

SpecuAR: An In-the-wild Exploration of Users' Perceptions of a Social Augmented Reality

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Figure 1: In this work, we identify the desired augmentations in public spaces through interviews with 64 participants. We then provide an implementation of a social augmented reality and evaluate users' perceptions in an in-the-wild study where participants walk around in a city in Switzerland using the Meta Quest 3.

Abstract

While head-mounted augmented reality (AR) glasses are becoming increasingly reliable and relevant for public scenarios, little is known about users' preferences and perceptions when experiencing AR in social spaces. In this late-breaking work, we investigate users' perceptions of augmented social environments tailored to their shared interests. Through interviews with 64 participants, we first identified 12 key usage scenarios, which informed the development of SpecuAR, a prototype for an augmented social reality. We then conducted an in-the-wild study with 18 participants to assess their experiences with SpecuAR. Our findings reveal that shared AR scenarios are generally perceived positively and can be seamlessly integrated into real-world environments to augment and further

enhance real-world spaces. Our exploration of augmented social spaces highlights important considerations and lays the groundwork for future studies and the realizations of augmented reality applications in everyday lives.

CCS Concepts

• **Human-centered computing** → **Empirical studies in HCI.**

Keywords

Mixed Reality, MR, Empirical Study, Augmented Reality, AR

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1 Introduction and Background

As augmented reality (AR) devices are becoming more accessible [6], new use cases are emerging, and applications in public spaces are becoming more viable [10]. While content experienced through a head-mounted display (HMD) is often only perceivable by one user [4], approaches such as that by Ran et al. [15] show how multiple users can experience a shared augmented environment in the same physical space. However, Olsson and Salo [11] outlined that AR applications were lacking strong concepts with noticeable practical benefits resulting in AR applications being used for their novelty rather than their commodity value. Experiences which have led to dissatisfaction were stated to be, in part, caused by irrelevance of the experience, lack of reliability and liveliness of the content, and physical risks related to the immediate surroundings [12]. From these works and the idea of embedding contextually aware AR in our everyday life (i.e., pervasive augmented reality [3]), we learn that the use of AR to augment a users' shared public space is promising; however, as of now, little is known about the scenarios in which users would want to use augmentations in their real-world environment and how they would perceive an in-the-wild implementation thereof that is relevant to their shared interests.

This late-breaking work addresses this gap by conducting two studies exploring (1) in what scenarios users envision an augmented social space to be beneficial (interview study in Section 2) and (2) how users perceive such an in-the-wild implementation (prototype and in-the-wild evaluation in Section 3). We first interviewed 64 participants to envision what a future in an augmented social space could look like. Based on the interviews, we created SpecuAR, an implementation of such an augmented environment, and evaluated the perceptions of 18 study participants when augmenting their reality. Experiencing this augmented social space, proven relevant by its pragmatic quality score, was perceived as a balanced experience between being self-oriented and task-oriented on the verge of desirability. Our late-breaking work provides key considerations in regard to augmented social spaces for future studies to further explore AR in the context of applications for public use.

2 Contribution 1: Laying Out a Design Space of a Potential Social Augmented Reality Environment

To provide early insights into the scenarios of everyday AR that contribute to a social augmented reality, we first conducted interviews with 64 participants in a public space to identify scenarios in which people could imagine extending their reality using everyday AR. We recruited 64 participants in a small city in Switzerland called St.Gallen. There were 41 males and 23 females, with an average age of 28.5 (SD=13.1). 34 participants considered themselves as locals, and 19 mentioned they had experienced AR before. All participants provided informed consent and the study underwent an ethics checklist.

2.1 Procedure

The interview started with a set of demographic questions. The participants were then introduced to head-mounted AR using a video of a local public place being augmented with an animated dinosaur (Figure 1). We intentionally chose a scenario that did not

appear to serve an important role in a public space to minimise potential biases. Participants were first asked in what scenarios they would like to augment their reality in social spaces, with the goal of collecting both use cases, as well as details on how the participants envision possible implementations thereof. Then, the participants were confronted with the concept of a shared augmented social space in which other users could see the same virtual content as the participant. The participants were then asked how they think such a reality would impact the scenarios they mentioned as well as what additional scenarios they could envision. If the participant had difficulties coming up with concrete ideas, we presented an image of a virtual bike parking being displayed on a street to further clarify the concept of an augmented social environment. While our interviews outline an exemplary design space for a social AR environment, we do not claim it to be exhaustive. We encourage further research to expand upon our late-breaking findings.

2.2 Data Analysis

The interviews were analysed by first transcribing the recorded audio to text. The key findings were then extracted from the individual transcripts using important keywords by two researchers working in parallel. Using affinity diagramming [16], the scenarios were clustered into groups of similar topics, and the concretions linked back to the original interview transcript using identification numbers.

2.3 Results

We present the interview findings, which resulted in an implementation of a social augmented reality (Figure 2). Our supplementary material shows a video with all implemented scenarios in everyday AR.

2.3.1 Navigation and way finding. Our interviewees expressed a desire for navigational aids using AR. Some concrete means of visual guidance that were mentioned include: a highlighted line along the designated path, similar to Google Maps, arrows which point out the route that has to be followed, and displaying street names in the sky.

2.3.2 Tour Guide. Participants noted that it is not always apparent what cultural significance certain objects and places in the city hold. Thus, a wish for a form of city guide was articulated by the interviewees. Ideas on how such a guide could be implemented ranged from simple signs that contain the necessary information in text form all the way to a virtual dynamic tour guide that acts as a companion and explains the cultural significance of buildings and statues.

2.3.3 Accessibility. During the interviews, participants recognized the potential of AR to improve the accessibility of the city. The area where this potential was regarded as most applicable was improving the visibility of easy access areas by using signs and markers which display recognizable accessibility symbols.

2.3.4 History. Alongside the city guide, another theme, experiencing history in more immersive ways, arose during the interviews. Participants mentioned opening virtual windows into the past and watching how history transpired. Another aspect that came up was

the possibility of showing how buildings and places used to look like in the past by overlaying model representations of the past over the current objects.

2.3.5 Advertisements. Advertisements were a recurring theme among the interviews. Participants mentioned that they could well imagine that the AR space could serve as a platform for advertisers and businesses to promote their products. The fashion in which these advertisements could appear was described as floating models of the products, indicators for restaurants, and even personalised floating panels that display adverts based on the user's preferences.

2.3.6 Public Transport Timetables. A commonly mentioned scenario was utilising the AR space to offer another way of displaying the arrival and departure times of public transport. The ability to position the timetable in a way that is more visible was noted as one of the reasons why this feature would be advantageous.

2.3.7 Traffic and Road Signs. Participants did not only consider how AR could be applied in the context of pedestrian zones, they also considered how further elements that make up the city, such as public road networks, could be augmented. In regard to this, participants mentioned that visibility and state of traffic lights could be displayed through artifacts on the ground, and that caution signals could be placed within the augmented environment. For motorists exclusively, the scenario of displaying closed-off roads or one-way streets was also discussed.

2.3.8 Construction Projects. A use-case people assumed would be applicable is visualising how potential construction projects would look within their respective environment. Participants explained that it can sometimes be hard to envision how a build proposal will look and thus felt that AR could be applied here in a meaningful way.

2.3.9 Art. Participants explained that they want to be able to better interact with existing physical artwork, by either being supplied additional information or having some way of interacting with the art. Additionally, participants expressed that they wanted to display and see custom artworks.

2.3.10 Virtual Monitor. A scenario where AR was perceived as a welcomed innovation in the day-to-day life of people was the possibility of utilising virtual monitors. Here, participants argued that having some sort of heads-up display, which is essentially an overlay that shows things such as the time and weather, would prove to be beneficial as it would remove the necessity of looking at one's smartphone to check up on essential things. Furthermore, participants expressed a desire to read books and watch movies in an augmented social space.

2.3.11 Seasons and Environment. A scenario that was frequently mentioned in the interviews was the desire to introduce more greenery into the gray environment of the city. Participants, however, not only expressed they wanted to spruce up the city but also would like to be able to change the season within the AR environment (e.g., from winter to summer).

2.3.12 City-related Augmentations. When people were asked to imagine scenarios that would prove useful within the environment

of a city, they explored ideas that would expand upon already established city-wide events. One concrete example that was described by an interviewee was a virtual Christmas-themed display with large spotlights that brings more attention to the city's Christmas market.

2.3.13 Perceived Opportunities and Threats. In addition to the scenarios described above, the interviewees speculated that AR could be used to improve the general public's understanding of what constitutes compliant behavior. One participant mentioned that AR can *"maybe make everyday life a little more organized"* (P26), with P45 further denoting that *"when riding on your bike and seeing parking spaces, knowing that you can park there without it being illegal would be pretty helpful"* (P45). These notions were usually accompanied by participants expressing a lack of pointers within the real-world environment to deduce whether certain actions are prohibited. Another topic that surfaced in many interviews was the prospect of reducing government expenses by removing the need to set up temporary signs in the physical environment and solely displaying them in the augmented environment. An underlying concern the interviewees raised regarding an augmented social space was an increase in technological ostracism among people that would not adopt this new technology. Additionally, participants outlined that AR could lead to a decrease in social interactions and further isolate people from each other. For instance, P38 voiced that *"it leads to more individualism and that you would no longer approach other people"* (P38). Some even speculated that unconventional behaviours could arise among those using AR in public, due to the interaction modalities of such AR-experiences.

3 Contribution 2: Concept, Implementation, and Evaluation on SpecuAR

Based on the interviews, we built SpecuAR, covering 13 scenarios that represent the interviewees' shared interests and explore users' perceptions thereof. With SpecuAR, a user can freely navigate a public space and see, as well as interact with, augmentations in their surroundings (Figure 2). While our interviews provided the foundation for what content SpecuAR should include, SpecuAR was evaluated in a study with 18 new participants, providing insights into users' experience and perceptions of the concept of a future reality that is enhanced through augmentations.

SpecuAR was implemented using a Meta Quest 3 headset [7], the game engine Unity [17], and the Spatial Anchors [9] from the Meta XR SDK [8]. Finally, a method was needed that allowed creating a 3D scene that was correctly scaled to the real-world route. We would construct this scene directly in Unity, leveraging the integration of the Map Tiles API from Google [2], which allowed us to build the scene inside a full-scale model of the real world. Our implementation is publicly available for reproducibility and future research: <https://github.com/Mihael10110/SpecuAR>.

3.1 In-the-wild Evaluation of SpecuAR

Our in-the-wild study was conducted with 18 participants, each of whom would complete a route taking them roughly 300 meters through St.Gallen. All participants were wearing a Meta Quest 3 to experience the location-based augmentations displayed in Figure 2.



Figure 2: Overview of the key themes that contribute to a social augmented reality according to our interviews with 64 participants. The implemented AR experience is available in our supplementary material as a first-person video recording.

Participants provided informed consent and the study underwent an ethics check.

3.1.1 Route Design. To implement SpecuAR in a way that lets the user focus on the experience, it needed to take place on well-maintained infrastructure, be free of safety hazards, and minimize physical strain [14]. Figure 5 in Appendix C shows the route our participants took. Each number represents one scenario that we implemented, visualised in Figure 2. The scenarios were as follows: (a) Christmas Market, (b) Store Review on Building Facade, (c) Floating Bus Timetable, (d) Store Advertisement, (e) Information Pole (interactable), (f) Augmented Tree (the color of the leaves can be changed), (g) Restaurant Advertisement, (h) Historic Scene, (i) Visualisation of a Building Project, (j) Virtual Flower Garden, (k) Caution Zone, (l) Art Display (interactable) and (m) Accessibility Marker (Figure 2).

3.1.2 Participants. We recruited 18 participants using social media and word of mouth. Of the participants, 12 identified as male, and 6 as female (average age 30.1, SD = 12.4). 14 of the participants considered themselves as locals. The participants rated their prior experience with AR on a 5-point Likert scale with $M = 3.2$ (5 being very familiar, SD = 1.6). Although our recruitment strategy resulted in some participants being familiar with the urban environment, we do not consider this familiarity to have significantly impacted our findings. The AR experiences investigated in our study are

designed to be generalisable and can be effectively integrated into a range of settings, rather than being exclusive to St.Gallen.

3.1.3 Procedure. Participants first completed a demographics questionnaire, which was followed by a video tutorial in which the controls of the AR application, the route, and the study were explained. They were then given the AR headset at the starting location of the route and tasked with walking along the route while thinking aloud. During this part, the interviewer would intervene if the participant diverged from the route or ask for perceptions if the participant did not comment on the scenarios. Finally, the participant would fill in the AttrakDiff questionnaire [1] about their experience with SpecuAR. After this was completed, the participant took part in an interview. This part focused on the participant's personal perception of the application, as well as their view on sharing information, such as scenarios with other users participating in the augmented social space. The full questionnaire used can be found in Appendix A.

3.1.4 Data Analysis. For the recorded think-alouds and interviews, the audio files were transcribed using Whisper [13]. The transcriptions were then prepared by two researchers in parallel, with the participants' notions being grouped into segments and concatenated in spreadsheets.

3.2 Results

3.2.1 Perception of the SpecuAR Experience. The visualization of a potential construction project in full scale was stated to be particularly useful by eight participants. On the other hand, the virtual caution zone, consisting of a virtual fence and floating exclamation mark, was perceived as not being effective by three participants. It was mentioned by P16 that experiencing virtual plants in the city had a positive impact on their mood, explaining *"I have to admit that the city or the place feels much greener right now"* (P16).

Regarding everyday use, it was raised by three participants that, for some scenarios, such as the Christmas market and the construction visualisation, the scenarios were too specialised to be seen as everyday applications. Furthermore, an animated display that advertises a store led to three participants voicing a fear of a world overloaded with augmented advertisements. P5 described *"what is overwhelming me here, is that every business throws in so many ads. I would like to live in a world, where it is not like this"* (P5). Throughout the study, the topic of personalisation was brought up multiple times. The ability to choose what objects are displayed where has been requested by three participants, and one participant even stated they would like to be able to insert their own objects. A desire for manipulating the environment, such as moving objects, was expressed by two other participants.

However, seven participants noted that discomfort was perceived when traversing through virtual objects, and six participants noted experiencing discomfort or fear when standing on a virtual object covering the ground and the view of the participants' bodies. As P4 described it, *"it is not intuitive, because, like I mentioned before, I have this strong desire not to walk into the objects"* (P4). Moreover, the lack of occlusion of people, body parts, and environmental objects was perceived as problematic by 13 participants. In this context, two participants brought up the desire to enable or disable scenarios on demand. Here, participant 9 stated *"now this building is like covering some passengers, so I cannot see if the passengers are coming from this way. For me now it's a bit annoying that I need to think about whether people are coming from this way."* Regarding the experience in general, one participant mentioned that the headset created a perceived barrier between them and the real world; however, they noted that this was not perceived in a negative way. As an additional feature, one participant expressed the desire to include acoustic augmentations in the experience.

3.2.2 AttrakDiff. The user experience of SpecuAR was further evaluated using the AttrakDiff questionnaire [1]. The pragmatic quality (PQ), hedonic quality (HQ), and attractiveness (ATT) of the user experience are assessed by having the participants locate how they perceived the experience on 28 seven-point scales, each placing the experience on a range between two opposing adjectives [5] (Figure 4 in Appendix B). The three main qualities (PQ, HQ, and ATT) assessed by the AttrakDiff questionnaire are further subdivided by splitting the hedonic component (HQ) into two sub-components: identity (HQ-I) and stimulus (HQ-S), forming the four dimensions we assess in this section. If we analyze the average values for each component, we can see that overall, SpecuAR scored the highest in attractiveness with 1.71. This is closely followed by the hedonic stimulus with 1.56. In pragmatic quality, a score of 1.02 was accumulated, showing that the application was perceived as

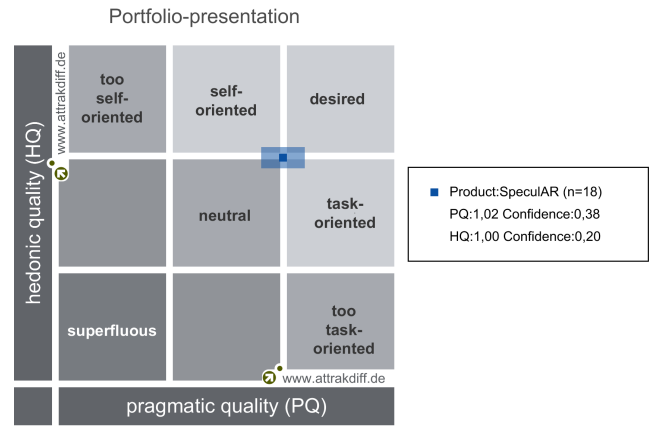


Figure 3: The intersection of SpecuAR's hedonic quality and pragmatic quality using the AttrakDiff questionnaire [1].

effective and efficient in helping the participants achieve their goals. The lowest score was obtained in the hedonic quality dimension of identity with 0.45.

Figure 3 visualises the average values of the pragmatic and hedonic qualities. SpecuAR falls between the quadrants desired, self-oriented, task-oriented, and neutral. This shows that the experience is neither too self-oriented nor too task-oriented, with the center point landing on the diagonal line between the two dimensions (PQ=1.02 and HQ=1). Figure 3 also shows that the experience is on the verge of becoming desirable, with the point being centered between the neutral and desired quadrants.

3.2.3 Interviews. The use cases for tourism, such as implementing a virtual tour guide, as well as those for personal navigation were brought up by more than five participants. Visualizing a potential construction project in full scale was explicitly mentioned as a strength by two participants.

Regarding other opportunities, convenience was mentioned by eleven participants, who would mainly refer to the ability to see relevant information, such as a restaurant review, located right at the corresponding location. Not having to invest effort to consult a mobile phone was mentioned explicitly. Additional opportunities raised were that commercial visibility and social awareness could be improved, and gamification exploited. One participant even mentioned that they find that a city that supported an augmented social space would be more appealing to be at.

Regarding potential threats, five participants noted that the augmented experience was providing a level of distraction that was perceived to be taking away from their feeling of living in the moment. It was also mentioned by four participants that there was a perceived threat of being controlled by the application and that this effect could be used manipulatively. Regarding the concept of object occlusion, twelve participants noted that they were afraid that potential danger, objects, or people could be covered by virtual content and five people were afraid of colliding with objects hidden behind or inside the augmentations. Finally, five participants noted that they expect that an augmented social environment could come

with less social interaction, one participant was concerned regarding privacy, and another participant mentioned that they perceived an inhibition to wear the headset in public.

4 Discussion

We built SpecularAR, an implementation of the concept of an augmented reality social space, containing scenarios brought up by 64 interviewees (subsection 2.3). Using SpecularAR, we evaluated the participants' perceptions of an augmented social space by conducting a second in-the-wild study (n=18) in which the participants experienced SpecularAR in St.Gallen (Section 3.1). Using the AttrakDiff questionnaire, we found that using SpecularAR was perceived as a positive experience that was on the verge of becoming desirable (Figure 3). Our findings from the users' impressions and interviews showed that the perception of such an augmented social space was sometimes subjective (Section 3.2.1). This indicates that customisation should be taken into account when creating such an application. This was even explicitly mentioned in the final interview by four study participants. Olsson and Salo [11] described that existing AR applications lacked strong concepts with noticeable practical benefits, which is outlined by the two most voiced reasons as to why users acquired AR applications being novelty-related. Thus, in our work, we contributed to this knowledge gap in the context of a social augmented reality environment. Our first study identified scenarios that are relevant to the public's shared interests, which is evidenced by the achieved pragmatic quality score (PQ = 1.02). In general, the participants considered the scenarios to have practical benefits, highlighting that with SpecularAR we were able to portray high user experience and acceptance in the context of an augmented social space. Regarding limitations of this work, it must be mentioned that the quality and attractiveness scores of SpecularAR are dependent on the participants' perceptions and interpretations of the concrete scenarios that were implemented. While those scenarios resulted from the interviews, it implies that the results might not be fully representative of augmented social spaces as a whole. Future studies could delve deeper into customisation aspects, referring to users' preferences in regard to position, scale, and stylisation of scenarios. Further explorations include exploring where the need for customization arises and for what reasons individuals perceive certain implementations superior to others. The user experience of the individual scenarios could be evaluated, and different scenarios or implementations thereof compared. Finally, based on our findings on participants' behaviours regarding object obstructions (Section 3.2.1), we propose further studying instinctive behaviours in in-the-wild experiences as well as how danger is perceived in such shared augmented realities.

5 Conclusion

We implemented and evaluated SpecularAR, a prototype augmented reality social space, designed based on interviews (n=64) uncovering how the public envisions such an experience to be like. Our in-the-wild evaluation was conducted with 18 participants in an uncontrolled public space. We found that experiencing an augmented social space, evidenced to be relevant to participants' shared interests by the achieved pragmatic quality score, provides a balanced experience between being self-oriented and task-oriented that is

on the verge of being desirable. We believe that our work uncovers key considerations in regard to augmented social spaces, paving the way for future studies, further exploring AR in the context of public augmented reality applications.

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A Study 2 Questions

A.1 Demography Questions

- Gender
- Age
- Are you from the region?
- Do you agree with the following statement: You have previous experience with Augmented Reality technologies.

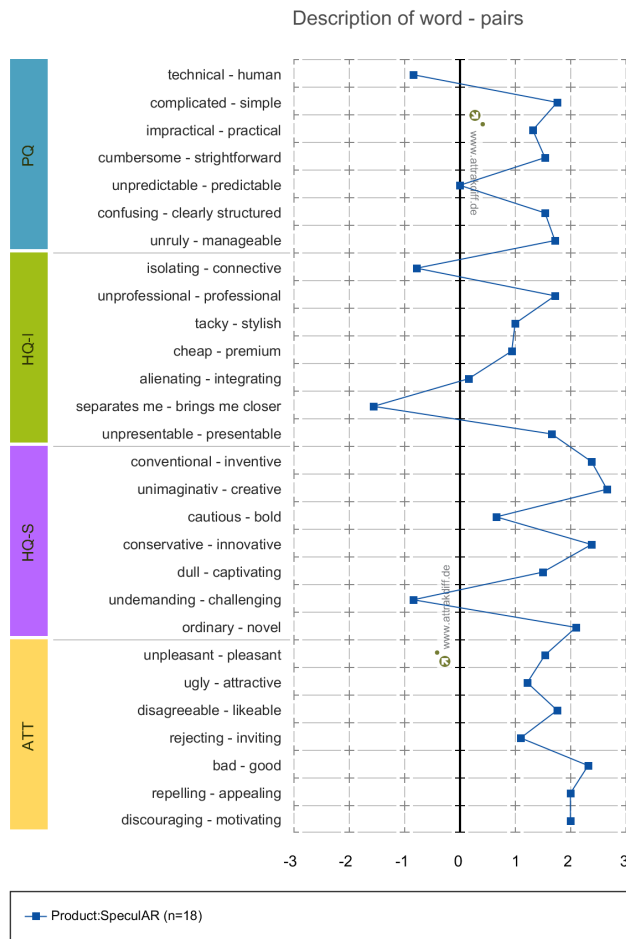


Figure 4: Diagram Description of Word Pairs: SpecuAR

A.2 Interview Questions

A.2.1 Individual Perception of the Application. This section focuses on how you perceived the experience you just had, testing SpecuAR in a public space.

- How would such an augmented reality change your everyday life?
- What opportunities do you see in the social application of this technology?
- What threats do you see in the social application of this technology?
- What would change in the application that you have just experienced?
- What did you miss in the application that you have just experienced?

A.2.2 Perception of Shared Scenarios. This section assumes you participate in a social environment in which multiple users experience an augmented social space. Both scenarios and information can be shared with other users.

- Assuming you use such a system, what information would you share with other users?
- Assuming you use such a system, is there any information you would not show publicly?
- Assuming people around you use such a system, what information from other users would you like to see?
- Now that you have seen some shared scenarios (e.g. art gallery), can you think of other scenarios that would benefit from sharing in augmented reality in everyday life?

A.2.3 Comments.

- Are there any comments on specific scenarios you would like to make?
- Are there any other comments you would like to make about this project or the study?

B Diagram of Word Pairs

The diagram of word pairs (Figure 4) shows that, overall, the user experience was positive, as the line connecting the data points is mostly to the right of the center line. Regarding pragmatic quality, the only outlier is the word pair: Technical – Human, revealing that the participants perceived the way an augmented social space was presented to them when using SpecuAR as too technical. Similarly so, in the hedonic quality category, where the users felt isolated and separated from others.

C Route Design

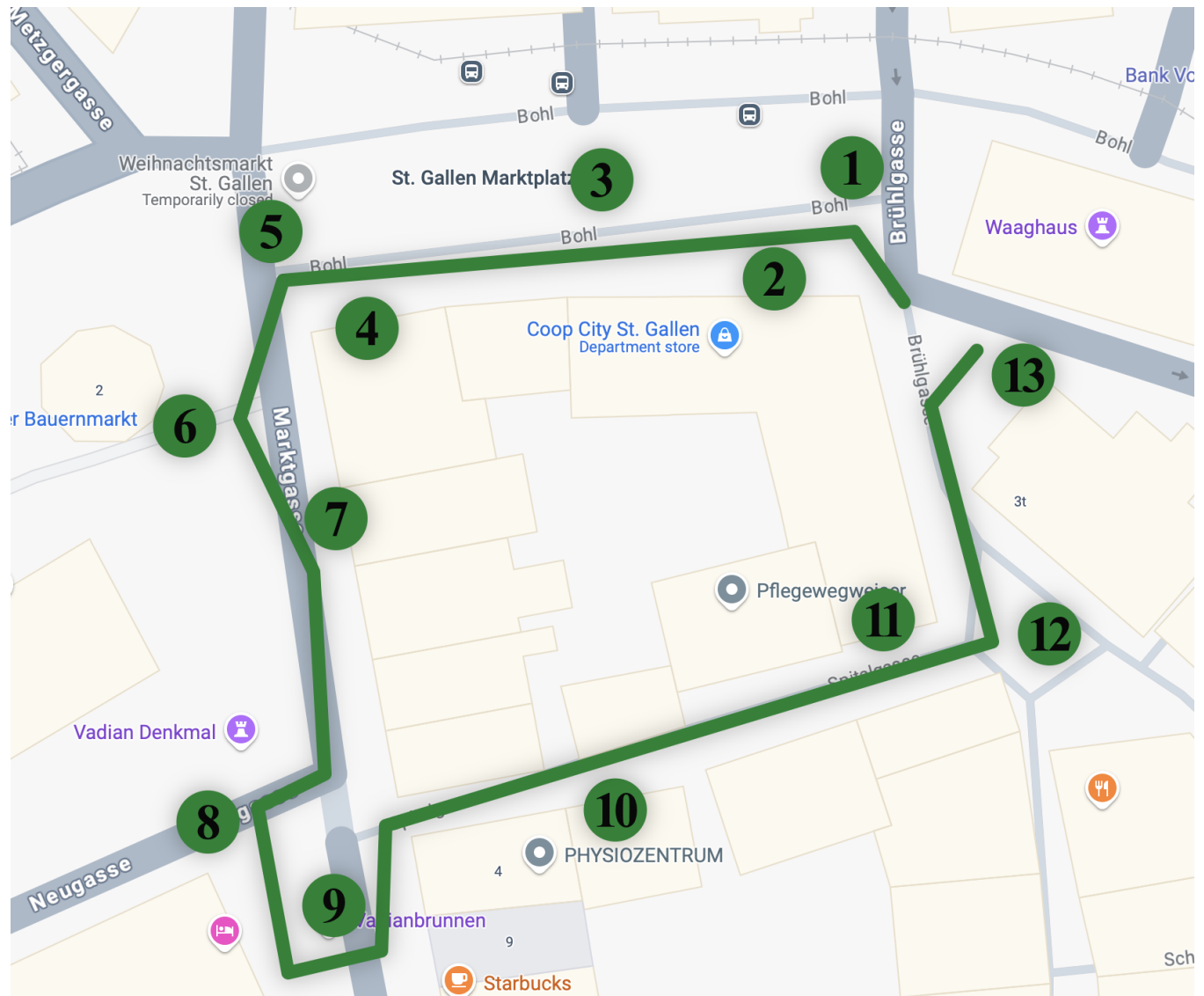


Figure 5: SpecuLAR: The route of the augmented scenarios that we used in Study 2. All participants walked the same route while wearing a Meta Quest 3.