience immersion from exhibitions and installations that convey spatiality. Seven out of eight participants expressed to an extensive degree that, whether or not an exhibition has technology implemented, spatiality is an essential factor since they experienced a stronger sense of immersion if implemented and interpreted successfully. In addition, participants 1, 3 and 8 mentioned how they appreciated when multiple usages of technology are used to create spatiality, specifically audio, light, and animations.

“There’s so much you can explore with technology, things you can’t do with analogue mediums. To create a soundscape, project art onto a wall; it adds another dimension.” - P8

“To create a room with just light or video or whatever, it really becomes a whole new immersive experience. A world, an experience... to have something move around you, it can feel like something’s really happening. Both because of the experience being more 3D and that things are happening around you and involving you...” - P3

When the perspective shifted towards the hologram and its potentials, they felt like it was a promising technology. However, with the provided version, they pointed out the value of the objects’ scale and that it needed to be animated to feel more immersive since they felt like it was way too small and static. The feeling of being around it or a part of it was something they claimed to be a crucial factor.

“Regarding immersion, it feels like it needs to be large enough, so you kind of can walk around it. Like if it was to be a part of an environment. Then it would have been more apparent... more enclosed... more immersive.” - P1

“Generally, it would be like, what do I say, more immersive with moving or interactive things. So, it would be so cool if I could walk around it and it could walk around me.” - P2

“It would’ve been so cool if it was bigger! When it’s more in your own space, then it would automatically make it more immersive due to its “wow”-potential!” - P3

6. Results - Mini-Exhibition

Here, the data collected from the mini-exhibition will be presented. The reasoning behind this structure is to demonstrate our design process chronologically, meaning that the results from the mini-exhibition are separate from the design workshop and should then be treated separately even if our findings collectively consist of them both in the end. Furthermore, the results presented below are only from seven out of our eight participants due to the results from one, unfortunately, being unusable.
6.1 Holograms Require Conditional Authenticity
Firstly, five out of seven participants exclaimed that whilst a hologram would benefit from immersive or complementary additions, it was still the context that determined whether or not a hologram requires such additions, in whichever way that seemed fit. Though, in general, they stated that the music applied to the exhibition fostered the impression of it all and that it gave a generally better experience than just being a stale, visual impression (P8) and that it posed the setting better for immersion, even when not being there physically (P7).

Equally, in the context which the participants were exposed to; a hologram depicting a moving sea angel with ambient music and light, all seven expressed how they appreciated the movement of something they know is a depiction of a real, living thing; making it more engaging and authentic (P1).

“The animation combined especially with the rotation makes it appear more alive; something which I kind of feel is the point with holograms... to show something that has an actual physical form together with movement really helps!” - P6

To further this, all of the participants stressed the fact that a hologram, especially something like ours, needed to appear as much as possible as its actual representation for them to feel immersed, meaning they want to see it “being alive and free”.

“When I look at this hologram specifically, it feels like I would have wanted it to live its own life in the room. The movement of it now would have suited so well if it could just flop around on its own.” - P3

6.2 Holograms Affords Seamless Interaction
Regarding the implemented interaction on the exhibition, all seven participants agreed that interacting with the hologram was a crucial part of the experience. However, six out of seven participants felt like our approach of interacting (using a physical controller) was not the optimal way to address this; the usage of a controller disconnected them from the art and the experience. Even though they understood the ease of use with a controller, they would instead use their bodies to interact with the hologram. Equally, a controller did not seem to be suitable for a group of people, which primarily participant 1 viewed as something of importance due to the social nature of an exhibition.

“To interact with your body feels more in line with the nature of the hologram than a controller, it makes it feel more disconnected and the immersion kind of disappears...” - P3

“I definitely believe that it would be better to use gestures or at least refrain from any type of physical aid in the interaction. I believe that it would be more effective to not use one - then it would eventually be more immersive if you use your own body.” - P2
Moreover, participants 1, 4, 6 and 7 wrote that gesture-based interactions affecting the hologram rather than the other way around were a better approach to the whole interaction. This was heavily referenced together with them wanting it to be more alive and free.

“The input could be different even though the controller is practical; it could remind you of games, or at least push your thoughts towards that... I’m thinking of those old school plasma balls – to use it to “call” for the hologram's attention through gestures... This interactivity gives another layer to the hologram, making it more alive.” - P6

6.2.1 Seamlessness Invites Co-Experience
Following the responses of our direct approach not being suitable for a group of people and them wanting the interaction to be more bodily, five out of seven participants further expressed how bodily interaction would better facilitate co-experience as opposed to a controller for a group. For example, participants 8 and 7 wrote that the social aspect would be enhanced if more people could interact simultaneously, posing it more like a fun game that one play together with others and the hologram (P7) or making the exhibition generally more inviting (P8).

“...this would’ve been so fun to interact within a group, it becomes more interactive, like socially, and I believe that people would be entertained to try and “control” it together.” - P8

“The primary difference between using this alone and with others is that if you interact with the hologram in a group, another layer emerges, and with that, you also interact with the group. You can tell each other what you see, and you experience it all together!” - P4

Lastly, five out of seven participants stated concerns regarding a decrease in the overall experience if the hologram allows for too many visitors interacting at the same time. The most prominent concern was that if there were too many interacting simultaneously and “fighting over it”, the experience for others would decrease and the immersion thereafter. But they did acknowledge that this would probably not be specifically for holographic showcases.

7. Discussion
This chapter will discuss the analysed results and answer our two research questions.

7.1 The Theory of Flow with Holograms
Throughout the data gathering and our literature review, we found several instances where people expressed immersion when exposed to similar technologies but not primarily holograms in exhibitional contexts, at least not to a satisfactory extent. Based on the responses from our participants, we will then test this theory with holograms by using the nine components of Flow (Csikszentmihalyi, 1990; Biasutti, 2017). However, one must
acknowledge that the components are interconnected and rely on one another to varying degrees hence why some repetition might occur.

Firstly, **immersion**, referring to the loss of reality and only a select range of affective information can be allowed into one's awareness before it is “broken”, was exclaimed repeatedly throughout the studies in relation to the hologram being perceived as **spatial**, with words such as magical, cool, “real” having a “wow”-factor and unique; they all reflect the sensation the participant got when exposed to the hologram and after the cognitive state of perceptual identification. This could be connected to what Turner (2010) calls appraisal theory; an iterative process of continuing with the pleasure of recognition until completion of the goal, meaning that there is yet something to be discovered even after the initial recognition. This is usually the case of contemporary or abstract art or with, in this case, a new medium (Kesner, 2014).

Exhibitions were stated to benefit from holograms' ability to enhance the sense of spatiality in an environment by creating and leveraging immersion. Holograms can be immersive even if they do not encapsulate the mind the same way a book does. They do not necessarily have to facilitate immersion in the sense that interaction with it is effortless, and, as a result, the experience becomes so immersive that one loses perception of one’s surroundings. Instead, our findings imply that the world and the objects it holds is already immersive, and the hologram becomes a part of it. In other words, a holographic 3D object can afford interactions similar to those found in real objects and, as such, is seen as just an addition to the objects that naturally occupy one’s environment, making it immersive and feel real; “It becomes something that’s “in the room” that you can explore” (P8).

“Spatiality increases immersion”, one of the most commonly mentioned features of holograms in our data, indicating that, in the context of art exhibitions, one should stimulate more senses by designing the hologram with greater interactivity if judged relevant for enhancing the experience of the art. Ryong Kim et al. (2019) showed similar conclusions where they could create unique in-store experiences through natural and tactile interactions enabled by mid-air sensory feedback. Nevertheless, participants 8 and 3 mentioned that having a stronger sense of spatiality would allow experiences one could not have gained with analogue mediums and how more deeply one could be involved with the art. Furthermore, they pointed to the small scale, and the low indication of “life” in our design was a limiting factor to the immersive experience. Equally, participants 1, 2 and 3 expressed how the hologram would have been more immersive had it been large enough that one could walk around it or that the hologram would offer a wow-effect by appearing alive and strongly connected to the participant's environment.

An instance related to **clarity**, something that has certainty in its purpose, is that holograms, in nature, can unconsciously be perceived as **real** due to their illusionary physicality. Participants 2 and 3 mentioned that they somewhat felt it is more interactive, even though these statements came from the design workshop with a primitive version of the hologram. By thinking about the affective affordances to identify what made them feel like it could be interacted with, especially about them feeling the sense of realness and stimulating more senses, we can see that qualities that afford a sense of presence and physicality can
generate interactive attitudes and behaviours. This can not only be found in the responses, where participants 2, 4 and 7 said that due to it being faithful to reality and that it could communicate effectively with one since it perceives to be touched, but also with the finding of Pietroni et al. (2019), Poretski et al. (2019) and Caggianese et al. (2020). They found that, even though their study objects could be directly manipulated, the physicality of the hologram afforded for a logical understanding of manipulation (Caggianese et al., 2020; Poretski et al., 2019) and that being “embodied” or a part of something reflected more engagement and positivity (Pietroni et al., 2019). Equally, this also correlates with the connection that one gets when looking at a hologram and feeling a sense of recognition; one, to an extent, knows what one is looking at, though with added layers of illusionary perceptions. There were several occurrences where the participants stated that the hologram felt real even though they knew it was not, resulting in them experiencing something that Kesner (2014) refers to as the pleasure of recognition. This refers to an unconscious state of perceptual identification, a process that automatically occurs when looking at anything and releasing endorphins when “completed with the task”. However, the feeling of realness was also dependent on factors such as the characteristics and design of the technology.

Given that our participants expressed how the scale of our pyramid hologram was unsatisfactory while still being able to envision the afforded interaction through bodily navigation, one could argue that the most intriguing part was the 3D object itself and a feeling that the object “existed” in the same way as any other object in the environment. This could be compared to Caggianese et al. (2020), whose participants at art exhibitions were more engaged in the hologram content than in the technology itself, whilst, in tech-focused exhibitions, it was the atmospheric elements that drew the most attention. Their design allowed extensive interaction such as speech- and gesture-based navigation that enhanced each participant’s user experience with the holographic object. A similar relationship between design and user experience can also be found in our data. For instance, it was described that stronger experiences could be had when there was something more to the object, meaning, something internal specifically to the hologram, like animation or interaction responses, or external that would add to the environment, like lighting or ambient audio, or any other thing that would add to the sense of spatiality. While discussing the 3D object itself, participant 4 referred to the hologram as something that “…makes it feel more faithful to reality…” and “…this being more of an experience than what this (GIF) can do.”, meaning that holograms could allow more authentic ways to experience digital objects.

Even though our design could only allow a primitive form of interaction, our participants stated that they could examine the object far more in the holographic state than in the flat GIF. It allowed them to understand the holographic object better, as if it were part of the physical space, even though they knew it was digitally crafted. Adding natural movements to the object would further contribute to the immersion, making it feel more true to life and imitating what we see and know is real. With the added content to the hologram, the mind will then continue to seek “the solution” to the viewing (Kesner, 2014). The hologram’s unique nature equipped with the complementary technologies could gild the artwork, prolonging the experience and continued immersion emerges since there is more than meets the eye. Even if one is provided
with more information about the viewing experience, which could limit the fantasy, a concern that participants 2 and 3 had, that usually “fill in the blanks”, the discussion surrounding it could linger thanks to these multi-sensory inputs. However, participant 8 worried that if not regulated, the additional information could potentially impair one’s capacity to appreciate the hologram and, rather than enrich the experience, generate unpleasant impression overloads in the user.

**Control** refers to the level of concentration a situation requires or a lack of worries about losing control. Since the actual act of controlling the hologram was not possible during the workshop, speculations and suggestions of how it could be were discussed, mainly **bodily interaction**. Bodily interaction can again be linked to the perception of holograms “feeling real” because one or several senses are being stimulated, resulting in the user trying to act upon these affordances (Dinet & Kitajima, 2018). This take is similar to what Bach et al. (2018) observed when their participants preferred to use their bodies when navigating AR; the ability to move and use their bodies seemed to fit that exposure, resulting in a more immersive experience, which means that the affective affordances, or **access points**, that holograms have, provides implicit suggestions for potential interaction (Hornecker & Buur, 2006). Comparing with Bründl et al. (2017), they equally found that if something is affording being interacted with, it must adhere to that unconscious behaviour (unless intended); an experience must be convenient and seamless to replicate the natural interactions one does when interacting with real objects (Ryong Kim et al., 2019). Because when one is being affected by an affordance that makes one cognitively act, the fulfilment of said action must somehow be met.

**Autotelic experience** is the last component, referring to the fact that being in a flow state is pleasurable and that gaining this is directly linked to the curious intention of engaging with the activity where the pleasure comes from the act of doing. According to Turner (2010), we seek to interact with things around us to gain a positive experience or explore pleasurably. Our participants’ responses and speculations imply that technology usage in exhibitions is widely appreciated and positively met by the general public. Why this was the case for holograms, according to them, was that it is **intriguing**. This statement usually stems from the fact that we as humans are fascinated by new and intriguing things, something which all eight participants agreed on. Few, however, pointed out exactly why, or rather what, they felt was intriguing with the hologram other than it is new, cool and exciting, which could in itself be enough. Radu & Schneider (2019) and Franz et al. (2019) came to this conclusion in their studies, stating that while their participants used a new type of AR technology, their engagement compared with others who did not use the same technology was increased. They concluded that the heightened engagement was simply due to the exposure to new technology, new ways of visualising and making the content more present, similarly to what Carrozzino et al. (cited in Caggianese et al., 2020, 362) discovered during their study. To view it from an artistic perspective, Benyon (1973) discovered, disregarding the article’s old age, that holograms powerfully affect human sensory response due to its direct medium, an attribute which does not require past artistic knowledge; the illusion is self-evident (Benyon 1973, 4). The correlation between the novelty of the hologram during 1970 and the observations during modern times with similar technologies show that such technology obtains intriguing factors.
“We engage with something because it is fun, pleasurable, interesting, rewarding and we also quickly disengage when this experience becomes negative, dull, no longer fun and so forth” (Turner, 2010).

The component relating to one's self-consciousness, reflection, was discussed as potentially applying to our data. However, though our data regarding this was determined lacking, we can only provide a potential explanation. Based on how our participants expressed a perception of realness toward the hologram in a sort of wow-moment, we theorise that they were convinced in their thought that the hologram was "real" and that their conception of what is real was clouded by the hologram’s ability to replicate the real world. While this illusion lasted only a short time and was quickly dispelled when inconveniences or a lack of properties hinting to the hologram's realness were discovered, the thought of the hologram being anything other than real was seemingly not considered. Using a hi-fi version of our hologram could have provided a more precise result as we currently have no reliable method to measure participant self-consciousness. The remaining components, challenging, feedback, temporal insensitivity and freedom, did not seem applicable to our data and were not considered in this analysis.

Conclusively, with the application of Flow, we identified a total of four characteristics of holographic art: adding to spatiality, perception of realness, affording bodily interaction and being intriguing, which will be briefly summarised in chapter 9.

7.2 Seamless, Interactive Holograms Affords Co-Experience

Since exhibitions are social environments, we wanted to explore if and how holograms could prompt for co-experience. Even though our mini-exhibition did not allow for our participants to actually come and socially interact (due to the pandemic), we still got applicable feedback regarding co-experience, though more of a speculative nature.

The interaction applied to control the hologram in the mini-exhibition did not seem to be a suitable option for a group of people, but rather for lone visitors, which in itself could work, but since the majority of exhibition visitors comes in groups, the more logical means for interaction would suit a broader scale of people. The participants then suggested bodily interaction, as mentioned above, to be the more suitable option which makes sense since that alone automatically invites multiple people to interact, as it benefits the sense of co-experience since when a product affords effortless, collaborative activities, it is perceived as positive (Forlizzi & Battarbee, 2004). To achieve co-experience then, one should adhere to the options in which one or several can analyse the object in terms of the resources offered for observing, accessing and interacting with it (Hornecker & Buur, 2006), which in turn also contributes to the object itself; supporting it being perceived as “real”. Depending on the intention behind the usage of the hologram, we would argue that if one is designing for immersion, then the seamless bodily interaction would be better. However, if it is for individual, explorative or more detailed-heavy/studying purposes, then the direct controlling would be suitable. In our case, the nature of the hologram affords it to be real and free. So why would one break that illusionary “barrier” with a controller?

As mentioned before, when referring to autotelic experience, several participants and resources (Bründl et al., 2017; Turner, 2010; Kocsis, 2009) have mentioned the enjoyment
increases if more people are involved in the experience; that seamless interactive holograms can foster co-experience. Kocsis (2009), for example, mentioned that with added sensory and interactive inputs, the opportunity for co-experience emerges and, in turn, heightened enjoyment since now all who are in the same space will benefit from these attachments since it creates a sense of togetherness. Exhibitions are social environments and therefore must include everyone there; as Pietroni et al. (2019) wrote, facilitators must ensure that any visitors must not feel abandoned or be left with frustration.

In addition, when the participants spoke about interactivity, they also mentioned that interactivity could foster heightened immersion. By comparing this statement to what Ivey and Sanders (2006) found when conducting their study on how an exhibition space should be designed to prompt for co-experience, they concluded that by applying a coherent environmental narrative that works naturally with the totality of the space, the sense of immersion and co-experience was heightened. Meaning, if one wants to achieve immersion or good experiences, one must think of the space in which the experience will unfold and adhere to all of the crucial parameters that reflect the whole. “...the attention towards digital contents decreases rapidly if they do not offer a good connection with the real contents of the museum and if the storytelling is not really engaging” (Pietroni et al., 2019).

7.3 “It always depends!”
As mentioned in 7.1, immersion can then be seen as a product of holograms’ ability to add depth and create additional dimensions of the user experience by enhancing spatiality. In this, our data state that the addition of atmospheric elements, such as lighting, audio or animation, can suffice to add to spatiality. This is consistent with Forrest (2013) and their research on experience quality and Atmospherics, touted originally as “the conscious designing of space to create certain effects in buyers“ (Kotler, 1974, p. 50 cited in Forrest, 2013). Relevant to our data, atmospherics describe how sensory and emotional mechanisms can influence people’s behaviour by manipulating the environment’s design (Forrest, 2013). For instance, “good” lighting positively correlates with visitors’ revisit intentions in a museum setting, while in another study, atmospheric elements such as lighting, colour, sound, and layout were recurring themes (Forrest, 2013). However, similar to Pietroni et al. (2019), our data also imply that not all holograms would benefit from technological additions, i.e. lighting, sounds, animations, and other elements that add to spatiality. However, a majority would benefit from this and enhance the immersiveness of an experience. Furthermore, the data describes how one must carefully analyse the need for such additions in the context of the intended usage and decide if the implementation of it is beneficial, rather than simply adding something more for the sake of adding more. For example, in our mini-exhibition, the ambient music we had included was, by enlarge, perceived as an excellent complement to the environment and spatiality.

In contrast, participant 7 noted how, without the music, the hologram could have been perceived as a less engaging and stale visual presentation. Furthermore, using additional attachments could have been overwhelming and exhausting if not carefully balanced. Then, what made the ambient music appropriate for our situation was how it subtly contributed to
the idea that the hologram was a real living sea angel captured on video. To achieve this, a hologram, as mentioned in chapter 5.2, had to appear authentic. Therefore, contextually informed ambient sounds and animation were implemented to the design of the sea angel, further emphasising the significance of replicating the real world, such as the illumination of the hologram, audio quality and the holographic content with the dynamic of the space it occupies.

Moreover, participants 1, 2, 4 and 5 stated that holograms are, in more ways than one, an inclusive medium. They pointed out that more people, in general, would feel more inclined to visit museums if the mediums used to show the art involves a broader audience. Participant 4 stated that the art world might be intimidating for less involved people, but when using other means of visualising art, like technology, it becomes more inviting (Benyon, 1973). While some attitudes stay the same, disregarding an individual's background and interest, new ones emerge if said interest is met with what as well as how it is displayed. This, in its turn, can generate a stronger sense of immersion since the subject of interest is heightened by the hologram. For example, if a person has an interest in technology and aquatic life (by exemplifying our mini-exhibition), the social aspect is enlarged and encouraged to be expressed in comparison to if it were to be displayed traditionally. This could equally be applied to digital artists today but are limited with the current means for visualisation. Either way, it always depends on the context in the end.

By basing the knowledge of the characteristics of holograms in relation to what we have managed to explore regarding co-experience, we have formulated two takeaways for one to more appropriately apply holographic art in exhibitions, which will be presented in chapter 9.

8. Limitations of the Study

When gathering participants, the people we had reached out to were all individuals we knew, and they all knew each other, something that could affect the results due to the potential sense of comfort amongst each other. The discussion in the workshop may have been affected by this fact. Likewise, the responses we got could have been altered slightly towards the positive side, thereby not giving us genuine feedback. To combat this issue, contacting Västerbottensmuseum or Umeå Academy of Fine Arts could have been a potential solution. However, this sampling strategy could also have generated another issue as it is time-consuming and highly unpredictable, likely resulting in an insufficient quantity of respondents.

Furthermore, when sending out the video of the mini-exhibition, we got some responses from four of our participants saying that they had a difficult time answering the questions regarding their experiences. Not being there in person caused them to feel a bit distant from the exhibition and could therefore not express themselves fully. Either way, almost all of them acknowledged and respected the reason why this method was employed and answered as truthfully and thoroughly as possible, which we sincerely appreciate.

Just as Mörtsell (2018) encountered through her study, we also found that by applying the “raw” version of the Flow theory, the context of the studied problem will disappear slightly. It most certainly helped us understand our study object, but we found, throughout the analytical
process, that the components of Flow were too broad and when trying to apply data to some of them, we had difficulties differentiating them and knowing where to draw the line of something potentially being way too vaguely interpreted. The ability to find signs of the other components, which we did not uncover in the existing framework, would have been enhanced if an adequate framework had been employed.

Lastly, our focus has been explicitly on how the viewer experiences holograms and how they can benefit art exhibitions; nothing has extensively been mentioned about the artists’ perspective. However, some comments were acknowledged during the design workshop regarding this, which made us consider this fact; a work of art needs to be created by an artist to exist, and if the means of displaying and expressing their art through holograms do not align with how they envision it to be, then they would not use it.

9. Conclusion

In this study, we explored the experiential characteristics of holographic art and how we can better inform holographic art exhibitions through an iterative, experience-centred design approach over two studies and generated new knowledge, which may be used to design for more immersive and co-experience-centred contexts. Two research questions were posed at the beginning of this thesis. Firstly, the four experiential characteristics of holographic art that we found through analysing the affective affordances within the theory of Flow are:

- **Holograms adding to spatiality** – being perceived as physical, it immerses the viewer with its illusionary ability to occupy space, just as real objects;
- **Perception of realness** – the nature of a hologram gives off the illusion of being physical with properties that imitates the real world;
- **Affording for bodily interaction** – due to it being perceived as “real”, one’s interactive behaviour instinctively triggers, and one then acts upon these impressions, and;
- **Holograms are generally intriguing** – stems from human behaviour of being curious about new things and thereby invites positive engagement.

Then, when we experience a hologram, a technology, something that in nature does not correlate with our “natural” reality, we are removed from our world of physicality and cognitive understanding and are re-situated in an experience with the holographic artwork and its surroundings. Furthermore, thanks to these unique characteristics of holograms, this new experience is interpreted by our, now detached, individual knowledge and familiarity of “reality” and the past perceived affordances of the environment together with the affordances of the hologram, hence creating a “new experience” of art unlike any other.

As we have acknowledged, due to our inability to gain contextual data about co-experience, we have managed to formulate two takeaways on which future designers could expand upon when wanting to utilise holograms in art exhibitions. These being:

- One should not set any barriers for multiple, seamless opportunities for interaction since the hologram affords spatiality within a space where the probability of several people being in it is high, and;
One should also make sure that not only the interaction is seamless, but also the attachments in which to enhance the holograms spatial properties, because if the hologram emits more sensory inputs that affect more than one person (i.e. by applying audio to the room in which the hologram is situated in rather than just to the hologram itself) more can then benefit and experience the exhibition together, thereby creating a stronger sense of co-experience.

Conclusively, we hope that with these findings, one would be informed about holographic art's capabilities by now being more knowledgeable on what it can generate. With more understanding of the attitudes and experiences with the medium, we have paved a clearer way for future developments, either technological or contextual, to expand upon art exhibitions. By providing more options for visualising art or enhancing desired experiences, one can now diminish the current experiential barriers with other technologies that do not seem suitable and widen the possibilities of positive experiences with visitors about technological art. Because why we engage with instances, technological in our case, is to seek pleasure, and if the said instance has been carefully designed towards the one who is engaging, the probability of gaining this pleasure is enlarged, hence proving that by analysing visualisation technologies from an experience-centred approach is fruitful for future development for positive interactions. Also, for designers within HCI, the knowledge generated here can equally be applied to the general future usage of holograms as well, as in our findings not being constrained to solely being useful for artistic contexts. As our research questions state that this thesis seeks to explore holographic art, the characteristics found, we believe, do go outside of the artistic field as well.

We would suggest that future research should continue from “where we left off” in our iterative process and design a physical, holographic art exhibition for people to interact with and experience without having to follow the restrictions caused by a pandemic. We believe that by doing so, more empirical data would emerge regarding co-experience, which then could further be iterated to the point of confident implementations of holograms in art exhibitions all around the world. Furthermore, the artist’s perspective should be investigated further because it is critical to understand how the artist views their creation and how it relates to viewers' experiences.
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xtokashx. 2016. *Miku Expo 2016 Live Concert In Toronto - "Miku" feat. Hatsune Miku by Anamanaguchi - 1080 HD.* Available at: [https://www.youtube.com/watch?v=KNrdGx69pCo&ab_channel=xtokashx](https://www.youtube.com/watch?v=KNrdGx69pCo&ab_channel=xtokashx)
Appendix 1: Design Workshop: Information Sheet

Hello everyone! Here’s more information about the workshop! The idea is that we will hold three sessions with three participants in each (so you are 9 in total participating in the study), but you will only need to attend one! Here’s how we’ll split up the sessions:

Session 1: Friday 5 March 6 pm
Session 2: Saturday 6 March 12.30 pm
Session 3: Saturday 6 March 3 pm

I would like you to respond to this message with answers to the following questions:
- Which time is your first and second choice, or if it does not matter which time you get?
- Do you have a tablet? Yes/No
- What is your address? (This info will not be shared with anyone else, it’s just for us to know where to post an item for you to use during the workshop).
- Briefly describe what you think an optimal digital art exhibition should have.

Once everyone has responded, I will send the workshop thing and let you know what time you got. On Monday, you will receive your final message from us, which will include some short videos to watch before the workshop kicks off and the link to it.

Just let me know if you have any questions or if you no longer want to participate. We do not intend to keep you as a participant against your will; that would be wrong.

See you!
Appendix 2: Participant Demographics

Participant 1 - the Choir Singer
- Age: 24
- Occupation: Student
- Interests: Choir music, the climate
- Previous experience of museums and exhibitions: Broad experience

Participant 2 - the Gamer
- Age: 24
- Occupation: Working
- Interests: Video games, true crime
- Previous experience of museums and exhibitions: Broad experience

Participant 3 - the Artist
- Age: 25
- Occupation: Student
- Interests: Drawing, video games
- Previous experience of museums and exhibitions: Very extensive experience

Participant 4 - the Illustrator
- Age: 26
- Occupation: Student
- Interests: Illustration, reading
- Previous experience of museums and exhibitions: Very extensive experience

Participant 5 - the Composer
- Age: 31
- Occupation: Student
- Interests: Music composing, future visualisation
- Previous experience of museums and exhibitions: Very extensive experience

Participant 6 - the Coffee Drinker
- Age: 41
- Occupation: Student
- Interests: Video games, drinking coffee
- Previous experience of museums and exhibitions: Lacking experience

Participant 7 - the Storyteller
- Age: 25
- Occupation: Student
- Interests: Drawing, storytelling
- Previous experience of museums and exhibitions: Very extensive experience

Participant 8 - the Movie Watcher
- Age: 26
- Occupation: Working
- Interests: Talking about and watching movies
- Previous experience of museums and exhibitions: Broad experience
Appendix 3: Design Workshop: Inspirational Design Kit

Hello again! Here's some material we'd like you to have a look at before the workshop. These videos will serve as a bit of inspiration and give you a deeper insight into the potential of holograms in artistic and creative exhibitions, while the workshop itself will have more focus on discussion, speculation and creative exploration. Watch them whenever you want and in any order but before the workshop, of course. For each video, I have written a small paragraph on why we chose the respective video as food-for-thought. If there's anything you're wondering about, just write! You will also soon receive a little thing, a plastic disc with a bit of adhesive putty, in the mail that we will use in the workshop; keep it safe! Please write to me when you receive it, so I know it arrived safe and sound!

Below are the links to the workshop. Make sure you get there on time!

Friday 6 pm:
https://umu.zoom.us/j/61481278918?pwd=eF1td1ZXCxGZxbzkoY2NrMENWQnIZUT09

Saturday 12.30 pm & 3 pm (we use the same room for both meetings on Saturday):
https://umu.zoom.us/j/63162365897?pwd=aWp2V1FzeFF5S1ZtOUVHdXBGNx6QT09

The first video actually has nothing to do with holograms but rather about technical uses for art and exhibitions. It shows what it can look like, what can be done, and we hope this one gives some creative thoughts in your head. It's also made by one of my favourite YT channels, so please enjoy it.
https://www.youtube.com/watch?v=pS3CHHT9mqg&t=4s&ab_channel=Rachel%26Jun%27sAdventures%21

These two videos are very similar as they both use the same hologram technology (Pepper's Ghost) and are from music concerts. Although these are from a context that is not what we are going to examine, these are meant to show how the technology is used today, the potential of it and some really sweet tunes, if I do say so myself. If you really don't feel like watching these all the way through, then a minute should be okay; we just want you to see how this kind of technology was used in the past.
https://www.youtube.com/watch?v=KNrdGx6opCo&ab_channel=xtokashx
https://www.youtube.com/watch?v=uJE8pPfVRo&ab_channel=2Pac-King

And finally, here are three super short videos showing some of the latest developments in holograms and what they can do! It's a bit of a shame that Corona is still going strong. Otherwise, we'd be doing our very best to do this workshop at university with some of the more advanced hologram techniques, but I think what we're going to do is going to be fun anyway!
https://vimeo.com/223640605
https://www.youtube.com/watch?v=GNoOixkXmYQ&ab_channel=ikinamo
https://www.youtube.com/watch?v=4pJxdNRA1CM&ab_channel=LookingGlassFactory

Before the workshop, we also want to make sure that you are ready and that you have everything. There's not much to fix. This is your checklist:
- Fully charged mobile/tablet and screen at full brightness
- Watched the videos
- The plastic disc you received in the post
- Transparent tape
- Sitting in a room that can be dimmed or turned off
- Computer with Zoom and camera

See you at your respective workshops!
Appendix 4: Design Workshop: Interviews- and Discussion Schedule

Interviews
Since the interviews were semi-structured, these are just indicative questions. The precise wording of the primary questions and the wording of secondary and additional questions were determined by the subsequent direction of each interview and interviewees’ answers. The answers to these and the discussion questions comprise the primary data.

<table>
<thead>
<tr>
<th>PRIMARY SEMI-STRUCTURED QUESTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is your experience of museums, art exhibitions or similar physical environments?</td>
</tr>
<tr>
<td>2. Do you have any experience with technical or digital art in an exhibition context?</td>
</tr>
<tr>
<td>3. What is your attitude towards the use of technology in the arts?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SECONDARY SEMI-STRUCTURED QUESTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>- What makes you want to go there? (1A)</td>
</tr>
<tr>
<td>- What makes you refrain from going there? (1B)</td>
</tr>
<tr>
<td>- If you do, what did you think of it? (2A)</td>
</tr>
<tr>
<td>- Do you know WHAT exactly it was that you liked/disliked? (2B)</td>
</tr>
<tr>
<td>- Follow-up question if answering &quot;NO, I have no experience...&quot;: If you imagine you are at a digital or technical art exhibition, how would you like the art to be presented and why? (2C)</td>
</tr>
</tbody>
</table>

Discussions
Since the discussions also were semi-structured, these are just indicative questions. The precise wording of the questions and the wording of additional questions were determined by the subsequent direction of each discussion topic and discussion participants’ answers. The answers to these and the interview questions comprise the primary data.

<table>
<thead>
<tr>
<th>PRIMARY SEMI-STRUCTURED QUESTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What differences did you experience between these two types of visualization (hologram versus flat screen GIF)?</td>
</tr>
<tr>
<td>2. What kind of digital art (which is our focus), more specifically, do you think is appropriate for holographic use?</td>
</tr>
<tr>
<td>3. Is this kind of technology, if you don’t think about how a good alternative to how you would like a work of art (or yours) to be experienced?</td>
</tr>
<tr>
<td>4. How do you think the public will react to this type of use?</td>
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<tr>
<td>5. What other possibilities do you see with holographic use?</td>
</tr>
<tr>
<td>6. Do you think holographic use can enhance feelings like immersion?</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>SECONDARY SEMI-STRUCTURED QUESTIONS</th>
</tr>
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<tbody>
<tr>
<td>- Why? (2A)</td>
</tr>
<tr>
<td>- Why do you think holograms can enhance these factors? (3A)</td>
</tr>
<tr>
<td>- What is it about holograms you think stands out from 2D, for example? (3B)</td>
</tr>
<tr>
<td>- Do you think holograms will attract new visitors? (4A)</td>
</tr>
<tr>
<td>- Why? (4B)</td>
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</tbody>
</table>
Hello again! Since Corona really doesn't want to settle down, we, unfortunately, have to have the last section of our data collection remotely again, and we don't want to put you in any danger either. So with that, we've recorded our "upgrade" of the hologram that you got to be a part of developing last time. We have analysed your responses and developed accordingly, and so with this message and accompanying video, we want to get the final piece of the puzzle; your thoughts! After watching the video, we would like you to send detailed, written answers as soon as possible!

Here is the link to the video. It is best viewed on a larger screen (like a computer) with headphones:
https://drive.google.com/drive/folders/15k3ePgDb6P5PHUVnV_T7F_6fxHeo6KD7?usp=sharing

The hologram in the video is based on the following feedback from you:
- Animated graphics
- Atmospheric music
- Direct manipulation/interaction
  - The interaction was done with a PS4 controller and moving it around
- Larger in size (about 26 cm, which may not show up well in the picture)

The questions we want you to answer are:
- In general, what do you think? Why do you think the way you do?
- Regarding the interaction, what did you think of it? Our approach was that as a visitor, you have control over how the hologram moves. Would you have preferred some other way regarding the interaction, like gesture-based or none at all; like you, as a visitor, see it "living its life freely around you" or something else? Justify.
- How do you think such an installation would work with a group of visitors? By this, we mean how do you think the interaction with the hologram would be between a single visitor and a group; would there be any difference in "admiration", or would it be beneficial to have such a visualisation?
- How could it be improved from this stage? Why do you want such an improvement?

Thank you very much for your contribution! We appreciate you so much, and we really hope you take care of yourself; soon, the effort will be over!

/Matilda & Johannes
Appendix 6: Zoom Call Screenshots from Design Workshop & Mini-Exhibition Video Setup

(Figure 1: A screenshot from the Zoom call during the Design Workshop - Session 1)

(Figure 2: A screenshot from the Zoom call during the Design Workshop – setting up the Pepper’s Ghost, Session 1)
Appendix 6: Zoom Call Screenshots from Design Workshop & Mini-Exhibition Video Setup

(Figure 3: A screenshot from the Zoom call during the Design Workshop - Session 2)

(Figure 4: A screenshot from the Zoom call during the Design Workshop - Session 3)
(Figure 5: A screenshot depicting the sea angel taken from the video showcasing the mini-exhibition)
Appendix 7: Student Contributions

During this thesis, the division of work followed a structure that was constantly communicated between each other over Facebook Messenger and Discord in the form of continuous updates on progress with each task. Both our mindsets have been wanting both opinions on each task even if it was done more or less completely by one. The impact and views of the other should always be communicated and considered in the tasks final form. The structure could be viewed as follows:

- In the very beginning, both Johannes and Matilda searched together for relevant articles and conducted a small literature review of the ones that were found.
- The abstract and keywords were written and edited by Matilda & Johannes.
- The introduction was written by Matilda and was read through and edited by both.
- The purpose, research questions and aim were written by Matilda, but only the research questions were influenced and edited together with Johannes.
- The chapter on the theoretical framework and related research was written by Matilda and read through by both.
- The method chapter was written by Johannes and edited by both.
- The result chapter was written and edited by both, where Matilda got an added task to find relevant quotes to add to the text.
- The discussion chapter was almost exactly divided so that Matilda wrote 7.3, Johannes wrote 7.2, and both wrote 7.1.
- The limitations chapter was written by Matilda and edited by Johannes.
- The conclusion chapter was written by Johannes and edited by both.
- The formulation and structuring of the reference list were done by Matilda and edited by both.
- The appendices were written, translated, and structured by Johannes.

Regarding the work which did not include the writing of the document, the design workshop, the mini-exhibition, and the analysis was done as follows:

- The pre-workshop research regarding the most optimal methods and designs of the activities used in the workshop was done by Johannes and evaluated by both.
- The design of the workshop was done by Johannes and re-designed by both.
- During the workshop, Matilda was “the face” of the workshop and held the interview, whereas Johannes made sure that all the technology was working and took notes and introduced the phases of the workshop.
- The transcription of the interviews and the general data from the design workshop was done by Johannes.
- The analytical phase for both studies (thematic analysis) was done by both over the digital workshopping platform Miro.
- The communication with the participants was held by Matilda but the text written to them was written by both.
- The construction of the mini-exhibition was done physically by Matilda in her home but was edited, animated, orchestrated and tweaked by Johannes.