The Effect of VR Hardware on User Experience in relation to transportation and reading intention

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Master thesis

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January 2022

Abstract

Digital literature is a relatively new form of literature that intertwines literary and digital components to create new experiences. Virtual reality can create possibilities to experience digital literature and could potentially be used as a tool for promoting literature. This study examined whether virtual reality head-mounted displays of higher general quality have a more positive influence on reading intentions than low-cost, cardboard head-mounted displays. It is hypothesized that this effect is mediated by the user experience of the head-mounted displays, which in turn affects transportation and presence effects. A between-subjects experiment was conducted to test this conceptual model. Contradictory to the proposed model, the results showed that the type of head-mounted display did not change reading intentions when used for short digital literature experiences. However, a positive relation was discovered between the user experience and the degree of experienced transportation and presence. This study suggests that the user experience of head-mounted displays affects important aspects of the VR experience. At the same time, it is concluded that cheaper head-mounted displays could still be used for short experiences of digital literature without compromising on positive effects like increasing reading intentions.

Keywords: digital literature, virtual reality, head-mounted displays, reading intentions, user experience

Contents

Introduction

As technology advances, new possibilities arise in all kinds of areas. One of these areas is literature. While the word 'literature' will most likely evoke the thought of text on paper, advancements in new media and technology have created a new form of literature called *digital literature,* which utilizes these advancements. Digital literature is an interplay between literary and digital components. It can be defined as a form of literature that is created digitally and which can only be read or experienced by digital means (Bouchardon, 2017). An example of digital literature is 'Lijn 3', a mobile app by International Silence (*Lijn 3*, n.d.) which utilizes augmented reality to show users parts of a poem floating around associated sites while travelling by tram through Amsterdam. The application combines digital (augmented reality) and literary (poetry) components to create digital literature. It is important to recognize that books read on an e-reader or e-books should not be considered digital literature. If the book's author did not create the book to be read on a particular medium, it should not be considered digital literature, even if it is read digitally.

One of the tools that can be used to create and experience digital literature is virtual reality (VR). VR enables people to be mentally transported to virtual environments of any kind (Lombard & Ditton, 1997). While research on VR is not new, the increase in accessible products on the consumer market is becoming noticeable, opening new possibilities. An experiment by Pianzola et al. (2019) suggested that VR could be used to promote reading. They hypothesized that people who read a narrative text in a VR environment would be more inclined to read the story further compared to people who read the same story on paper. The results showed that the VR environment increased transportation into the story world, which in turn increased the reading intentions of the readers who read the story in VR.

Transportation indeed can be defined as a way in which a person feels like they are transported into a story world. When transported into the story world, the reader becomes

immersed in the narrative (Green & Brock, 2000). Transportation has even been shown to have a persuasive function as ideas portrayed in a narrative are more likely to be accepted when a person is transported (Green & Brock, 2000). While transportation is possible to occur in a VR environment (Green, 2021), it should be mentioned that transportation is mainly achieved by the narrative and is different from mental transportation into a VR environment, which is called presence (Lombard & Ditton, 1997). Both concepts are pretty similar, and Pianzola et al. (2019) argued that because of the presence that occurs in VR, readers in VR are more inclined to get transported into the story world. They did, however, not measure presence in their experiment.

Although the experiment by Pianzola et al. (2019) showed promising results regarding the increased reading intentions of reading literature in VR, it can be argued that showing a chunk of text in VR does not match the definition of digital literature. The way in which the literature in the VR environment was presented by Pianzola et al. (2019) had more similarities with an e-book being presented in VR rather than digital literature. The narrative presented in virtual reality did not contain elements that could be exclusively experienced by digital means, as is essential according to the definition of digital literature by Bouchardon (2017). The current study aims to explore digital literature further by utilizing the digital component of digital literature more. An experiment will be conducted using spoken poetry being read in a VR environment with supporting visuals and animations that are especially created to be experienced while the poetry is being listened to.

In addition to further examining the link between transportation, presence and reading intentions, the current study will incorporate and examine the role of VR hardware in the context of digital literature. Placing people in a virtual environment can be realized using a VR head-mounted display (HMD). These HMD's can be separated into two categories: standalone and tethered HMD's (Angelov et al., 2020). Standalone devices contain the necessary hardware and computing power required to show VR experiences, while tethered devices require an

external computer to control the device. A subcategory of standalone devices are the mobile HMD's that do not have any computing power built-in but consist of a smartphone slot in which a smartphone must be placed to act as the computing device and the display. Tethered devices can display the highest quality of VR because they are not limited by the built-in computing power of the HMD, while standalone and mobile HMD's are cheaper and more accessible for consumers (Angelov et al., 2020).

One of the most accessible HMD's is Google Cardboard. Google Cardboard is an open-source, mobile HMD design created by Google that can be produced entirely with low-cost materials (Google, n.d.). Powell et al. (2016) conducted an experiment in which they evaluated the VR experience using a Google Cardboard HMD. They concluded that the VR quality of the cheap HMD could not match the experience that more expensive HMD's can offer, but that the low-cost HMD should not be disregarded considering its greater accessibility to the broader public.

In addition to varying VR experiences resulting from the difference in computing hardware, an underexposed difference between the types of HMD's could be the user experience. The quality of Google Cardboard HMD's is generally lower and consists of fewer features than expensive HMD's. Google Cardboard products are made out of cardboard and other low-cost materials (Google, n.d.). It would be interesting to assess how users perceive the overall experience of using an HMD of lower overall quality. If users are being disturbed or distracted by the quality of the HMD, it could negatively impact the transportation or presence effects. Especially the transportation effect could, in its turn, negatively influence the intention to read further, as suggested by Pianzola et al. (2019)

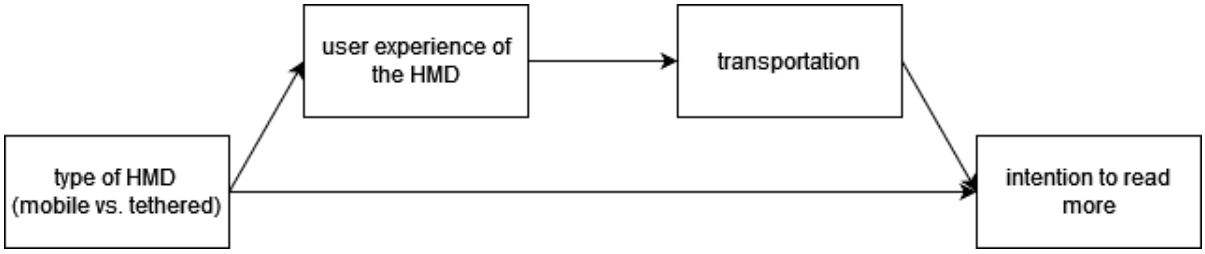
Pianzola et al. (2019) demonstrated that virtual reality could be used as a tool to promote reading by increasing the user's reading intentions of a narrative text. The current study seeks to examine whether these results still apply when cheaper mobile HMD's are used to experience

digital literature. It is likely for the average consumer to get introduced to VR with a cheaper (mobile) HMD. As a result, it is necessary to know whether accessible HMD's can achieve the desired results of motivating to read more if the intention is to use VR as a tool to promote reading effectively.

This study proposes a conceptual model based on the discussed literature, which illustrates the hypothesized relationship between the type of hardware and the intention to read more with the user experience of the hardware and transportation effect as mediators. Figure 1 presents this model.

Figure 1

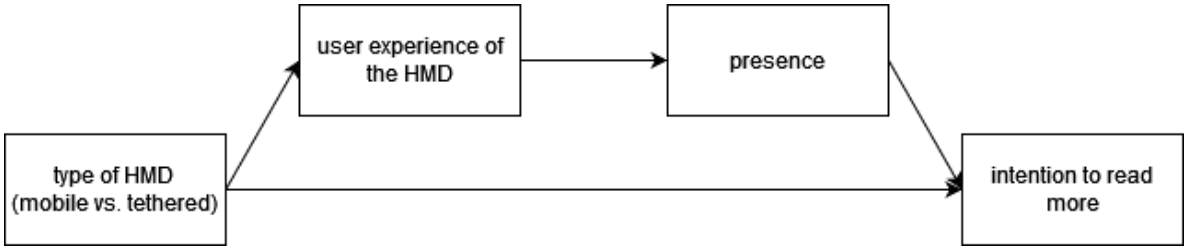
Proposed conceptual model 1



Pianzola et al. (2019) suggested that presence, which is more commonly used in VR research, could also be one of the reasons that enabled the increased reading intentions when reading in virtual reality. They did, however, not incorporate it in their research. It could be interesting to assess the effect of presence on the reading intentions and whether the user experience of the HMD influences it. Therefore a second model is proposed that focuses on presence instead of transportation as a mediator. Figure 2 presents this model.

Figure 2

Proposed conceptual model 2



Based on the considerations outlined above, the following research question is presented: *To what extent does the type of HMD relate to the intention to read more and to what extent is this relationship mediated by the user experience of the HMD and the degree of transportation and/or presence perceived by the user?*

Theoretical Framework

Digital literature and VR

The most common definitions of digital literature involve the presence of literary and digital components in a work of digital literature (Bouchardon, 2017). In essence, digital literature must be created with a digital medium, and it must be experienced via a digital medium. Digital literature cannot be printed without losing (parts of) its meaning. Digital literature is a broad concept. Therefore it is important to define it more accurately and specify what should be considered digital literature.

Bouchardon (2017), by considering e-books, argues that the definition of digital literature could be more explicit. Generally, an e-book is not considered digital literature because it can still be experienced the same way when printed. Nevertheless, many e-readers have functions that make it possible to interact with literature in a way that is impossible on paper. An e-reader can, for example, enable users to use hyperlinks or make digital annotations of the text. It could be argued that this experience cannot be printed. This raises the question of whether e-books should now be considered digital literature only because literary and digital components coexist. According to Bouchardon (2017), this should not be the case. Therefore, they suggested a tension-based definition that states there should be a tension between digital and literary components. This means that only the coexistence of literary and digital components in an experience is not enough to be considered digital literature. An experience should only be considered digital literature when the roles of the literary and digital

components are meaningful and share a connection that is necessary to experience a work as intended.

Digital literature that meets the discussed definition of Bouchardon (2017) can be found in different kinds of ways. An example of digital literature that fits Bouchardon's (2017) definition is 'Lijn 3' by International Silence (*Lijn 3*, n.d.). This mobile app utilizes augmented reality to show parts of a poem floating around sites in Amsterdam. The poem can be fully experienced by taking a tram ride through Amsterdam that passes by all associated sites. Notice how the digital (augmented reality) and literary (poem) components depend on each other to maintain the intended experience.

Another technique that could be used to experience digital literature is VR. In recent years VR has been getting more advanced and accessible to consumers. VR enables people to immerse themselves in a virtual environment and experience a feeling of presence (Lombard & Ditton, 1997). Presence occurs when a person feels like they are being transported into another environment. The person experiencing presence will feel like they are mentally in another place than their body is. The ability to experience presence through VR makes VR a technology that can enable readers to experience and interact with digital literature in new ways. An example of the use of VR in digital literature which utilizes the feeling of presence is 'ROZSYPNE', a story created to be experienced in VR about eastern Ukraine in 2014 during the civil war (*ROZSYPNE*, n.d.). The creators of the experience wrote a story in which users could experience a bit of the impact which the civil war had on Ukraine with their own eyes. The experience tells a story by actively using a changing virtual environment. The virtual environments created for the experience are essential to understand and experience the story as intended by the creators. Again, the literary (the story) and digital (telling the story by using a virtual environment) components depend on each other.

Transportation, presence, and intention to read more

Pianzola et al. (2019) conducted an experiment that suggested that VR could be deployed as a tool to promote the reading of fiction. One of the relationships the study examined was the relationship between transportation and intention to read further. This relationship is important for the current study. Therefore their study will now be discussed more comprehensively.

The study by Pianzola et al. (2019) theorized a model containing the relationship between media format (VR vs. print) of a narrative text and the intention to read the text further. The researchers argued that narrative absorption and empathetic engagement with fictional characters would mediate this effect. It was discussed how narrative absorption and empathy would increase reading enjoyment, thus increasing reading intention.

The researchers suggested that using VR while reading a narrative could result in a more involving experience than reading on paper because of fewer distractions from the real world. Therefore, a more involving experience could lead to a higher level of narrative absorption. The researchers used the Story World Absorption Scale (SWAS) by Kuijpers et al. (2014) to test narrative absorption. Pianzola et al. (2019) discussed the subsections of SWAS consisting of 'attentional focus', 'transportation', 'emotional engagement' and 'mental imagery'. For the current study, only the subcategory transportation is of importance. As defined by Green & Brock (2000) and discussed in the study by Pianzola et al. (2019), transportation is the deictic shift from the real world into the story world of a narrative. Pianzola et al. (2019) noted that presence and transportation share similarities but cannot be compared directly. Presence focuses on the virtual environment, while transportation focuses on the story world. However, the researchers argued that presence in VR transports readers easier into the story world as the shift from the physical world into the virtual environment has already happened.

An experiment with 83 participants was conducted to test their hypotheses. Participants were either assigned to a VR or print condition. In both conditions, participants got to read the first chapter of the novel "Alice's Adventures in Wonderland". Participants in the VR condition got to read the chapter on virtual web pages in a virtual environment. An autumn park was used as the background scenery in the virtual environment. Participants in the print condition got to read the chapter on printed pages. To measure the intention to read further, participants were asked after the reading experience if they would read Alice's Adventures in Wonderland further if they had the time.

The results showed that VR significantly increased the intention to read further compared to participants who read the printed text. However, instead of narrative absorption and its subsections, only transportation mediated the effect of VR on reading intentions. This means that in the VR condition, more transportation was experienced, which resulted in higher reading intentions.

The current study seeks to find out more regarding the relationship between transportation and reading intentions in the context of digital literature. While the discussed study did utilize VR as digital means to present literature, it did not fit the definition of digital literature by Bouchardon (2017). The literature presented in the VR condition of the study by Pianzola et al. (2019) did not use any elements that made the digital and literary components dependent on each other. The literature did not change in any meaningful way when the text was shown in the print condition. Using VR to experience digital literature could be by matching the story world and the virtual environment and making them dependent on each other. Even in a digital literature setting, VR would likely still lead to an opportunity for transportation to occur, as shown by Pianzola et al. (2019). Therefore the following hypothesis is presented:

H1a: A higher degree of transportation increases the intention to read more.

While Pianzola et al. (2019) did not measure presence in their research, it still appears to be an important factor considering it increases the feeling of being mentally present in the virtual environment (Lombard & Ditton, 1997). It is also suggested to make it easier for transportation to take place (Pianzola et al., 2019). Due to the similarities of presence and transportation, it would be interesting to examine whether the feeling of presence has a comparable effect on reading intentions as transportation. The following hypothesis is presented:

H1b: A higher degree of presence increases the intention to read more.

User experience

In addition to examining the role of transportation and presence as influencing factors on reading intention, the current study also aims to investigate the role of VR hardware in a digital literature context. The current section seeks to explore how the user experience of VR hardware could play a role for the users.

To better understand the role of user experience and VR hardware for digital literature, it is important to define 'user experience'. Hassenzahl & Tractinsky (2006) describe user experience as an experience about more than just the functional characteristics of a product. They state that user experience focuses more on a person's emotional and affectional states when using a product. A more explicit definition of user experience can be found by Nielsen Norman Group firm which specializes in user experience research (Experience, n.d.) and is generally well known in the industry. According to Nielsen Norman Group, an excellent user experience needs to ensure that the user of a product can do what they need without any difficulties. The product must be a pleasure to use, and the product must give the users more than they say they want. From both definitions it could be concluded that the user experience is about giving the user an effortless and fun experience when using a product.

Placing people in a VR virtual environment can be realized using an HMD. Two important parts of an HMD are the display and tracking sensors. The display of the HMD needs to be placed close to the eyes to create the VR effect. In addition, modern HMD's have sensors that can track where the user is looking. Angelov et al. (2020) examined and compared different tethered HMD's. They examined the display, tracking, controllers and, ergonomics. All four elements will briefly be discussed. The quality of the display is, according to the researchers, one of the most critical aspects of the VR experience and can even lead to a higher presence in the virtual environment. The tracking parts of the HMD determine where the user is looking in the virtual environment. This tracking needs to be precise and fast for the best experience. The accuracy and speed of the tracking can also influence presence (Cummings & Bailenson, 2016). Controllers enable users to interact with the virtual environment. Controllers can, for example, determine where a person's hands are positioned at each moment. The last aspect examined by Angelov et al. (2020) is the ergonomics of the HMD. The ergonomics include things like the design, comfort and usability of the HMD. The researchers note that it is difficult to determine the overall ergonomics of an HMD because of its subjective elements. Weight is an ergonomic element that can be assessed and which is important for the user experience according to the researchers. They state that the weight should be minimal.

According to the definition of user experience, as discussed above, the examined factors could all influence the user experience. Furthermore, some of the most important factors like display and tracking have even been suggested to influence the presence in the virtual environment (Angelov et al., 2020). Additionally, ergonomics could play a role in influencing presence (Cummings & Bailenson, 2016). In the study by Pianzola et al. (2019), it is suggested that VR can help by removing distractions from the real world when reading a narrative. It is argued that by having fewer distractions, higher levels of narrative absorption can be reached, of which the transportation effect is a component. HMD's that are uncomfortable or too heavy

could potentially produce new distractions for the user, which could negatively impact transportation and presence.

Based on the discussed literature, the following hypotheses are presented:

H2a: A better user experience of the HMD enhances the user's transportation into the poem.

H2b: A better user experience of the HMD enhances the user's presence in the virtual environment.

Types of Head-Mounted Displays

If the user experience of an HMD does indeed influence the transportation or presence, it is important to understand what the differences between HMD's are and if they can potentially lead to different user experiences.

HMD's can generally be separated into two main categories, standalone and tethered HMD's (Angelov et al., 2020). Standalone devices are HMD's that contain all necessary hardware to be able to show VR experiences. Computer chips that can offer the right amount of computing power are built right into the device. On the other hand, tethered devices generally lack most of the computing power but instead rely on an external computer to provide the necessary power. This makes tethered devices generally the most powerful HMD's because they are not reliant on pre-defined computing power produced by the manufacturer. A subcategory of the standalone HMD's is the mobile HMD. Mobile HMD's, in contrast to the typical standalone HMD, do not have computing power built-in but consist of a particular slot for the users' smartphone, which acts as the computer and display. HMD's can vastly differ in quality. As Angelov et al. (2020) discussed, display, tracking, and ergonomics are important factors that could vary per HMD. Mobile HMD's are the cheapest option to experience VR and are therefore the most accessible.

One of the cheapest and most accessible ways into VR is the Google Cardboard mobile HMD design. Consumers and manufacturers can quickly produce them with accessible and

low-cost materials. Google recommends cardboard HMD's on their website for as low as €8.- (Google, n.d.). These cheap HMD's are made out of cheap materials like cardboard. Because of the low build quality, it is reasonable to assume that the cardboard devices' display, tracking, and ergonomics are worse than those of more expensive consumer-level HMD's like the Oculus Quest 2, which starts at €349.- (Oculus, n.d.). The cheap lenses of the Google Cardboard could, for example, lower the display quality.

The current study will examine a mobile Google Cardboard HMD and a tethered Oculus Rift s HMD. Especially the quality of the display and ergonomics of the two types of headsets differ significantly. The Oculus Rift s consists of a built-in high-resolution display and is made of soft materials, while the case and lenses of Google Cardboard HMD are made out of cheap materials. The display behind the lenses is dependent on the user's mobile phone, which makes it likely that the display quality of the mobile HMD is lower in most cases. These hardware features are likely to play a role in the user experience.

An additional comment should be made regarding ergonomics. While the build-in quality of the tethered headset is generally higher, the tethered HMD requires to be placed around the person's head using the HMD, while the mobile cardboard HMD requires the users to hold the HMD before their eyes. The Google Cardboard HMD is a much smaller and less weighing device. Weight is an important factor for the ergonomics of an HMD (Angelov et al., 2020). It could be argued that these factors could impact the user experience, transportation and presence effects. However, participants of the current study will only use the HMD for a relatively short amount of time, which makes weight unlikely to have a significant impact.

The following is therefore hypothesized:

H3: The type of HMD predicts the user experience, in that tethered HMD's yield a higher user experience score compared to mobile HMD's.

When tethered HMD's can positively influence the user experience, and the user experience can positively influence the transportation/presence effect, which in their turn increase the reading intention, it can be hypothesized that the type of HMD can influence the reading intention. Therefore the following is hypotheses are presented:

H4: Tethered HMD's increase the reader's intention to read more compared to mobile HMD's.

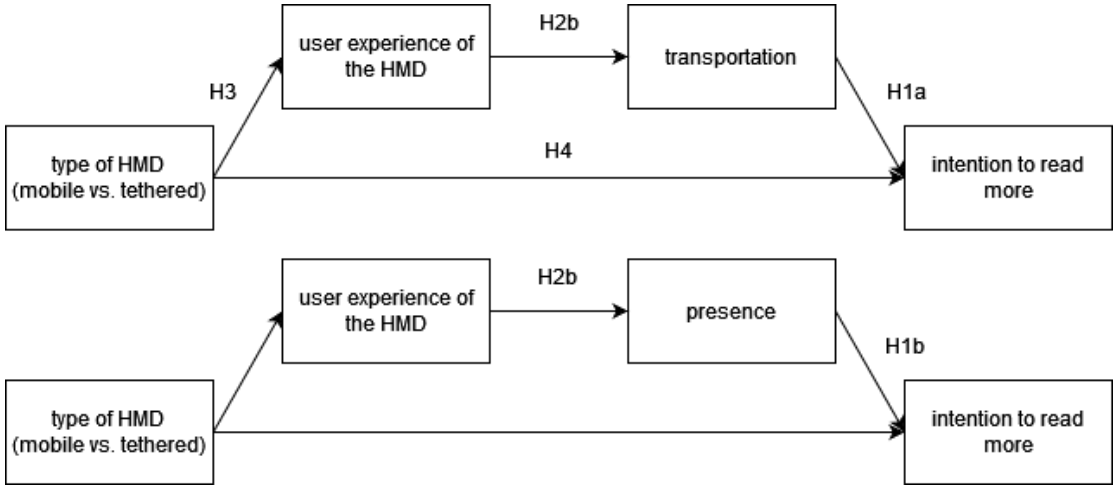
Finally, a mediation hypothesis can be established which brings the conceptual model for this study together:

H5: Tethered HMD's increase the reader's intention to read more compared to mobile HMD's through a mediation of the user experience of the HMD and the degree of transportation and/or presence.

Figure 3 includes an overview of the two conceptual models, including the accompanying hypotheses formed in this section.

Figure 3

Proposed conceptual models 1 and 2, including hypotheses



Method

Design

A between-subjects experiment was conducted to test the hypotheses. The dependent variable was the intention to read more. The mediating variables were user experience, transportation and presence, and the independent variable was the type of HMD with mobile

and tethered levels. Participants were randomly assigned to one of two conditions. Participants either got to participate in the tethered condition that used an Oculus Rift s HMD or participated in the mobile condition that used a Sweex Google Cardboard HMD.

Participants

Participants were gathered over around a month by asking random students at Tilburg University and by utilizing the researcher's private network. The total number of participants for this study was 43 (30 male, 13 female). The experiment was conducted in the Netherlands, and all participants were Dutch students. The poem read in the virtual environment was recorded in the Dutch language. Therefore the experiment was conducted in Dutch with only participants who had Dutch as their native language. The age of the participants was, on average, M = 21.1 (SD= 2.2*)* years old. The youngest participant was 16 years old, while the oldest was 25.

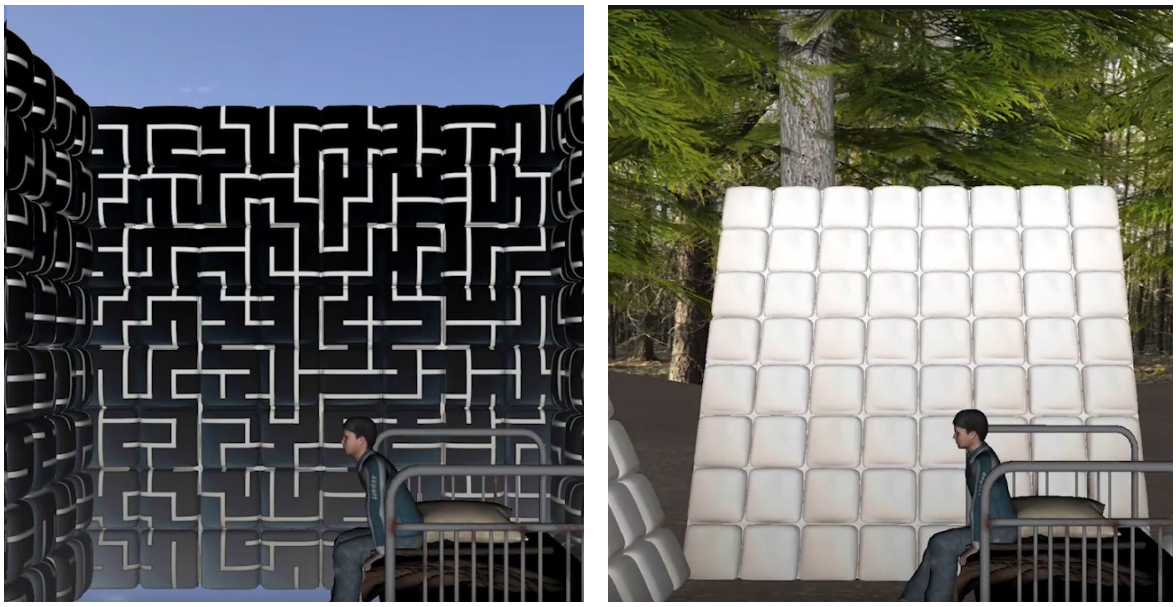
Materials

Digital Literature

In both conditions, participants were presented with a pre-recorded poem called 'In het gedicht' written by Jotie 't Hooft read out in a Virtual Environment. Participants were shown supporting visuals and animations in the virtual environment made for the poem by designer Jeroen Derks. The poem was not shown in text, and the virtual environment contained no interactive elements. The VR experience took about 60 seconds. An image of the virtual environment is shown in Figure 4.

Figure 4

Virtual environment with animations in which a poem is read out



HMD's

Participants were either assigned to the mobile condition with a Sweex Google Cardboard HMD or the tethered condition with an Oculus Rift s HMD. An iPhone X was placed in the smartphone slot in the mobile condition. Users did not wear headphones, and the audio was provided by the built-in speakers of the Oculus Rift s and iPhone x. The sound volume and screen brightness for both devices was kept the same for every participant.

Measures

Transportation

This study used the same items to measure transportation as used by Pianzola et al. (2019). They used the story world absorption scale proposed by Kuijpers et al. (2014). The current study only used the story world absorption scale questions that measured transportation specifically. The scale consisted of five 5-point items, ranging from 'completely disagree' to 'completely agree'. For the current study, a Dutch version of the construct was used that was made available by the researchers of the story world absorption scale (*Story World Absorption Scale*, 2020). Some words used in the items were adjusted to better fit the material used in this

study (e.g., 'the story' was changed to 'the poem' and 'reading' to 'listening'). A list of all items used to measure transportation is included in Appendix A.

Presence

The self-location items that indicate spatial presence from Spatial Presence Experience Scale (SPES) (Hartmann et al., 2016) were used to measure presence. The construct consisted of ten 5-point items, ranging from 'completely disagree' to 'completely agree'. The items were translated to Dutch for this study. A list of all items used to measure presence is included in Appendix B.

Intention to read more

Because this study does not use reading material but spoken poetry, a construct of a single item was generated. On a 5-point scale ranging from 'completely disagree' to 'completely agree', participants were asked whether they would like to read more poems by the poem's author. The statement was presented in Dutch, which is included in Appendix C.

User experience of the HMD

In their VR study, Manis and Choi (2019) used existing hardware acceptance constructs and adjusted them for VR hardware. 'Attitude towards using VR hardware' is a construct aimed at the general impression of using VR hardware. This construct has been used with the questions being adjusted to evaluate the overall VR experience instead of asking especially about the use of the VR hardware. The construct consisted of five 5-point items. The items were translated to Dutch for this study. A list of all items used to measure the user experience of the HMD is included in Appendix D.

As the user experience construct is quite general, an open field was added to the questionnaire. Participants were asked to briefly explain why they gave the chosen scores on the user experience page. This question was not used to determine the user experience scores but rather to gain possible insights for discussion purposes.

Procedure

The experiment was conducted partially at Tilburg University and partially at participants' homes. All experiments were conducted in a quiet environment without other people present in close range. Participants were randomly assigned to one of the two conditions. Participants first provided informed consent through an online Qualtrics survey. They were then asked whether they had used VR before and read poems on a 5-point scale ranging from 'never' to 'often'. Next, the survey was put on hold and participants were asked to put on the HMD belonging to their assigned condition. Participants were told they could stop with the experiment anytime and that the VR experience would last for only 60 seconds. After participants put on the HMD, the digital literature experience in VR was started. After the poem ended, participants were told to remove the headset and continue with the survey, which measured transportation, presence, intention to read more and, the user experience of the HMD.

Data analysis

The gathered data in Qualtrics was exported to IBM SPSS Statistics 27 for Windows, where a sequential mediation analysis with two mediators was performed using the PROCESS macro for SPSS (Hayes, n.d.). Model 6 of PROCESS was used in SPSS to perform this analysis.

Results

The experiment involved one dependent variable, one independent variable, and three mediating variables. The dependent variable was intention to read more, the independent variable was the type of HMD containing levels mobile and tethered. The mediating variables were user experience, transportation and presence.

Table 1 shows an overview of the general descriptive statistics. The means and standard deviations of the dependent and mediating variables are displayed. Table 2 displays the means and standard deviations of experience with VR and experience with reading poems. An

independent samples t-test showed no difference between the two experimental groups concerning previous VR ($p = 0.58$) and poem reading experience ($p = 0.9$).

Table 1

An overview of all means (SD) of the measured constructs per condition.

	Mobile HMD ($N = 23$)	Tethered HMD ($N = 20$)
User experience of the HMD	3.61 (0.87)	3.91 (0.71)
Transportation	2.89 (0.95)	2.99 (0.75)
Presence	2.53 (0.88)	3.10 (1.03)
Intention to read further	2.43 (0.95)	2.50 (1.00)

Table 2

Mean (and SD between brackets) experience with VR and experience with reading poems.

	Mobile HMD ($N = 23$)	Tethered HMD ($N = 20$)
Previous experience with VR	2.35 (1.23)	2.15 (1.04)
Experience with reading poems	1.78 (0.90)	1.75 (0.79)

Assumptions

As the independent variable (type of HMD) was categorical and interaction variables were used, it was impossible to test for the assumptions of normality and homoscedasticity. The mediation analysis was bootstrapped (5000 samples) to control for normality. To control

for heteroscedasticity, the heteroscedasticity-consistent interference option 'HC4 (Cribari-Neto)' was selected (Hayes, 2018, p. 576) in the PROCESS macro for SPSS (Hayes, n.d.). As dummy variables were used for the independent variable, the assumption of linearity was not a concern.

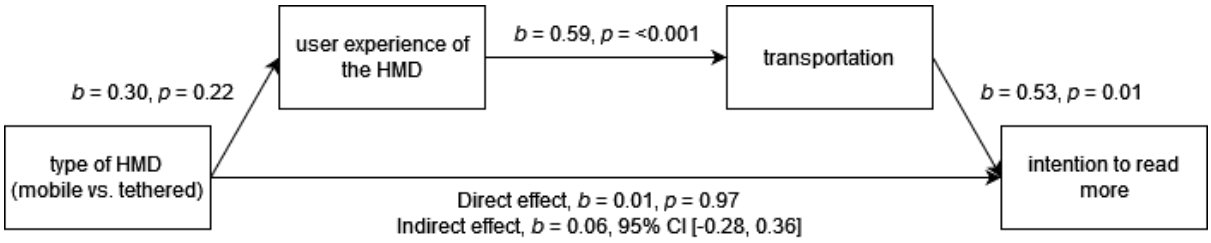
Mediation analysis

To answer the research question and test the hypotheses, two sequential mediation analyses were conducted using the PROCESS macro for SPSS (Hayes, n.d.). Model 6 of PROCESS macro was used for both analyses.

The first sequential mediation analysis examined the first conceptual model and tested H1a, H2a, H3, H4 and H5. The results of this analysis are displayed in Figure 5.

Figure 5.

Conceptual model 1 with the sequential mediation analysis results per hypothesis

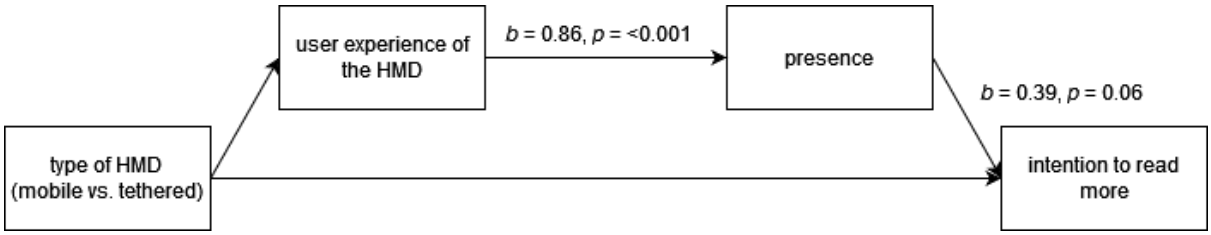


The sequential mediation analysis results showed a significant positive effect of transportation on intention to read further (b = 0.53, p = 0.01). These findings support H1a. Furthermore, the user's degree of transportation was significantly positively influenced by their user experience of the HMD (b = 0.59, p = 0.01). Therefore it can be concluded that H2a is also supported. No significant relation was found between the type of HMD and the user experience of the HMD (b = 0.30, p = 0.22), which shows that H3 was not supported. Similarly, no significant effect was found between the type of HMD and the intention to read, neither a direct (b = 0.01, p = 0.92) nor indirect effect (b = 0.06, 95% CI[-0.28, 0.36] were found. This indicates that H4 and H5 were not supported.

A second sequential mediation analysis was conducted to examine the second conceptual model and test hypotheses H1b and H2b. The only difference between the two models was the replacement of transportation with presence. Therefore the results of those connections are indicated in Figure 6.

Figure 6

Conceptual model 2 with the sequential mediation analysis results per hypothesis



The results indicate no significant relationship between presence and intention to read further ($b = 0.39$, $p = 0.06$). Therefore Hypothesis H1b is not supported. Finally, a significant positive influence was found between the user experience of the HMD and presence ($b = 0.86$, $p = <0.001$). These results indicate that H2b was supported.

Discussion

To what extent does the type of HMD relate to the intention to read more and to what extent is this relationship mediated by the user experience of the HMD and the degree of transportation and/or presence perceived by the user? This study hypothesized two sequential mediation models containing the relationship between types of HMD's and reading intentions. The mediating variables were hypothesized to be the user experience of the HMD and transportation/presence into the story world/virtual environment. An experiment was conducted to examine the hypotheses. Participants were either assigned a condition where they experienced a 60-second digital literature experience with a tethered Oculus Rift HMD or with a Google Cardboard mobile HMD. The hypotheses established in this study and their results are summarized in Table 3.

Table 3

Summary of the hypotheses and results

	Results
H1a: A higher degree of transportation increases the intention to read more.	$b = 0.53$, $p = 0.01$
H1b: A higher degree of presence increases the intention to read more.	$b = 0.39$, $p = 0.06$
H2a: A better user experience of the HMD enhances the user's transportation into the poem.	$b = 0.59$, $p = <0.001$
H2b: A better user experience of the HMD enhances the user's presence in the virtual environment.	$b = 0.86$, $p = <0.001$
H3: The type of HMD predicts the user experience, in that tethered HMD's yield a higher user experience score compared to mobile HMD's.	$b = 0.30$, $p = 0.22$
H4: Tethered HMD's increase the reader's intention to read more compared to mobile.	$b = 0.01$, $p = 0.97$
H5 Tethered HMD's increase the reader's intention to read more compared to mobile HMD's while being mediated by the user experience of the HMD and the degree of transportation.	$b = 0.06$, 95% CI [-0.28, 0.36]

Transportation, presence, and intention to read more

Pianzola et al. (2019) suggested that VR could potentially be used as a tool to promote reading. They conducted an experiment where participants read a short story in VR or on printed paper. They found that participants in the VR condition had a greater feeling of being transported into the story world than participants in the print condition. The researchers demonstrated that because of the increased transportation into the story world, the reading intentions of participants in the VR condition were higher compared to the participants in the print condition.

The study of Pianzola et al. (2019) showed promising results regarding the use of VR for reading promotion. However, the current study sought to utilize the technology more and aimed to determine whether this effect would still be observable when put in the context of digital literature. Because of the similarities between the concepts of transportation and presence, the current study also incorporated presence. While Pianzola et al. (2019) noted that presence could be one of the reasons for an increased transportation effect in VR, they did not consider it in their experiment.

The current study hypothesized that a higher degree of transportation would increase the intention to read more (H1a). It was also hypothesized that a higher degree of presence would similarly result in higher reading intentions (H1b).

As expected, participants who experienced a higher degree of transportation also had an increased intention to read more. Therefore H1a was found to be supported. This result corresponds with Pianzola et al. (2019) and suggests that even in a different literary setting, like spoken poetry and digital literature, transportation into the literary work can increase reading intentions of literature. Therefore, it could be argued that digital literature that utilizes VR could also be used as a tool to promote reading.

A higher degree of presence was surprisingly not found to have a significant relationship with reading intentions. Therefore H1b was not supported. This result is surprising given the similarities between the concepts. More so because Pianzola et al. (2019) argued that presence could be one of the reasons that enabled transportation to happen more easily.

The short duration of the VR experience could be a reason for this result. The experience only lasted for about 60 seconds. This could mean that there was not enough time for presence to have a noticeable effect on the user. Another note should be made regarding the small sample size of the study. While the reasons for this will be discussed more thoroughly in the limitations subsection, it could be a reason for this insignificant result. Results of H1b

yielded a *p*-value of 0.06, which is close to being statistically significant. Because of the small sample size, one or two more participants could have already changed the *p*-value to represent a statistically significant result. This would not be unlikely regarding the results with a similar construct in H1a. Because of this unreliability, conclusions drawn from H1b should be treated with extra caution.

User experience

The current study also examined the relationship between the user experience of an HMD and transportation and presence. Hardware plays a significant role when using VR, and the most common way to experience VR is with an HMD. Angelov et al. (2020) showed that different factors of an HMD could influence the user experience, with the most important ones being the display, tracking, controllers and, ergonomics of the device. These device aspects could impact the user experience and possibly the feeling of transportation and presence. The quality of the display (Angelov, 2020) and the ergonomics of an HMD could, for example, influence the presence in the VR environment (Cummings & Bailenson, 2016). Pianzola et al. (2019) argued that distractions could negatively influence transportation into the story world. The current study argues that the build quality and user experience of an HMD can also distract the user, thereby influencing transportation into the story world.

Therefore, the current study hypothesized that a better user experience of the HMD could enhance transportation into the story world (H2a) and presence in the virtual environment (H2b). Both hypotheses were found to be supported. Participants who perceived the user experience as better also reported experiencing a higher degree of transportation and presence.

These are interesting results, as the importance of user experience regarding the use of VR hardware has not been studied a lot. It can be suggested that the user experience of the hardware can impact important factors of the VR experience, which could thus affect the end

goal of an experience. In the case of digital literature or reading promotion, the reading intention could be increased or lowered depending on the user experience.

An aspect that could be explored further is the reason for the difference in the user experience of an HMD. In the current study, participants did use different HMD's. However, those did not cause a significant difference in user experience, as will be discussed in the following subsection.

It could be possible that subjective factors could play a role, like the expectations of the user experience. However, it is difficult to reach any conclusions in this study regarding the 'why' question considering the user experiences construct was measured very broadly. An attempt was made to gain qualitative insights by asking participants in an open question why they valued the user experience the way they did. While participants did explain why they did or did not like the overall experience, the answers were generally still too broad to reach valuable conclusions. One participant wrote, for example, that they could not get immersed into the experience because of the 'quality of the simulation' without further explanation. Another example is a participant who wrote that their experience was 'pleasurable'.

Types of HMD

Two categories of HMD's were discussed in this study: Tethered and mobile HMD's. While tethered HMD's are generally more expensive and powerful (when connected to a computer that supports VR), they are not as accessible as mobile HMD's like Google Cardboard. It was already hypothesized that user experience could influence transportation and presence in VR. An obvious influence on the user experience could be the HMD hardware.

The Google Cardboard HMD's are exciting products as they are the most accessible way to take advantage of VR possibilities. However, these devices' built quality is lacking compared to more expensive HMD's like the tethered Oculus rift devices. The overall quality of the VR experience of an expensive tethered HMD cannot be matched by Google Cardboard

HMD's (Powell et al., 2016). This difference is especially important as factors like the display quality, and the ergonomics of the devices can negatively impact the user experience (Angelov, 2020). The current study sought to explore whether these devices of lower quality could still be used for experiencing digital literature while still maintaining a sufficient user experience. Especially considering the user experience could influence important factors for digital literature in VR like transportation and presence.

It was hypothesized that the type of HMD would predict the user experience, in that tethered HMD's yield a higher user experience compared to mobile HMD's (H3). This hypothesis was not supported by the results as there was no significant relationship between the type of HMD and the user experience.

This is a surprising result considering that a better user experience significantly enhanced the transportation and presence effects. Despite the theoretical differences between both HMD's, participants did not seem to be affected enough by the differences to evaluate the user experience of each device differently.

A possible reason for this result could be the duration of the experience of the digital literature. The total experience only lasted for about 60 seconds, and it could be argued that some parts of the HMD hardware, which can impact the user experience, did not stand out in that short amount of time. It can, for example, be assumed that it is less likely for people to get frustrated with the weight or positioning of the HMD (ergonomics) when they only have to use it for a relatively short amount.

Another aspect of the digital literature experience used in this study could be an additional reason for the surprising result. User interaction was not part of the experience. Google Cardboard HMD's have generally a reduced ability for interaction with the virtual environment compared to tethered HMD's which support advanced controllers. The inability for user interaction can reduce the presence in a virtual environment (Angelov et al., 2020). It

should be considered that the results could therefore be different when user interaction would have had a prominent role in the VR experience.

Nevertheless, it is interesting that for a short digital literature experience in VR, which did not use user interaction, it did not seem to matter whether participants used an expensive tethered HMD or a low-cost Google Cardboard.

Direct and indirect effects of HMD on reading intentions

A conceptual model was proposed that argued that if the type of HMD could indeed affect the user experience, the user experience could affect the transportation/presence effect, which in their turn could influence reading intentions. Two hypotheses were formulated to complete the conceptual model. First, it was hypothesized that tethered HMD's could increase the reader's intention to read more compared to mobile HMD's (H4). Finally, a mediation hypothesis was proposed, which stated that tethered HMD's increased the reader's intention to read more compared to mobile HMD's while being mediated by the user experience of the HMD and the degree of transportation. Considering the results discussed in the previous subsections, it is unsurprising that both hypotheses were not supported. No direct or indirect effect on the type of HMD on the reading intentions was found.

Considering the results of H3, H4, and H5, it can be assumed that the types of HMD used in this study did not change the digital literature experience significantly. In itself, that could be considered good news as it could be suggested that an expensive HMD is not necessary to increase reading intentions by using VR in a digital literature context. Digital literature in combination with accessible VR hardware could potentially be used to promote reading literature.

The results should, however, still be dealt with cautiously. The previously discussed short duration of the experience and the exclusion of user interaction could be important variables impacting the results of this study. Furthermore, the digital literature used for this

study was a project that used animations and spoken poetry in a virtual environment. It should be considered that digital literature in VR can see many forms, which could contain other variables beyond the scope of the current study.

Limitations

While having discovered more about the effects of VR on digital literature and the importance of user experience, some limitations of this study need to be addressed. Most notably is the relatively low sample size of 43 participants used to conduct the experiment. This study was written during the COVID-19 pandemic, and continuously changing circumstances made it exceedingly difficult to gather participants and conduct the experiment. While designing the experiment, the intended participant recruitment method was to randomly request the participation of students present at certain locations at Tilburg University. Unfortunately, recruitment strategies had to be flexible due to 'stay-home' advice and multiple types of lockdowns. In the end, around half of the participants were gathered using the private network of the researcher, and half the participants were gathered at Tilburg University on days it was allowed. Despite the sample size, most hypotheses were convincingly supported or rejected based on the sequential mediation analyses. Only H1b ($b = 0.39$ $p = 0.06$) should be treated with extra caution due to the sample size. The p-value observed is so close to 0.05 that a couple of more participants could change the hypothesis to being statistically supported instead of rejected. Therefore, research on VR presence and its effects on reading intentions should especially be examined further in future work.

Another limitation was the duration of the experience presented in the experiment, which lasted only for 60 seconds. While this study has discovered that the results of short VR experiences are likely not dependent on the HMD hardware, no claims can be made about longer experiences. This is especially evident considering the literature discussed in this study pointed at a relationship between the type of HMD and the user experience. When finishing

the experiment, some participants even stated that they were only just started to 'get into' the virtual environment.

The same can be said for the lack of user interaction or the use of controllers. No claims can be made about digital literature experiences in VR that require interaction with the virtual environment. This is important as literature also suggests a relationship between user interaction and presence (Angelov et al., 2020).

Societal relevance

Pianzola et al. (2019) wrote their research intending to explore the possibilities of using VR as a tool to promote reading. They showed that VR could indeed be used for such applications. While Pianzola et al. (2019) focused on reading traditional texts by using technology, this study aimed to utilize the combination of literature and technology more. This combination could be found in digital literature, in which digital and literary components depend on each other to create a digital and literary experience. One of the aims of the current study was to examine whether the findings of Pianzola et al. (2019) could also apply to digital literature. The results suggest that they do. The degree of transportation into the story world positively affected the reading intentions, like in the study of Pianzola et al. (2019). Participants who had a greater feeling of transportation into the story world also indicated to want to read more poetry (of the same author).

Moreover, this study incorporated HMD hardware as a factor of interest. VR research is often conducted with more expensive HMD's like in the study of Pianzola et al. (2019). The current study argued that low-cost mobile HMD's like Google Cardboard could potentially be a tool for making VR more accessible. While the hardware of a cardboard HMD is of lesser quality, the current study results suggested no difference between reading intentions when using a low-cost mobile HMD or a high-end tethered HMD when undergoing a short digital

literature experience. Therefore, the current study finds that VR could also be used to promote the reading of literature without the necessity of advanced and expensive VR hardware.

Future research

Some aspects of this study could be explored further in future research. As already discussed, some variables regarding the digital literature experience could be investigated further. Experiences of a longer duration and experiences that enable interaction with the virtual environment are the most obvious next steps regarding digital literature research and VR. These variables could change the user experience in such ways that hardware quality may play a more significant role as opposed to the experience presented in this study.

The current study discovered the relationship between a better-perceived user experience and enhanced transportation into the story world and presence in the virtual environment. However, it is unclear why the user experience was perceived as it was, considering there was no difference between the HMD conditions and the perceived user experience. Future research could have a more in-depth exploration of why the user experience is perceived differently for different people and how it can be increased. This study already showed that increasing the user experience could potentially be used to create a higher sense of transportation or presence.

Conclusion

The current study examined the relationship between the type of VR HMD's (Mobile and Tethered HMD) and the intention to read more poetry. Mediators of this relationship were theorized to be the user experience of the HMD and the transportation into the story world or presence in the virtual environment.

The results of a between-subjects experiment showed no relationship between the type of HMD and the intention to read more in a short VR digital literature experience. This suggests that an expensive, tethered HMD is not necessarily required to increase reading intentions by

using VR. These results could be considered good news as mobile HMD's like Google Cardboard are very accessible and can be produced for relatively low costs.

The experiment results also showed a positive relationship between the user experience and transportation into the story world and presence in the virtual environment. Transportation into the story world was found to have a positive relationship with reading intention. Therefore it can be argued that VR could be used as an accessible tool to promote the reading of literature.

Future research could examine other variations of digital literature in VR, like longer and more interactive experiences. These other factors could also potentially influence the user experience and, ultimately, reading intentions.

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Appendix A

Transportation

1: Tijdens het beluisteren van het gedicht leek het soms alsof ik zelf ook in de wereld van het gedicht was.

2: Tijdens het beluisteren van het gedicht waren er momenten waarop de wereld van het gedicht leek te overlappen met mijn eigen wereld.

3: De wereld van het gedicht voelde tijdens het lezen soms dichterbij dan de wereld om mij heen.

4: Toen ik klaar was met beluisteren van het gedicht voelde het alsof ik net een uitstapje had gemaakt naar de wereld van het gedicht.

5: Omdat al mijn aandacht uit ging naar het gedicht, leek het soms alsof ik niet meer los van het gedicht bestond.

Appendix B

Presence

1: Ik had het gevoel dat ik echt aanwezig was in de virtuele omgeving.

2: Het leek alsof ik actief deelnam aan de virtual reality ervaring.

3: Het was alsof mijn echte locatie was verschoven naar de virtuele omgeving.

4: Ik had het gevoel dat ik fysiek aanwezig was in de virtuele omgeving.

5: Ik ervoer de virtuele omgeving alsof ik een andere plaats was binnen gestapt.

6: Ik was ervan overtuigd dat er dingen echt om me heen gebeurden.

7: Ik had het gevoel dat ik midden in de actie aanwezig was in plaats van het enkel te observeren.

8: Ik had het gevoel dat de objecten in de virtuele omgeving me omringden.

9: Ik ervoer zowel de gesloten als open ruimtes alsof ik er echt was.

10: Ik was ervan overtuigd dat de virtuele objecten zich op verschillende plaatsen rondom mij bevonden.

Appendix C

Beantwoord ondestaande stelling:

Ik zou graag meer gedichten van deze auteur willen lezen.

Appendix D

Ik vond deze virtual reality ervaring:

Slecht – Goed

Positief – Negatief

Voldoende – Onvoldoende

Gunstig – Ongunstig

Onaangenaam - Aangenaam