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Virtual Reality as a Tool for Political Decision-Making? An Empirical Study on the Power of Immersive Images on Voting Behavior

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One of the strengths of virtual reality (VR) is to provide a highly realistic user experience. How would VR's power of realism affect political decision-making, for example, when experienced by citizens before they cast their vote on an issue? We set out to empirically assess if and how voting information presented in VR would influence people's voting behavior, compared to the traditional text presentation format. In a 2 (format: text vs. VR) × 2 (argumentation: pro vs. con) between-subject factorial experiment, we assessed participants' voting behavior on a fictitious popular initiative. We first asked all participants ($N = 179$) to cast their vote based on a brief text, inspired by the traditional Swiss voting booklet (baseline). We then randomly assigned participants to one of four experimental conditions containing the same pro or con arguments concerning the voting issue. Participants could then adjust their previously-cast vote. This was followed by retrospective interviews ($N = 32$) to gain deeper insights into the decision-making process of the participants. Our study shows that the presentation format has a reinforcing effect, that is, leading to more YES votes for the VR group, and fewer YES votes for the text group. Irrespective of the pro or con arguments, participants show an overall increase in YES votes in VR, which is not the case for the text group. We identified six factors that may have led to this positive change with VR: (1) the affirmative power of images, (2) the vividness of immersive images, (3) first-person storytelling and storyliving, (4) the greater affordances of VR for engagement through interaction, (5) the design of the VR environment, and (6) the novelty of the VR technology.

Keywords: virtual reality, immersive images, VR design, decision-making, visual framing

INTRODUCTION

Alongside the rapidly developing digitalization in society and respective hardware and software improvements in information technologies, virtual reality (VR) has become less expensive, easier to use also by a non-specialized audience, and thus increasingly accessible to the general public. Beyond the gaming industry, VR has entered various academic and professional fields such as healthcare, medical education, psychology, psychotherapy, marketing, urban development and

planning, journalism, and political communication. The strengths of VR are (a) to provide a highly realistic user experience where users can fully engage with a topic or with different stakeholders (Slater and Sánchez-Vives, 2016), (b) to provide settings where users can learn what it might feel like to be in unfamiliar situations (Bailenson, 2018), and (c) to simulate settings and scenarios that cannot be visited in person or do not exist (yet) at all. Would VR thus also be suitable for communicating socio-political topics in a more comprehensible and tangible way compared to traditional presentation formats such as text, and even for increasing citizens' interest in democratic processes? This very general question was the starting point of our exploratory empirical research. More specifically, we wanted to investigate:

1. how the presentation format, i.e., a VR experience, would influence people's political decision-making in a voting scenario in comparison with traditional text-based information
2. whether, aside from the format, the content of the voting issue (i.e., positive or negative framing) would affect voting behavior.

Inspired by past Swiss initiatives, a fact-based and realistic (but fictitious) popular initiative (the Hyperloop initiative, section Selecting the Suitable Popular Initiative) serves as the voting context in which we wanted to investigate how supporting (positively- and negatively-framed) voting information presented in text or VR format would affect people's voting behavior. Because there is no prior empirical evidence of the role of VR in political decision-making compared to traditional media (including text), and the empirical evidence of the role of VR in public communication is either thin or inconclusive, we set out to empirically explore whether and how depicting voting issues in VR with positive and negative arguments would influence voting behavior, compared to the traditional text format.

As our experimental scenario deals with content related to current affairs and political communication (more specifically, a realistic voting issue), next we will contextualize our study with prior work on the use of VR in public communication.

RELATED WORK

We are aware that our study touches on several disciplines and research fields, e.g., psychology and human behavior in VR; narrative techniques in video games; design of VR environments; media and framing effects, to name just a few. Since we aim to shed light on the role of VR in public communication, we will focus mostly on the related fields of journalism and political communication and the respective power of immersive images.

VR in Public Communication

Public communication is still at the stage of experimenting with VR. For example, journalists in news organizations such as *The BBC*, *The Guardian, The New York Times, National Geographic, El País*, or *Al Jazeera* have started to use 360-degree videos and VR as a tool for immersive storytelling. The purpose is to expose users to unfamiliar scenes or places such as wars or refugee camps so that they feel like they are involved in the unfolding events instead of just consuming a traditional, typically non-interactive, news report. The aim is to awaken empathy for what is going on in the world (e.g., Domínguez, 2017; Archer and Finger, 2018; Pimentel et al., 2021). An often-cited example of immersive storytelling is the award-winning VR production *We wait* (BBC, 2022) that enables users to experience what it feels like to be a refugee crossing the Mediterranean Sea. While researchers have started to investigate the challenges, benefits, and limitations of immersive storytelling in journalism (Sundar et al., 2017; Watson, 2017; Steed et al., 2018; Mabrook and Singer, 2019; Bujić et al., 2020; Wu et al., 2021), VR in political communication has been little studied so far (Pérez-Seijo et al., 2022).

VR and 360-degree videos have served to build awareness and supported educational and cultural purposes, sometimes even with ideological underpinnings (Pérez-Seijo et al., 2022, p. 122). Especially political parties have employed immersive technologies as a tool for their strategic communication during election campaigns (Mason, 2015; Healy et al., 2016; Pérez-Seijo et al., 2022). Activists and social justice advocates are using VR as a tool to achieve legal change (Hao, 2017) or to protest against the government. For instance, a group of students in Hong Kong created a virtual reality game that allows people to experience the anti-government demonstration from the perspective of frontline protesters (Reuters Staff, 2019). The United Nations (UN) employs VR not only to raise awareness of humanitarian crises, but also to motivate citizens to engage in democratic processes. One such example is *Clouds over Sidra*, a film shot in VR for the UN, where people can experience life within a Syrian refugee camp as seen from the perspective of a 12-year-old girl. According to the UNVR website, various civil societies have used *Clouds over Sidra* to target public opinion [United Nations Virtual Reality (UNVR) (n.d.)].

In addition to the claimed benefits of raising awareness and empathy, engaging target groups with ongoing political events, or connecting with new audiences, VR is also used to serve as an innovative alternative for education and for orientation on electoral or sociopolitical issues (Pérez-Seijo et al., 2022, p. 128). However, the new and exciting possibilities of VR can also be seen as risks, since it is possible to manipulate viewers' feelings, attitudes, and also voting behavior. This could be achieved, for example, by emphasizing fake news, unbalanced content selection (i.e., propaganda, distorted stories etc.), graphics manipulations (exaggerating certain graphic elements, omissions, blurring, etc.), or other multimedia effects (i.e., sounds, music, etc.). Such manipulations are nothing new for traditional presentation formats, but perhaps because viewers are fully immersed in the VR image worlds and experience them directly, it makes the experience even more real than reality itself (Slater et al., 2020; Sun and Botev, 2021). While journalism research and communication studies seem to argue for VR as a way to increase credibility and trust (Sundar et al., 2017; Nielsen and Sheets, 2021; Wu et al., 2021), Sun and Botev (2021) review article points to various negative issues related to trust when experiencing VR. Slater et al. (2020) propose a list of possible negative outcomes including negative trust issues after

prolonged exposure to VR (and AR) with strong place illusion and plausibility.

Not only does the way information is conveyed (i.e., medium or format) have a crucial impact on how people perceive certain issues and how they think about the world, but this is also true of how the information itself is designed. Comprehensive research on media effects in journalism and political communication suggests that public opinion can be shaped by agenda setting and framing. Framing is defined by selection and salience, that is, "to select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation for the item described" (Entman, 1993, p. 52). In recent years, the effect of framing has received great attention through major discourses such as global climate change (e.g., Schäfer and O'Neill, 2017) or the refugee crisis (e.g., Zappe, 2021).

In their seminal research on human decision-making, Tversky and Kahneman (1986) have empirically demonstrated that the decisions we make are often not rational. This is because human decisions are not only influenced by how information is depicted or described (i.e., framed), but also because of humans' inherent cognitive biases. Shafir (1993) could empirically show that positive dimensions of given options presented to a decision-maker are weighted more heavily when choosing an option compared to when rejecting an option, and conversely, negative dimensions are weighted more heavily by decision-makers when rejecting an option compared to when choosing an option. In a political context, Bizer et al. (2011) suggest that any given attitudinal position can be framed as one of opposition or support, and in the domain of politics, this distinction is especially prominent. These authors provide empirical evidence that the valence of framing (i.e., pros or cons) has a direct strengthening effect on people's attitudes. Framing has thus direct consequences on human decision-making.

While communication and media research is increasingly addressing the issue of visual framing in the media (e.g., Coleman, 2010; Rodriguez and Dimitrova, 2011; Parry, 2012; Geise and Coleman, 2016), to date, it is unclear how framing a political scenario (i.e., positively or negatively) in the context of VR might influence decision-making and behavior. One might argue that political decisions should be made logically, rationally, and without any emotional sensations (Staerklé, 2015). Would the immersive power of images in VR then be useful at all for political decision-making in general and for voting support compared to commonly used text-based information?

The Power of Images

The power of images has been discussed from different theoretical perspectives (e.g., Roland, 1964; Freedberg, 1989; Kress and van Leeuwen, 1996; Domke et al., 2002; Grau, 2003; Hill, 2004; Mitchell, 2005; Kjeldsen, 2015, 2021; Alloa, 2021). Image types differ in material, semiotic resources, affordances, and in the way they are produced and consumed. Despite this distinctiveness, we do not believe that immersive images represent an entirely new visual type, as some semiotic properties are common to all kinds of images. On the one hand we can build upon existing theoretical approaches related to the power of images. On the other hand, it is difficult to transfer these approaches directly to our study of immersive environmental indoor and outdoor scenes, as these images are always connected to a physical real-world experience in a virtual environment. A theory of the power of immersive images has yet to be written.

Generally, one can argue that the power of images lies in their provision of visual evidence (Boehm, 2008). They possess visual evidence by demonstrating and making things visible; they illustrate or flesh out an issue and can make a verbal description that is difficult to understand more easily comprehensible. By doing so, images reinforce with graphic evidence the notion that indeed reality is as shown in the image. Particularly photographs and images with a naturalistic coding suggest authenticity and veracity by the act of showing—they tell us "Look, that's how it is", and "that's how it happened" (Weber and Rall, 2017). What is seen in the image exists, what cannot be seen does not exist; thus, the image has affirmative powers. In contrast to texts, images cannot *not* show; they cannot negate or express modalities such as uncertainty, probability, or possibility. In order to do so, they need either assistive text or additional graphical elements. Their affirmative power, evidence, and immediacy easily disguise their constructed nature—constructed because they are always artifacts of an agent, a creator, be it an artist, a designer, or a photographer. As visual artifacts, they provide "a thick and rich representation of the situation" (Kjeldsen, 2015, p. 200).

Another term to describe the power of images is vividness. Vivid information can generate attention or involvement and evoke emotions (Nisbett and Ross, 1980), which supports the retention of information. In the continuum of vividness proposed by Hill (2004, p. 31), the most vivid type of information is an actual experience in the world, followed by moving images with sound, while the least vivid information types are "abstract, impersonal analysis and statistics." Since VR can be considered an actual (physical) experience (see section The Power of Immersive Images), immersive images would reach the highest level of vividness according to Hill's vividness continuum (2004, p. 31), while abstract texts would be on a very low level. Thus, the stimuli used in our study differ greatly in terms of the degree of vividness, which will be relevant when discussing the effect of VR on political decision-making (section Discussion).

In addition, images and texts differ in their affordances for conveying information, that is, their potentials, materiality, inherent logics, and limitations (Kress, 2010). What can be expressed easily in the visual mode might not be expressed as easily in the verbal mode and vice versa. A photograph, for instance, can show the surface of an object in much more detail than a string of words can do. But a photograph cannot tell the viewer how much the object weighs or what the name of its owner is (Engebretsen and Weber, 2022). Words, in contrast, can name things, contextualize objects, and express causality, coherence, and logic. Processing of text information is linear and engages the reader's slower analytic thinking mode (Kahneman, 2011), whereas processing of visual information is parallel and engages the fast, automatic, and intuitive brain processes of the viewer (Kahneman, 2011). And while still and moving images put participants in the role of observers, immersive

images go a step further, which brings us to the power of immersive images.

The Power of Immersive Images

Immersive images prompt active participation, interaction, and exploration, thus leading to greater engagement, empowerment, and a sense of the presence of a viewer in the depicted world. Immersive images differ from still and moving images in that they can expand the presented information by a third spatial immersion, that is, users are mentally and physically fully immersed within a computer-generated 3D world (Sherman and Craig, 2019, pp. 8–13). Unlike 2D images, the events that take place in the virtual environment are not distant in space and time: the visual world is experienced immediately and not just passively observed from the same perspective. Immersion thus emerges from the interplay between the viewing perspective, the content or the story, and the employed technology (Riva and Mantovani, 2014; Sundar et al., 2017).

Slater and Wilbur (1997, pp. 604–605) define immersion as "the extent to which the computer displays are capable of delivering an inclusive, extensive, surrounding, and vivid illusion of reality to the senses of a human participant." *Inclusive* here means that the user is fully immersed in the artificial world while being disconnected from the real world. *Extensive* refers to the multimodal or multisensory impressions and experiences. Multimodal environments allow user interaction and, supported by sound, smell, and touch, give the viewer a sense of presence, that is, being right there in the world rather than just looking at it. VR allows the creator not only to trigger emotions and empathy, but perhaps even to develop a better understanding of other people's perceptions, feelings, and attitudes through perspective changes (Heeter, 1992; Slater and Wilbur, 1997; Sundar et al., 2017). *Surrounding* means that a virtual environment should completely surround the users and is not limited to a narrow field of view. *Vividness* points to a deep and "thick" representation (Kjeldsen, 2015) of the visual world, capitalizing on semiotic resources such as spatial resolution, fidelity, color, auditory elements, and rich multi-layered information content (Slater and Wilbur, 1997). Because of the immersive nature, people quickly accept the virtual environment as real: they are able to move through it, interact with it through haptic elements and even perceive their own body parts (e.g., hands) visualized in that world.

With this in mind, VR is less seen "as a media experience, but as an actual experience" (Bailenson, 2018, p. 47). We can therefore define the VR experience as story-living rather than story-telling (Maschio, 2017; Mabrook and Singer, 2019), which adds a crucial component to the affective or emotional power of images. Referring to Hill (2004), we hypothesize that in our study the degree of vividness of immersive photorealistic images depicting environmental indoor and outdoor scenes experienced with a head mounted virtual reality display will be greater than that of information equivalent text descriptions with abstract graphs, containing impersonal official language and read on a computer screen.

It is also worth mentioning that (immersive) images can only unfold their power if they are able to activate pre-existing mental schemata (e.g., beliefs, experiences, perceptual and cognitive structures) of a target audience (Domke et al., 2002; Kjeldsen, 2021). Images are not just isolated visual artifacts; their power must be evaluated in relation to their context of use, to humans' individual differences, predispositions and values, as also Domke et al. (2002) argue for the context of news photography, or, in the words of Kjeldsen (2021, p. 9), "[p]ictures are good at confirming and reinforcing what we already think and feel."

In summary, the power of images depends on various factors: the text accompanying an image; individual differences and abilities; different target groups; the historical, social, and cultural context; the individual task or context for which the image is consumed (see also Kjeldsen, 2021), including the positive or negative framing of the image. Given that all these factors are relevant for our empirical study, the first step was to develop the VR-use context and design respective experiment stimuli, which we detail in the next section.

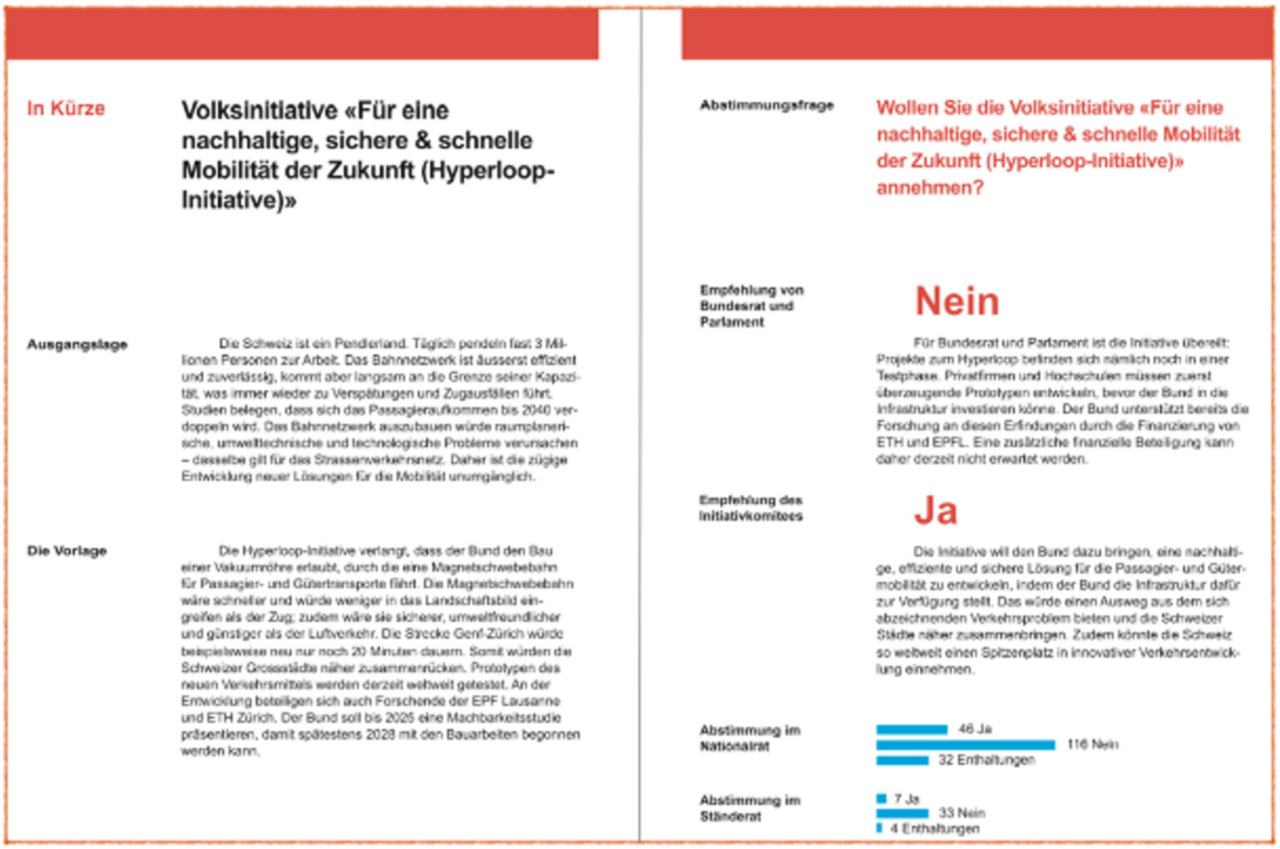
MATERIALS AND METHODS

In order to empirically compare VR and text formats for public communication in the context of political decision-making, we first developed a voting scenario suitable for presentation in both VR and text. For the text format, we followed the graphic layout, content structure, and verbal style of the Swiss voting booklet (**Figures 1**, **2**). This explanatory booklet published by the Swiss Federal Council serves as the common basis for informed decision-making about any voting issue for the majority of Swiss voters. The booklet, predominantly in text format, sets out the pros and cons of the issues that will be voted on. Occasionally, also graphic materials complement the verbal information (Bundeskanzlei, 2017).

Selecting the Suitable Popular Initiative

Relevant selection criteria for the voting issue included the following: (1) The voting issue needed to have an inherently spatial component (i.e., building, planning, environment, etc.) so that it could be visualized in an immersive environment. (2) It had not been already voted on in Switzerland, but would be considered realistic enough for our target population. (3) It had to produce an outcome with a narrow margin, because it is well-known that polarized voting outcomes are difficult to swing by any means, irrespective of presentation formats.

To find the suitable scenario, we devised 24 popular initiatives to be voted on at the Swiss Federal level. Twelve of them were based on past initiatives (recycled) and 12 were developed from scratch (invented). We developed a 2 (initiative: recycled vs. invented) $\times$ 2 (recommendation by the Swiss Federal Council: YES vs. NO) between-subject factorial design, to be tested on 456 recruited participants ($N = 456$; female 265; male 191). The target sample consists mainly of university students from the greater area of Zurich, of voting age, allowed to vote in Switzerland, and of varying academic backgrounds recruited by mailing list from ZHAW Zurich University of Applied Sciences. Participants were asked to decide for each initiative how they would divide 100 points given to them into a YES or NO pot in an online questionnaire. In doing so, we aimed



In Kürze

Volksinitiative «Für eine nachhaltige, sichere & schnelle Mobilität der Zukunft (Hyperloop-Initiative)»

Ausgangslage

Die Schweiz ist ein Pendlerland. Täglich pendeln fast 3 Millionen Personen zur Arbeit. Das Bahnnetzwerk ist äusserst effizient und zuverlässig, kommt aber langsam an die Grenze seiner Kapazität, was immer wieder zu Verspätungen und Zugausfällen führt. Studien belegen, dass sich das Passagieraufkommen bis 2040 verdoppeln wird. Das Bahnnetzwerk auszubauen würde raumplanerische, umwelttechnische und technologische Probleme verursachen – dasselbe gilt für das Strassenverkehrsnetz. Daher ist die zügige Entwicklung neuer Lösungen für die Mobilität unumgänglich.

Die Vorlage

Die Hyperloop-Initiative verlangt, dass der Bund den Bau einer Vakuumröhre erlaubt, durch die eine Magnetschwebebahn für Passagier- und Gütertransporte fährt. Die Magnetschwebebahn wäre schneller und würde weniger in das Landschaftsbild eingreifen als der Zug; zudem wäre sie sicherer, umweltfreundlicher und günstiger als der Luftverkehr. Die Strecke Genf-Zürich würde beispielsweise neu nur noch 20 Minuten dauern. Somit würden die Schweizer Grossstädte näher zusammenrücken. Prototypen des neuen Verkehrsmittels werden derzeit weltweit getestet. An der Entwicklung beteiligen sich auch Forschende der EPF Lausanne und ETH Zürich. Der Bund soll bis 2025 eine Machbarkeitsstudie präsentieren, damit spätestens 2028 mit den Bauarbeiten begonnen werden kann.

Abstimmungsfrage

Wollen Sie die Volksinitiative «Für eine nachhaltige, sichere & schnelle Mobilität der Zukunft (Hyperloop-Initiative)» annehmen?

Empfehlung von Bundesrat und Parlament

Nein

Für Bundesrat und Parlament ist die Initiative übereilt: Projekte zum Hyperloop befinden sich nämlich noch in einer Testphase. Privatfirmen und Hochschulen müssen zuerst überzeugende Prototypen entwickeln, bevor der Bund in die Infrastruktur investieren könnte. Der Bund unterstützt bereits die Forschung an diesen Erfindungen durch die Finanzierung von ETH und EPFL. Eine zusätzliche finanzielle Beteiligung kann daher derzeit nicht erwartet werden.

Empfehlung des Initiativkomitees

Ja

Die Initiative will den Bund dazu bringen, eine nachhaltige, effiziente und sichere Lösung für die Passagier- und Gütermobilität zu entwickeln, indem der Bund die Infrastruktur dafür zur Verfügung stellt. Das würde einen Ausweg aus dem sich abzeichnenden Verkehrsproblem bieten und die Schweizer Städte näher zusammenbringen. Zudem könnte die Schweiz so weltweit einen Spitzenplatz in innovativer Verkehrsentwicklung einnehmen.

Abstimmung im Nationalrat

46 Ja
116 Nein
32 Enthaltungen

Abstimmung im Ständerat

7 Ja
33 Nein
4 Enthaltungen

FIGURE 1 | Introductory text "In Kürze" (Eng. in a nutshell) of the fictitious popular initiative "Hyperloop" based on the layout, structure, and verbal style of the official Swiss voting booklet.

Argumente

Initiativkomitee

Schnell

Günstig

Sicher

Nachhaltig

Innovativ

Empfehlung des Initiativkomitees

Ja

Argumente

Bundesrat

Technologie noch nicht ausgereift

Sicherheit noch ungeklärt

Abwanderung in die Städte

Zerstörung des Landschaftsbilds

Teure Technologie

Empfehlung von Bundesrat und Parlament

Nein

FIGURE 2 | Pro version (left) and con version (right) of the text format based on the layout and verbal style of the original Swiss voting booklet.

for a more detailed quantitative analysis rather than simply collecting YES or NO votes. Our analysis identified the so-called "Hyperloop" initiative as the topic with one of the smallest margins, with 51.8 percent voting YES and 48.2 percent voting NO.

The fictitious Hyperloop initiative (**Figure 1**) asked for significant amounts of state funding for the construction of a Hyperloop infrastructure in Switzerland. The concept of a Hyperloop is an ultrafast passenger transportation and cargo system that runs above or below ground, connecting cities

in minutes rather than hours. It is a real global engineering project; first prototypes are currently being developed by various companies and research institutions across the globe, including Switzerland (e.g., Taub, 2020; HyperloopTT, 2021; TUM Hyperloop, 2022). We therefore assumed that participants had, at best, little prior knowledge of the Hyperloop to draw on, but no physical experience.

Developing the VR Experience and the Text Content

To draft the extended text version of the Hyperloop initiative with detailed pro and con arguments and to be able to develop a corresponding VR scenario, two interviews were conducted with Swiss Hyperloop experts (EPFLoop from EPFL[1], and Swissloop from ETH[2]). The purpose of the interviews was to achieve the most realistic description of the Hyperloop for the voting issue, that is, to gain insights into possible concepts of architecture and design, speed, costs, risks, and security measures, including arguments for and against investing a great deal of public money into a Swiss Hyperloop project.

Based on insights gained from the expert interviews, we developed the text and VR formats by enriching each format from two different perspectives:

- a *positive (pro) framing* supporting a YES vote by providing five arguments in favor of the Hyperloop: 1. fast; 2. low in price; 3. secure and convenient; 4. sustainable; 5. innovative.
- a *negative (contra) framing* supporting a NO vote by providing five arguments against the Hyperloop: 1. still immature technology; 2. safety is still unclear; 3. urban-rural gap; 4. destruction of the landscape; 5. expensive technology.

Framing the content of the initiative positively and negatively was critical to determining whether manipulating the content would have an impact on decision-making, i.e., the decision to support or reject the Hyperloop initiative. This allowed us to assess the differential impact of pros and cons on the decision-making process. The design of the two (pro/con) text variants was again based on the Swiss voting booklet (**Figure 2**).

For the development of the two immersive (pro/con) VR experiences, we adopted an iterative, user-centered design. First, the content of the two VR framings was outlined based on the text of the fictitious Hyperloop initiative. In both scenarios, users can experience an interactive ride from Zurich to Geneva in the Hyperloop, as seen from a first-person perspective. The pro scenario emphasizes the positive implications and opportunities of a Hyperloop ride, while the con scenario shows the negative implications and risks of using such a high-speed transportation system. **Table 1** lists the design elements of the VR scenarios (pro/con) to convey the differently-framed narratives.

Next, we developed storylines for each scenario and implemented interactive components based on overarching design guidelines and user requirements. The two (pro/con) scenarios were implemented using the Unity3D® Game Engine for the VR head-mounted system HTC Vive Pro Eye. The entire project team acted as pilot testers at this stage of the stimulus development process. We tested preliminary versions of the design, which were then iteratively modified by the developer team based on our feedback. Special attention was paid to maintaining visual consistency and to avoiding interactions that could induce nausea (also known as simulator sickness), such as rapid body movements or visual actions in the VR. This process was repeated until the VR application met the initially stipulated design and use requirements. Both VR scenarios included elements of interaction, e.g., buying a ticket from a vending machine or buckling up in the Hyperloop. There was no voice-over narration.

TABLE 1 | Examples of design elements of the VR scenarios.

VR	Pro scenario	Con scenario
Design elements	- Positive ad campaign at the station. - Smooth ticketing system. - Visible safety measures (seatbelt). - Display showing CO_2 footprint. - WiFi is working. - News coverage on problems trains have due to heat wave, but hyperloop is not affected.	- Negative ad campaign at the station. - Ticketing system out of order. - Visible safety warnings. - Display shows delay of arrival. - WiFi is not working. - News coverage on tax increase due to Hyperloop cost.

Figure 3 shows typical scenes of the developed VR scenarios, including the visualization of the above-mentioned pro arguments (left column) and con arguments (right column). In the first scene (**Figure 3A**), participants see escalators to an underground Hyperloop platform. They can look around the surroundings and might already discover some of the pro or con arguments, visualized as pro/con political campaign posters at the entrance of the escalators (**Figure 3A**, green and red panels to the right of the escalators). Once on the underground platform, participants can buy a ticket (**Figure 3B**). Then, they enter the Hyperloop, choose a seat, and are asked to buckle up for the ride. During the short ride, various information items are displayed on a screen mounted on the passenger seat in front of the participants (**Figure 3C**). After arriving in Geneva, participants unbuckle and leave the Hyperloop. The scenario ends on the platform.

Design of the VR and Text Stimuli

Transferring content from a text format to a visual format affects not only how the information is conveyed, but also what is presented. As explained in section Materials and Methods, text and images have different affordances. While in the voting text stimuli, the information is written in a sober and impersonal style, following an argumentative logic in accordance with the verbal style of the Swiss voting booklet, the information in the VR format is conveyed as a multimodal interactive narrative in which participants can experience a ride in the Hyperloop from a first-person perspective (**Tables 2**, **3**).

As mentioned earlier, what can be easily expressed with words might be difficult to depict in a visual mode and vice versa. For

[1]École Polytechnique Fédérale de Lausanne.
[2]Swiss Federal Institute of Technology, Zurich.

TABLE 2 | Examples of pro arguments in the text format and their execution in VR.

Pro	Text	VR (see also **Figure 3**)
Fast	- With the Hyperloop, it is possible to travel from Zurich to Geneva within 20 min. - This is because magnetic levitation enables the Hyperloop to reach a top speed of around 900 km/h.	- Display showing travel time of 20 min. - Display showing travel speed of 900 km/h.
Low in price	- Due to low operating and maintenance costs, the Hyperloop ticket costs similar to a train ticket. Travelers therefore pay significantly less for a ride on the Hyperloop than for a flight ticket.	- Smooth ticketing system showing the ticket price (similar to that of a regular train), but cheaper than a flight ticket.
Secure and convenient	- Current transportation systems such as the railroad are vulnerable to extreme weather conditions. The Hyperloop, however, is safely protected from heat, snow, and storm because it runs in a vacuum tube.	- Visible safety measures (seatbelt). - Hyperloop is connected to the world outside through a working WiFi - News coverage on problems that trains are having due to heat wave, but hyperloop is not affected.
Sustainable	- In addition, the Hyperloop can be used not only for passenger transport but also for cargo transport. The Hyperloop thus decongests traffic on the roads and railways.	- Green ad campaign for the Hyperloop at the entrance of the station. - Display showing CO_2 footprint.
Innovative	- By accepting the initiative, Switzerland will remain innovative where it has always been strong: in the transportation sector.	- Innovation award logo on the outside of the Hyperloop.

TABLE 3 | Examples of con arguments in the text format and their execution in VR.

Con	Text	VR (see also **Figure 3**)
Still immature technology	- The Hyperloop is still a prototype and therefore not a fully developed transportation system for passenger traffic—It still needs a lot of research to clarify all the technical issues.	- Ticketing system out of order. - Display shows delayed arrival of 10 min. - WiFi is not working.
Safety is still unclear	- Many questions about safety in the Hyperloop are still unclear. Especially the safety in the event of an earthquake is questionable. Are the pillars and vacuum tubes strong enough in such a case? What happens in the event of a power outage? Or how to deal with a drop in pressure in the pods? How can passengers be evacuated from the tube in case of emergency? - Unlike on a train, you have to wear a seat belt during the ride. In addition, nausea could occur while driving. People with heart problems or pacemakers are not allowed to ride the Hyperloop.	- Display showing a message on the current earthquake risk (2%). Hyperloop is not affected. - Visible warning sign on the platform: Boarding is not allowed for people with pacemakers. - Sickness bag at the seat.
Urban-rural gap	- The Hyperloop only serves cities that are already economically relevant today. Unserved localities would no longer be attractive as places to live and work.	- During the ride, only large cities are shown on the screen. Only the two largest cities in Switzerland are served by the Hyperloop illustrated by a connecting line.
Destruction of the landscape	- For example, the construction of the hyperloop will affect the landscape. The long-term effects on nature are still completely unclear.	- Negative ad campaign at the entrance of the station.
Expensive technology	- The construction of the Hyperloop pods and the vacuum tube results in very high development and construction costs. These costs would have to be covered by the federal government, which in turn would result in a tax increase.	- News coverage on tax increase due to Hyperloop cost.

our study, for example, this meant that abstract concepts (e.g., the urban-rural divide in Switzerland), uncertainties in technology (prototype nature of the Hyperloop), and technological limits (i.e., communities that are excluded from a Hyperloop network) were difficult or impossible to visualize. Due to ethical and legal concerns, that is, to protect test participants, we refrained from depicting frightening, stressful, or potentially harmful visual content such as accidents or other dangerous situations, e.g., earthquake, power outage, drop in atmospheric pressure. While text can easily switch between different places and points of time (e.g., past, present, future), the VR experience focused on a single event with a sequence of actions, and from one perspective: the experience of a train ride from Zurich to Geneva from a first-person's point of view. And while the text version can describe the Hyperloop as a vacuum transportation system that transports people and cargo with high speed above or below ground, the actual depiction of the experienced Hyperloop required numerous design decisions and visualization choices, including the visual appearance of the interior of the pod, such as colors, seat type and shape, and visual design of the platforms, the station, staircases, doors, and tickets.

Prior graphics research suggests an ideal balance of realism vs. abstraction in highly realistic VR worlds, particularly to avoid the so-called "uncanny valley" effect (Seyama and Nagayama, 2007) that might provoke uncanny or strangely familiar feelings of eeriness and revulsion in observers. We therefore aimed for a

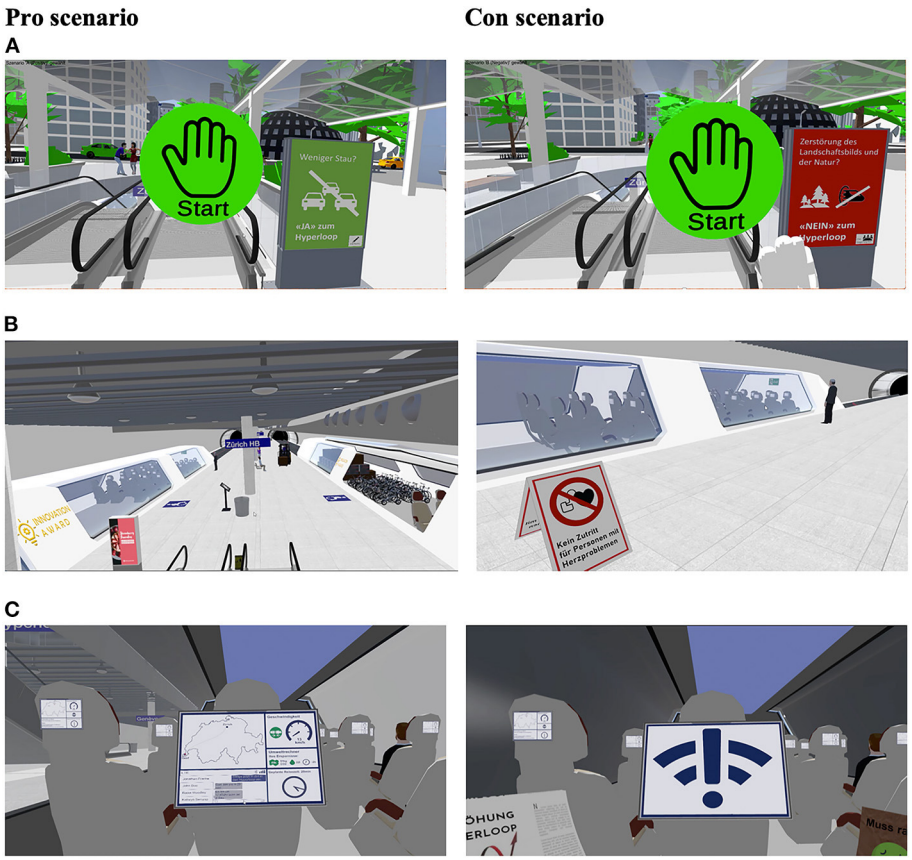


FIGURE 3 | Screenshots taken from the VR format. Pro arguments are shown on the left-hand side; con arguments on the right-hand side. **(A)** Getting ready to use the escalator. **(B)** Moving down the escalator to the platform. **(C)** Traveling with the Hyperloop.

simple design solution, not only as realistic as necessary, but also as factually correct as possible. The design of the VR scenarios is based on our own research on ongoing Hyperloop initiatives and similar high-speed transportation systems, as well as on the interviews we conducted with the Swiss Hyperloop experts. We purposefully used visual and audio elements that the recruited participants would be familiar with from the real environment (e.g., the design of Swiss Federal train station signage and currently used announcement jingles). The whole design was ruled by minimalism, striking a balance between neither too complex nor too detailed to avoid distracting participants. Only details relevant to the voting issue were shown in the VR scenarios. We used the same number of pro and con arguments for the Hyperloop initiative as presented in the text format, thus providing participants with similar information content in both formats.

Procedure

We combined an experimental research design using quantitative methods as commonly employed in cognitive psychology coupled with retrospective interviews commonly applied in qualitative media research. The experiment is based on a 2 (format: text vs. VR) × 2 (argumentation: pro vs. con) between-subject factorial design where participants were randomly assigned to one of the four conditions: text pro: $N = 45$; text con: $N = 44$; VR pro: $N = 46$, and VR con $N = 44$. For both test groups (i.e., the text format and the VR format), we first administered an online survey (Unipark), including several questions related to participants' background (e.g., political affiliation, media consumption, etc.).

First, all participants[3] (SD = 5.8 years; $N = 179$; 58 percent female), almost exclusively students (age: mean = 26.2, SD = 5.8) from Zurich universities, were asked to read the introductory text entitled "In Kürze" (Eng. in a nutshell), providing a brief description of the initiative (**Figure 1**). The text outlines what the initiative is about, in a language comprehensible for the broad public. The content includes: the voting issue to be decided on; the main points of the initiative; the voting recommendation of the government, parliament, and the initiative committee; and the voting results of the parliament in the form of a bar chart. After reading the short introductory text, participants were asked to decide whether they would vote for or against the presented

[3]Participants either received credit points for their workload or could participate in a draw to win one out of three iPads.

initiative by allocating 100 points to a YES or NO vote pot (Vote 1).

Then, participants were either invited to read through a more detailed text version of the voting information that provided more details with pro or con arguments, or to experience the pro or con arguments in VR. The text format was presented as PDF on a computer screen. To experience the VR scenario, we asked participants to don a head-mounted VR display including headphones. They were instructed to use the HTC Vive Pro controller for navigation and interaction with the VR. When participants were asked to take a seat in the Hyperloop pod, a real chair was carefully placed near them to match the position of the passenger seat in the visualized Hyperloop in VR. The VR experience, on average, took only a handful of minutes. Motion sickness or feelings of discomfort were not reported.

Finally, after being exposed to one of the four conditions, participants in the text and the VR group were asked to vote again on the same issue (Vote 2). In doing so, participants' voting behavior and respective potential changes (dependent variables) can be directly inferred as a result of the experimental manipulation of the presentation format and the pro and con arguments (independent variables).

Retrospective Interviews

For the retrospective study, randomly selected participants ($N = 32$; 62.5 percent female) from each condition ($N = 8$) were interviewed after the experiment (section Procedure) to assess their understanding of the arguments for and/or against the Hyperloop initiative. Retrospective interviews are a reflexive practice to better understand participants' perspectives and reasoning, i.e., why they responded or behaved the way they did (Budach, 2012). The interviews provide deeper insights or process information into measurable decision outcomes of our study, thus enriching our quantitative results. One might wonder why far fewer participants were interviewed compared to the recruited pool. The low number of participants can be explained by the fact that the participants' statements quickly reached a high degree of saturation, the so-called saturation limit, meaning that interviewing additional participants would not yield significantly additional or different insights.

The interviews were conducted face-to-face following a semi-structured interview guide and recorded with participant consent. Each interview took about 30 min with 10 interview questions for the text group and 11 for the VR group[4]. The transcripts were anonymized and then analyzed by two coders using the software MAXQDA (2018.2). The focus was on a qualitative analysis following the approach of Mayring (2000). The coding categories were deductively derived from the research questions and the interview guide. After a trial run with six interviews, the categories were discussed, evaluated, and modified. A second check showed that no further revisions of the main coding categories were needed for the final coding. The coding categories included: decision-making; VR experience; VR design; impressions of the text format; the VR experience compared to text reading experience; and the credibility of the selected voting initiative in both formats. The criteria were applied top down to the text material. The results were then evaluated and interpreted.

Specifically, we aimed to gain deeper insights into the immersive experience compared to the experience of reading the text in order to contextualize the impact of the VR technology on the voting decision-making process. The interview questions also elicited participant responses on media use, political issues as well as what they felt were the advantages or disadvantages of VR technology, and whether participants had noticed any kind of manipulation in the VR or the read text. We also included questions specifically aimed at the different presentation formats and participants' perceived exposure effects. We elicited responses in the VR group about their VR experience, and asked about their impressions on VR-specific design elements. For the text group, the questions dealt with the layout, structure and verbal style of the text and its credibility, the perceived potential of included biases, and the advantages and disadvantages of text compared to other media formats. We also asked if they had changed their voting for Vote 2 compared to Vote 1, after having been exposed to one of the four experimental conditions.

RESULTS

We start the results section with the main experimental effects from the quantitative VR experiment and present outcomes from *post-hoc* analyses, where appropriate (section Findings From the VR Experiment). In section Findings From the Retrospective Interviews, we contextualize voting behavior results with participant self-reports elicited in the retrospective interviews. The qualitative analysis of the retrospective interviews provides first explanations for the outcomes of the voting decision, i.e., the main effects. In doing so, retrospective interviews additionally offer deeper insights into participants' verbalized VR experiences, and what the impact of the VR format might have had on their decision-making.

Findings From the VR Experiment

The boxplots in **Figure 4** below visualize the YES votes in percent cast by our participants in two voting rounds (Vote 1 and Vote 2), grouped by the presentation format experienced (text condition vs. VR condition). As explained earlier, all participants in both experimental groups (text group and VR group) were asked to vote twice. The first vote came at the beginning of the experiment after reading a summarized and brief version of the voting issue. This first vote (blue boxplots in **Figure 4**) can be considered the baseline vote as both groups were given the identical voting information in the identical presentation format (introductory text "In Kürze," **Figure 1**). For this Vote 1, the voting issue is accepted on average by both groups, i.e., the average votes are above 50 percent YES. With an average of 51.39 percent of YES votes (SD = 19.65%), the text group is slightly lower, compared to the 52.44 percent YES votes of the VR group (SD = 21.05%). As both groups made their voting decision with the identical text version, we would not expect a significant difference in this first vote. Indeed, the between-subject ANOVA run in IBM SPSS

[4]The additional question in the VR group related to whether it was the first VR experience for the participants.

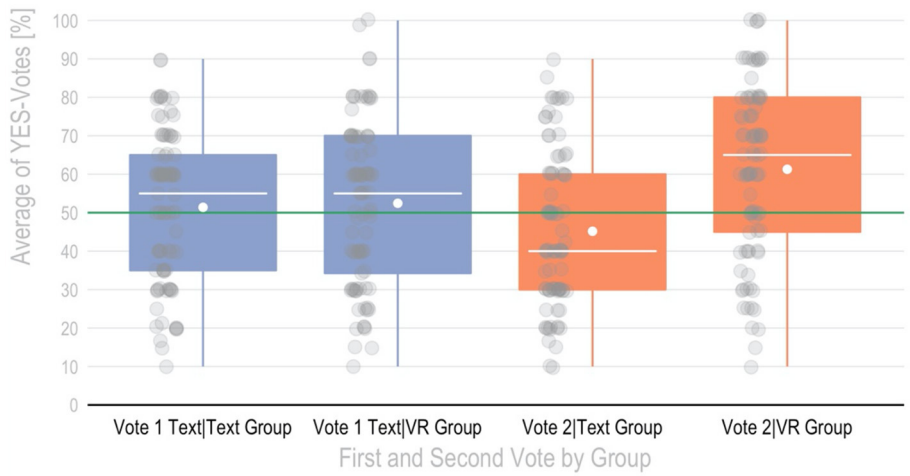


FIGURE 4 | In Vote 1 (blue boxplots), both groups were given the identical text information. In Vote 2 (orange boxplots), after participants experienced one of the four conditions, the voting outcomes show that the presentation format has an effect on participants' YES votes cast for the Hyperloop voting issue.

Statistics Version 28.0.1.0 Build 142 is not significant [$F_{(1, 177)} = .119$, $p = 0.730$, n.s.].

For Vote 2 (orange boxplots in **Figure 4**), i.e., after participants experienced either the text format or the VR format with additional pro/con arguments, the voting outcomes look different.

Overall, on average, the **presentation format** of the fictitious Hyperloop voting issue had a direct effect on participants' voting outcomes for Vote 2, that is, after participants had been exposed to either voting information presented as a text or as a VR experience. Interestingly, compared to Vote 1 (the experimental baseline), after the text group received more detailed information (either additional pro or con arguments), they vote on average against the Hyperloop initiative (M = 45.17, SD = 19.95 percent of the YES votes). In contrast, the VR group votes more strongly for the Hyperloop initiative in Vote 2 after receiving additional pro and con arguments, with an even higher average of YES votes (M = 61.29, SD = 22.23 percent of the YES votes), compared to Vote 1. In other words, irrespective of pro or con content, the VR format yields more YES votes. Because the data of the second voting round is not normally distributed, we ran a Kruskal Wallis Analysis to assess voting differences. The main effect of the presentation format for Vote 2 is significant [$H_{(1)} = 22.03$, $p < 0.001$], at the alpha level of 0.05 for all statistical tests. The presentation format with additional pro and con arguments seems to have had a strengthening effect, either more strongly against the Hyperloop initiative (i.e., lower percentage YES votes) for the text group or more strongly for the Hyperloop initiative (i.e., higher percentage YES votes) for the VR group.

To further investigate this overall voting behavior, we also analyzed participant voting outcomes considering the **pro and con arguments**, as shown in **Figure 5**.

Voting outcomes in Vote 2 show that the content with pro arguments yielded a higher percentage YES vote average for the VR condition, compared to percentage YES votes based on the con arguments (**Figure 5**). Compared to Vote 1, participants in the *text pro condition* cast a higher average of percentage YES votes, compared to participants in the *text con group* (blue boxplots in **Figure 5**). This pattern is repeated with the VR conditions (orange boxplots in **Figure 5**). Hence, irrespective of the presentation format, pro arguments lead to more YES votes on average. However, while participants in the *text con group* would have rejected the Hyperloop voting issue (M = 36.98, SD = 14.92 percent of the YES votes), participants in the *VR pro condition* (M = 64.80, SD = 19.80 percent of the YES votes) and the *VR con condition* (M = 57.61, SD = 24.20 percent of the YES votes) would have both accepted the Hyperloop initiative, and with significantly higher percentage YES vote averages, compared to the text conditions [$H_{(3)} = 36.21$, $p < 0.001$]. Pairwise comparisons using a rather conservative Bonferroni correction for multiple tests suggest that the percentage YES votes averages of the *text pro group* and *text con group* differ significantly ($z = -3.619$, $p = 0.001$), but not for the participants in the *VR pro* and *VR con group* ($z = -1.353$, $p = 0.528$, n.s.). Moreover, the percentage YES vote average of the *text con* group is significantly lower than that of the *VR con group* ($z = 4.131$, $p = 0.000$). In summary, the VR presentation format yields, on average, a higher percentage of YES votes, irrespective of the pro or con arguments experienced in VR.

Findings From the Retrospective Interviews

The findings from the 32 retrospective interviews allow us to dig deeper into the understanding of the voting behavior. In summary, the following emerged from the analysis of these interviews:

- Participants were indeed very familiar with the Swiss voting booklet, and thus with the layout and verbal style we used for

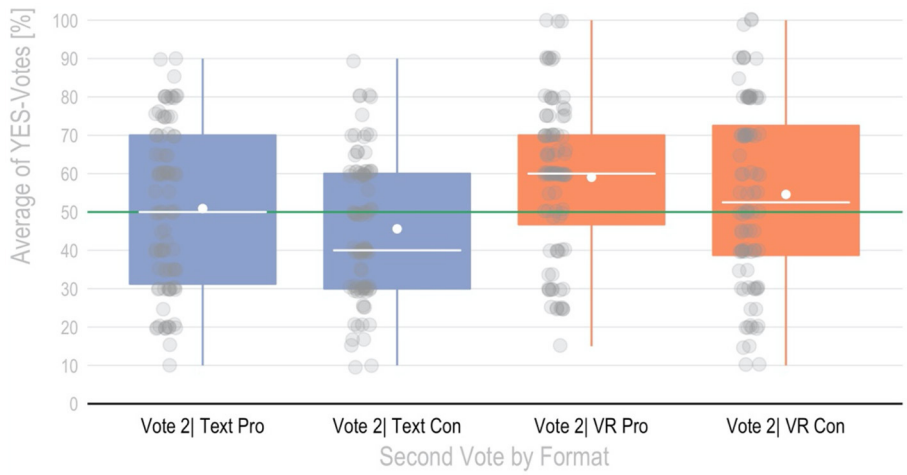


FIGURE 5 | Pro arguments lead on average to more YES votes (in percentage) than con arguments.

our experiment. This is also because participants showed high political engagement in Swiss nationwide votes.
- Most of the participants randomly assigned to the VR condition had no or very little prior experience with VR. In other words, most have been exposed for the first time to this novel media technology in our study.
- Participants knew little to nothing about ongoing Hyperloop-projects, so the level of prior knowledge or pre-existing attitudes can be assumed to be negligible.
- Participants indicated a broad spectrum of media consumption and awareness of the different potentials and limitations (affordances) of different media types. This may indicate a higher degree of media literacy and reflective thinking compared to the targeted general public.

Effect of the Presentation Format on Voting Behavior

The analysis of the interviews reveals that seven out of 32 interviewees (text and VR) changed their vote after the VR experience, and eventually cast a YES vote in Vote 2, supporting the initiative. Of these, one participant had experienced the text format and six participants the VR format. Strikingly, for the VR format, it did not matter whether participants were in the pro or con VR condition. This follows the pattern seen in the voting outcomes (**Figures 4**, **5**), that is, the increase in YES vote averages in the VR group, irrespective of the pro or con arguments. When asked, "Do you feel that the virtual experience has changed your attitude toward the initiative?" participants responded as follows:

P2: *I changed my mind afterwards. In VR, it just felt like I was on a fast train. I was more skeptical about the initiative before than after the experience.*

P3: *First, you just have no idea what it will look like, and now you've seen the station, for example, I think it helped a bit to confirm my opinion.*

P10: Yes, *I find it very attractively done and I like the futuristic setting. (…) VR influenced the whole process.*

Almost half of the interviewed participants mentioned that the presentation format did not have any influence on their decision-making and offered two main reasons for this. Either they already had a very strong opinion on the issue after reading the introductory text for Vote 1, or they felt a lack of information in the presentation format they experienced (the latter being especially relevant for interviewed participants in the text group). Four interviewed participants changed their vote in Vote 2 against the initiative; three of these were in the text group with con arguments.

P13: *After reading the first page, I thought it would be great solving the traffic problem. But when I read the argumentation of the Federal Council and actually saw what it means and that the technology is not very advanced yet, or how it would affect the urban-rural development, then I changed my opinion.*

The participant responses provide some possible reasons for the quantitative results, which suggests that the user experience in the VR environment resulted overall, on average, in more YES votes, irrespective of the pro or con arguments. This can be compared to the participants exposed to the text format, who on average cast fewer YES votes overall compared to the VR group, especially when they were exposed to con arguments.

Impressions of the VR Format

Most of the participants of the VR group were positively inclined toward the design of the VR stimuli and user experience, including the visual elements and sound bites, reminiscent of their real-world experience as passengers of the Swiss Federal Railway SBB system.

P18: *I thought it was pretty realistic. I could imagine it very well. The visualization and implementation were good, although I'm sure there's a lot more to come in the next few years.*

Some participants mentioned that the scenes appeared sterile, that they were bothered by the bright lighting of the scenes, or that they disliked the less realistic graphic level of detail when describing individual objects or the visual scenes in general.

P11: It just was not that realistic and the colors were not that appealing to me. The whole thing was very cold.

Nevertheless, participants were mostly impressed by the VR technology and confirmed its immersive effect on them.

P3: I found the design was mega cool and exciting. (. . .) It was cool to experience it interactively.

P7: As soon as I put on the VR goggles, I was inside and found it great to sit in the Hyperloop, even though I was only sitting on a normal chair, of course. But it gave you the feeling that you were actually in it and riding it.

P10: It really shows you what it might feel like to go on a trip.

Some participants of the VR group also highlighted a lack of some information, but it was not clear what kind of information they were actually missing. Generally, they appeared to be overwhelmed by the VR experience in such a way that only very few participants were able to recognize positive or negative framings of the VR scenario. Considering the earlier discussion about the limitations of VR, we also were interested to hear more about the potential strength of the text format.

Impressions of the Text Format

Many participants in the text group pointed out that the text is lacking some information and that it had been written either in favor or against the initiative. This suggests that all interviewed participants did indeed notice the positive or negative framing of the text format, that is, that they had been presented with only one side of the argument, which was definitively not what participants told us in the VR group or what the quantitative results suggest.

P13: The arguments of the other side were missing.

P23: When I got the con arguments in detail but not the pros, it brought me to a different decision or rather to no decision.

P29: I have seen a lot of no arguments, that is, rejection of the initiative. If it were neutral, then yes and no votes would have to be equally weighted.

Participants also explicitly highlighted the strength of the text format. The text allows for more reflective and focused examination of the topics presented, which is in line with prior research.

P9: You have a text in front of you, and you can repeat it, read through it several times, and analyze it and engage with it at your own pace.

Disadvantages of the text format, according to interviewed participants, are the perceived complexity of the text, its lower degree of vividness, and its less engaging character.

P21: Maybe there are people who do not like reading that much or who find it too boring or too dry. They might also need some entertainment to be able to better engage with the topic.

Impressions Comparing the VR Experience to Reading Text Information

Most interviewed participants agreed that the initiative was designed in a realistic and credible manner with a tendency for the text format to be considered more credible.

P2: If I had only had the VR, I would not have believed it. But together with the text [the introductory text of Vote 1], it's a complete package that was presented here, and it helped a bit make the opinion more positive.

P10: I find the text more credible. The VR is a bit manipulative, but I still think it's cool and I'm not opposed to showing how it could be, but in the end, I trust the text more.

P14: Yes, it was credible. The pros and cons were validly presented. You could form an opinion, but you would need more information for a final opinion.

P15: It reminded me of a normal initiative. It could have been real.

Participants see great potential in VR for visualizing things and events that are hard to imagine, and, thus, its potential for fostering better comprehensibility of such issues at hand. In addition, participants regard VR as a tool for facilitating the explanation of abstract or complex issues.

P3: One advantage would certainly be to make something unimaginable imaginable.

P16: You can better assess the positive and negative consequences because you can experience it yourself. When just reading, it is difficult to assess what might happen.

P18: Maybe for some people it's easier to imagine. Like a plastic surgeon showing me what I could look like, and then I can decide if I like it or not.

Only a few interviewees pointed to the possible risks of VR in terms of user manipulation.

P8: With VR, of course, you can present the information in a way that is attractive and, thus, influence the formation of opinion.

P12: There's a risk that opinion will be influenced because it's presented so well that you like it.

Despite the skepticism expressed by some participants toward the VR technology and its potential to manipulate users, this concern had apparently no effect on the decision-making, as the YES votes generally went up after participants experienced the voting issue in VR. Finally, only three interviewed participants (<10%) considered the Hyperloop to be unrealistic*:*

P30: I found the text a bit far-fetched. The idea is cool, but is it true that there is already a Hyperloop in development? I have never heard of it.

DISCUSSION

The goal of our study was to investigate (1) whether the presentation format (text vs. VR) affects voting behavior, and if so, in what way (2) and whether, aside from the format, the content of the voting issue (i.e., positive or negative framing) would affect voting behavior. We found that participants who experienced the voting information in VR, on average, cast more YES votes compared to voters exposed to the text format. This is irrespective of the pro or con arguments presented. In other words, the VR presentation format had indeed an effect on people's decision-making, more strongly than the pro or con arguments of the content presented. The retrospective interviews reveal that participants in the VR group did not notice any particular positive or negative framing of the voting information presented. In what follows, we discuss possible factors that may have led to these outcomes in the context of the theoretical

debates in section Related Work. One line of explanation could be that the novel, previously little experienced, and emotionally exciting VR experience could overpower the rational judgment of voters and lead to more agreement (i.e., more YES votes) on presented voting issues, irrespective of the pro or con arguments.

VR Experience Yields More YES Votes, Irrespective of the Pro or Con Framing

Earlier, we argued that the power of images depends on whether they can trigger pre-existing perceptual experiences or cognitive patterns. Because the Hyperloop concept was new to our study participants, they did not have any prior experience, and/or pre-conceptions about this novel mobility technology. We contend that they would have thus found it difficult to imagine a Hyperloop riding experience by simply reading text information about it. Our Hyperloop initiative has a significant technical dimension that probably requires more specific explanation than topics related to social issues or issues that are being discussed in public discourse (e.g., migration, climate change). As some participants told us in the interviews, they got a clearer picture of what a Hyperloop ride actually may look like in the future, after experiencing it in VR. The change in voting behavior could therefore be attributed to the powerful act of showing a concrete instance or visual token of a more general abstract concept that does not yet exist in voters' knowledge base. The immersive nature of the images emphasizes the factual evidence of a Hyperloop existence in simulated "reality" because people could actually see, feel (sitting on a real chair while being in the VR) and thus experience it first-hand and in first person view for the first time (Sundar et al., 2017; Wu et al., 2021).

Alternatively, as mentioned in the literature review, VR, like many novel and thus lesser known and less well-understood digital technologies, could be perceived to pose risks of user manipulation (positive and negative), and thus people would be more inclined to be less positive (fewer YES votes) or more critical of voting issues presented in VR, irrespective of the pro or con arguments.

Although a few participants indeed mentioned the possible risk of user manipulation regarding the VR technology in the retrospective interviews, we did not find that this awareness of manipulation was reflected in the voting results. To explain this discrepancy between reflection on media influence and actual voting behavior, we refer to McLuhan's media theory and his catchphrase "the medium is the message" (McLuhan, 1994). It captures the idea that the form of the medium, including its technology, affects human perception and behavior. In other words, when people are immersed in a technologically-mediated environment, they remain "as unaware of the psychic and social effects of [their] new technology as a fish of the water it swims in" (McLuhan, 1969). Therefore, one line of explanation could simply be that novel display technology such as VR is generally being positively perceived as exciting and awe-inspiring. As most of our participants in the VR group have been exposed to novel visual display technology in our study that was also mostly new to them, they might have been more focused on the display technology itself than on the information provided in the scenes they experienced. The immersive VR experience may have simply overpowered rational reasoning (Hill, 2004, p. 33; Barreda-Ángeles et al., 2021), or what Kahneman (2011) would call analytical brain System 1 thinking. This may have led participants to make an intuitive and fast heuristic decision in favor of the Hyperloop (Kahneman, 2011), while ignoring the actual details in the content presented, that is, the arguments for or against it.

P10: When I saw the VR scenario, it was like an aha moment. That's when I realized: Hey, this is the future.

The effect of increased YES votes as a result of the VR experience may also be explained by the fact that VR facilitates visual storytelling, that is, triggering emotion and affect while presenting a sequence of facts. Extensive research on storytelling has shown that narratives are more persuasive than presenting a number of abstract facts (e.g., Bullock et al., 2021). Both VR scenarios (pro and con) enabled participants to fully immerse themselves in a story where they were the sole protagonist. In doing so, they were not only able to experience a "real existing" Hyperloop with all its visual details and characteristics, but also to live the Hyperloop story from their own, first-person, perspective. As Domínguez (2017) suggests, it is not just a matter of feeling transported to a place, but rather to experience a place first hand, in which also real stories are unfolding in real time. With the presented narrative of embarking on an immersive Hyperloop ride, the VR already offered a high degree of vividness, because it gave participants the feeling of "being really there" and becoming part of the Hyperloop ride story. In contrast, the degree of vividness in the text format (pro and con) had to be first generated in the reader's mind, and thus can be considered rather low. This is because the voting text is typically not written with storytelling in mind, or does not specifically employ an emotion-supporting narrative style. On the contrary, the purpose of official voting information is communication of facts and nothing else. For this, a detached, sober, impersonal, and argumentative style is preferable to use (Campos et al., 1999). Consistent with previous research, we also find that VR, probably because it is still in its infancy phase, generally elicits excitement and a positive attitude from our participants (e.g., Archer and Finger, 2018; Bujić et al., 2020; Mabrook and Singer, p. 1418), and this is perhaps the reason why VR overall yielded more YES votes on average compared to text.

Framing Effects Less Pronounced in VR

While the participants in the text conditions told us in the retrospective interviews that they realized that the text was framed in a certain way (pro vs. con), this seems not to have been the case for the participants in the respective VR conditions. One explanation could be that text and images have different inherent affordances (Kress, 2010) and that images more generally have affirmative power (Heßler and Mersch, 2009). One limitation was that we found it difficult to visualize abstract concepts such as the urban-rural divide, uncertainties related to immature technology, potential risks to human lives (i.e., drop in air pressure in the pod), or long-term impacts on the landscape (i.e., additional infrastructure). What can be easily described explicitly with text, e.g., the risk of a train accident or an environmental

disaster, is more difficult to visualize in VR without unsettling or even shocking participants. One such version of the con VR condition would have meant to graphically explicitly depict human accidents or the impact on the Hyperloop infrastructure or riders resulting from natural disasters, but this would have raised ethical issues. One interviewee (P7) commented on the VR design of the study:

P7: From my point of view, it was designed very neutrally. Of course, one could have depicted a huge crash in this experience and that everything explodes and bursts into flames to evoke fear.

Of course, portraying such shocking and arguably rare events of a Hyperloop ride might have had a greater impact on voting behavior compared to our solution, showing a headline in large print on the front page of a newspaper placed on a seat next to participants, containing a graph about a tax increase due to Hyperloop costs or a visible sickness bag in the back of participants' front seat, reminiscent of possible effects of turbulent rides known from airplanes. But how can risks, accidents, power outages, or environmental impacts be designed in an ethically responsible way? This shows that the ethical challenges of developing VR environments cannot be ignored, and that ethical guidelines are indeed needed in certain disciplines and professional fields related to VR development and use (Kool, 2016; Madary and Metzinger, 2016; Kang et al., 2019; Mabrook and Singer, 2019; Slater et al., 2020). The active storyline in VR was taking a ride in the Hyperloop and arriving safely at a destination, which participants in both the VR pro and con condition perceived in similar ways. The pro and con arguments were included in this journey. But the visualized arguments of the con scenario were either overlooked due to the novelty of VR use or intentionally ignored.

The relatively low salience of the pro and con arguments in the VR format may have contributed to this overall YES vote increase. For example, we designed the con arguments by showing a political campaign poster at the entrance to the station (**Figure 3A**), by visualizing an alert related to a missing internet connection on the back of the front seat screen (**Figure 3C**), or, as mentioned earlier, by placing a sickness bag in the seat pocket. These implementations of the pro/con arguments also mentioned in the text format might not have been visually salient enough, or understood. Neo et al. (2021) suggest incorporating highly photorealistic textures, e.g., high-resolution images from real products, as one essential VR design strategy. They argue that this is important if participants are expected to pick up objects or to examine them more closely. We made a conscious decision not to use highly photorealistic textures in the developed scenes to avoid visual overload and to avoid distracting participants from the main storyline. The imagery of our VR scenarios therefore offers a lower degree of semiotic richness and vividness due to its arguably sterile and less elaborate design style, compared to real-existing environmental indoor and outdoor scenes, and due to the few options for interaction with the images. Lower degree of semiotic richness and vividness here refers to the design possibilities VR offers in general as we encounter them, for instance, in highly photorealistic VR movies, VR animation, or VR games. The degree of realism, semiotic richness, and vividness in VR environments to be used in political contexts, and the related power of immersive imagery need to be explored more systematically in future studies (Lokka et al., 2018). Another weakness of our VR design might be that we did not provide enough storytelling guidance through additional visual and/or acoustic effects to ensure that participants do not miss important clues or graphic elements in the VR, specifically related to the argumentative line of the visualized voting issue.

According to our interview analysis, the con arguments were presented in a clearly understandable, coherent, and fact-based manner and were therefore better understood than the informationally-equivalent con scenario in VR. This could have been a reason for the increased number of NO votes in Vote 2 for the participants in the text groups. Here we do find one advantage of the text format for public communication: the possibility to convey multiple perspectives and arguments in a way that allows for slower analytical and rational cognitive processing by the reader, even possibly triggering the necessary distance for critical observation. This is in comparison to the immersive, visceral nature of VR, possibly leading to stronger emotional involvement, and thus to intuition-based heuristic decision making.

In summary, transforming static, fact-based information into an immersive, interactive first-person narrative accompanied by immersive, interactive scenes including graphics, text elements, and sound has turned a sober voting issue into a multimodal experience with increased epistemic value. In doing so, it has made the Hyperloop initiative more tangible for a non-expert audience. At the same time, the argumentative value of the information presented in VR decreased compared to the traditional text format, as the richness of the visual experience combined with a novel and exciting technology may have distracted participants from the relevant arguments necessary to make an informed voting decision.

Limitations of the Study

Participant recruitment for the VR experiment started in September 2020 and thus data collection happened in the midst of the unfolding COVID-19-pandemic, following safety regulations issued by Swiss authorities. Measures put in place for the protection of participants (distancing rules; face coverings; disinfection of equipment) during the global health pandemic did affect participation in the study and possibly participants themselves. Because of said restrictions, it was nearly impossible to recruit participants outside of the university, and thus our sample, predominantly of students and staff members of higher academic institutions, might not be considered the most appropriate representation of the general public. This could be one reason that our participants exhibited a higher degree of media literacy and political engagement, compared to what would be expected in the general public. The VR experience of the participants, however, was low, and as long as people still have little experience with VR technology, more studies are needed to further investigate the relationship of VR modality (technology) and VR messaging (content) on human decision-making processes and human behavior.

While we did include the same number of pro and con arguments that we had obtained from the Hyperloop expert interviews across the tested VR and text presentation formats, we do recognize that the two formats themselves offer different modalities and affordances for information access. We cannot claim that our study design offered full experimental control in this respect. Having said that, while this might be interpreted as lesser internal validity, our goal was to achieve high ecological validity, as is typical for use-inspired experiments.

As for further studies, it would be interesting to compare the effects of various multimodal formats on political decision-making (e.g., explainer videos, 360-degree immersive video, VR with room-sized wall-displays offering participant collaboration). In such a study, the degree of immersion, vividness of images, and interactivity could also be varied. Finally, we were guided by the theoretical concept of the immersive power of images in our study and data analysis. Theoretical concepts from the psychological literature and cognitive sciences related to decision-making, framing, and the role of emotion and presence could also serve as an alternative starting point for follow-up studies.

CONCLUSION AND OUTLOOK

The aim of our study was to gain first insights into the power of immersive images in the context of political communication. We set out to empirically investigate the impact of immersive images presented in VR compared to traditional text-based voting materials on voting behavior. Our empirical findings suggest that indeed the presentation format has an impact on voting behavior. In other words, experiencing information related to a voting issue presented in VR does have a positive strengthening effect on voting outcomes compared to reading equivalent information in a text format. Irrespective of the pro or con arguments presented in VR, participants in the VR group show an overall increase in YES votes compared to participants reading the same information in the text format. Insights obtained from the retrospective interviews allow us to understand these results more deeply. Several factors may have led to this increase in YES votes in VR: (1) the affirmative power of images, (2) the vividness of immersive images, (3) first-person storytelling and storyliving, (4) the greater affordances of VR for engagement through interaction, (5) the design of the VR environment, and (6) the novelty of the VR technology.

At this stage of our research, we can already conclude that the immersive nature of the (head-mounted) VR tends to reinforce positive framings of the visualized information, but also mitigates negative framing, provided that the negative framing is designed in an ethically responsible manner, so that it will not shock or harm people. The power of immersive images can be considered a double-edged sword, particularly in political communication. On the one hand, VR can be leveraged to support the adoption of different perspectives on a given issue or it can be useful to increase empathy for other people or novel situations. It is also a powerful tool for visualizing complex or abstract future scenarios by making these more tangible. It could thus be harnessed by authorities to either maintain potentially dwindling proportions of people still engaged in political decision-making processes, and/or even reach citizens not yet engaged in politics or voting, thus increasing citizen participation in democratic processes. VR might also support stakeholders such as NGOs, activists, political parties, and the mass media to re-connect with their target groups or expand their member base. On the other hand, VR bears the potential to influence people without them being aware of it, as our study has shown. VR applied in political contexts can therefore be easily misused as a manipulation tool for propaganda purposes or the dissemination of fake news. Either way, immersive images can have tremendous persuasive powers by making the virtual feel real. The question remains as to how this power can be harnessed in an ethical and socially responsible manner.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary files, further inquiries can be directed to the corresponding author. The transcribed interview data (only in German) are available on SWISSUbase (https://www.swissubase.ch/en/).

ETHICS STATEMENT

The participants provided their written informed consent to participate in this study. The informed consent for the study was approved by the Legal Services Office of the ZHAW Zurich University of Applied Sciences.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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