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Moritz Schweiger, Jeffrey Wimmer, Gregor Nagler, Ruben Schlagowski

Angaben zur Veröffentlichung / Publication details:

Schweiger, Moritz, Jeffrey Wimmer, Gregor Nagler, and Ruben Schlagowski. 2021. "Augmenting the city: the photo-realistic animation of a historic building and its influence on spatial perception and meaning." *International Journal of Film and Media Arts* 6 (2): 107–28. <https://doi.org/10.24140/ijfma.v6.n2.07>.

AUGMENTING THE CITY

THE PHOTO-REALISTIC ANIMATION OF A HISTORIC BUILDING AND ITS INFLUENCE ON SPATIAL PERCEPTION AND MEANING

MORITZ SCHWEIGER

JEFFREY WIMMER

GREGOR NAGLER

RUBEN SCHLAGOWSKI

Moritz Schweiger, research assistant at the Institute of Media, Knowledge and Communication at Augsburg University and member of the research project DIGISTA (www.digista.de) (moritz.schweiger@phil.uni-augsburg.de)

Jeffrey Wimmer, Professor at the Institute of Media, Knowledge and Communication at Augsburg University and member of the research project DIGISTA (jeffrey.wimmer@phil.uni-augsburg.de)

Gregor Nagler, PhD in Architectural history and member of the research project DIGISTA (gregornagler@gmail.com)

Ruben Schlagowski, research assistant at the Chair for Human-Centered Artificial Intelligence at Augsburg University and member of the research project DIGISTA (ruben.schlagowski@informatik.uni-augsburg.de)

Corresponding Author

Moritz Schweiger

moritz.schweiger@phil.uni-augsburg.de

Augsburg University

Universitätsstraße 10

86159 Augsburg

Germany

Acknowledgements

The authors would like to thank Lisa Weißenberger and Antonia Wurm for their support in the data collection process.

Funding: This work was supported by the German Federal Ministry of Education and Research [grant numbers: 01U01820A].

Paper submitted: 8th March 2021

Accepted for Publication: 7th October 2021

Published online: 17th December 2021

Abstract

Augmented Reality (AR), defined as the holographic overlay of physical space with virtual objects in real time (Azuma, 1997), can be considered a prime example of mediatization. This development is particularly evident in the public space of the “mediatised city” (Hepp, Simon & Sowinska, 2018), being a focal point of the latest media technologies already overlaid with a multitude of AR content. But how does AR change the perception and meaning of urban space? And how can researchers capture methodically the appropriation of complex, large-scaled AR content experienced via high-tech AR glasses? To answer these questions, a historical building, that had been destroyed during the Second World War, was reconstructed as a holographic animation on a public city square. In order to resurrect this building in AR, old photographs, paintings and postcards were evaluated and used to create a virtual model in the original size and place it at its original location. The test subjects were then able to view the hologram from various different angles using AR glasses (Microsoft HoloLens 2), move freely around the square and even enter it. Combining quantitative, before-and-after questionnaires and qualitative thinking-aloud protocols, our results show that the holographic animation of a historical building can influence both the sensual-aesthetic perception and the personal meaning of a public square for city dwellers. Specifically, our test subjects perceived differences in its accessibility, coherence and aesthetics, simplicity, atmosphere and legibility. The meaning of the square was altered with regard to personal memories (= the self), typical groups of people (= others) and certain opportunities (= environment) associated with it by city dwellers.

Keywords: Augmented Reality, Augmented Space, City Square, Spatial Meaning, Spatial Perception, Urban Space

1. Introduction

The holographic overlaying of physical space with virtual objects in real time, also known as augmented reality (AR) (Azuma, 1997), can be considered a prime example of mediation. This increasing penetration of our perceived reality by photo-realistic animations is particularly evident in the public space of the “mediatised city” (Hepp, Simon & Sowinska, 2018), which is already overlaid by a variety of AR content such as holographic game characters (Woods, 2020), travel guides (Han et al., 2014) or buildings (Reinwald et al., 2014). Aurigi & Cindio (2008) describe this development as the emergence of an “augmented space” that is tied to the conditions of urban space and is largely constituted by AR.

In scientific research on AR, it is thus important to consider a fundamental but often neglected characteristic of this medium: its spatial reference. While generic AR content such as Pokémon Go or Snapchat can be experienced and become meaningful regardless of its location, locative holograms are bound to the characteristics of the physical environment, spatial relations and the exact position in space. Only at these user-selected locations can they unfold their significance and add new layers of meaning to urban space that have a lasting impact on our perception. This is exemplified by the AR app Layar, through which users can independently create, place and perceive holograms with their smartphone. For example, Layar users augmented the meaning of St. Mark's Square in Venice by placing artists rejected from an international art exhibition there as holographic animations to question the power structures relating to the cultural sector in Venice (Liao & Humphreys 2015, pp. 1428-1430).

Recent technological developments such as the Microsoft HoloLens 2 or rumours about the Apple Glass¹ show that in addition to so-called “handheld” AR via smartphone or tablet, “headworn” AR glasses will also play a more significant

role for the smart city in the near future, as they enable an even more immediate and user-friendly experience of holographic animations (Liao, 2018). Advances in graphic representation also suggest that in addition to small, simple AR content, it will also be possible for large-scale, more complex holograms, including holographic buildings, to overlay urban space. In contrast to previous AR-research focusing on contemporary building holograms (Boulos et al., 2017), the question we posed was to what extent historical buildings can be holographically reconstructed through AR and how this might influence the experience of urban space. Our guiding research question was therefore:

To what extent does the holographic animation of a historical building through AR influence the spatial experience of a city?

To answer this question, we conducted a field study in which a building that had been destroyed during the Second World War – the stock exchange of Augsburg – was holographically animated and presented to the participants via AR glasses. In the following, we will first describe the historical background of the stock exchange and its significance for the city and its inhabitants before we provide more detail about its holographic reconstruction (chapter 2). We then explain the theoretical background that can be used to conceptualise the experience of augmented space (chapter 3). In chapter 4, we describe the methodological procedure used to empirically capture the experience of augmented space before presenting our results in chapter 5. The article closes with a critical reflection on the results (chapter 6).

2. The stock exchange building of Augsburg

2.1 Historical background

The Augsburg stock exchange was significant for the city in several respects: in terms of urban history, Augsburg had been

1 <https://www.macrumors.com/roundup/apple-glasses/>

one of the most important money trading centres in Central Europe since the 16th century. Founded in 1540, the Augsburg stock exchange was one of the first institutions of its kind in the German-speaking world and only lost its importance at the beginning of the 20th century (Zorn, 1961). Architecturally, the building, which was inaugurated in 1830 according to plans by Johann Nepomuk Pertsch, was the most imposing example of classicist architecture in Augsburg. Pertsch chose Florentine Renaissance forms for the façade with its central avant-corps and angled side sections. In terms of urban planning, the importance of the stock exchange building was reflected in its central location at the heart of the city. It stood on the Rathausplatz (the city hall square) at the former Herren- und Kaufleutestube from the 16th century – one of Augsburg's most important meeting places until 1806 (Nerdinger, 1980).

In 1944, the building was severely damaged in Allied air raids. The remains of the building were demolished in stages until the early 1960s. An administration and bank building was to be constructed in place of the stock exchange and its neighbouring buildings. However, these plans for a city's building council failed because of the Augsburg residents, who voted in a referendum for an undeveloped Rathausplatz in order to preserve the frontal view of the city hall (Nagler, 2015). As a central meeting place, it is a popular and lively spot; in the summer, the square enjoys the sun until well into the evening and numerous events are held here throughout the year.

However, the architectural interplay of historic buildings and the formerly funnel-like square space was permanently obliterated by the successive demolition of the stock exchange and its neighbouring buildings. The west and south sides of the square are now dominated by buildings dating from the 1950s and 1960s, which are not appropriate to the size and significance of the Rathausplatz. As a result, the current urban and architectural appearance of the city hall, the stock exchange and its neighbouring buildings is no longer coherent.

2.2. Holographic animation and experience

The history of the development of the stock exchange² and the Rathausplatz has been the subject of numerous publications (Zorn, 1961); the history of Augsburg as a money trading centre has also been presented several times. Pictorial sources relating to the stock exchange include a design plan preserved in the Architecture Museum of the Technical University (Nerdinger, 1980, p. 351) and another plan at the Augsburg Art Collections and Museums. The exterior view of the stock exchange can be seen in several drawings, copperplate engravings, and photographs of Augsburg's city centre – from the square or from the air. The ruins are also documented photographically. To date, only one photograph of the interior of the stock exchange is known; it shows the so called Harmoniegesellschaft ballroom. For this research, city maps of Augsburg were also consulted, which depict the urban situation of the Rathausplatz before 1944.

Based on plans and photographs, several drawings and sketches of the Rathausplatz in its former (Fig. 1) and present form (Fig. 2) were made. For the holographic modelling, a scan of the design plan, a façade plan of the neighbouring building and several photographs and postcards of the stock exchange and the square were provided. After modelling the hologram, the result was reviewed by an architectural scientist and art historian to verify its correct representation and approved for this study.

The study participants then had the opportunity to view the holographic animation of the Augsburg stock exchange in its original size on the Rathausplatz using AR glasses (Fig. 3.1 and 3.2). First, they listened to a short audio file explaining the historical and architectural background of the building and the square. Afterwards, they were able to move freely around the square and view the hologram from different angles. However, due to the lack of sources of interior recordings, it was only

2 In the interests of simplicity, the term "stock exchange" is always used synonymously for the "building of the stock exchange".

possible to holographically reconstruct the exterior façade of the building (Fig. 4 and 5) – when entering the hologram, only the back of the exterior façade was visible.

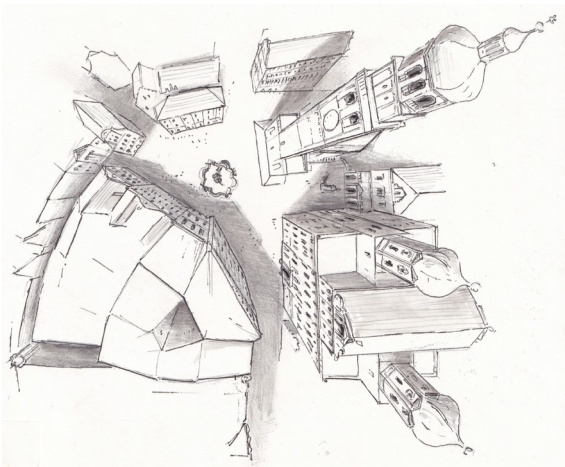


Fig. 1 Rathausplatz (city hall square) and the stock exchange (left) and the city hall itself (right) in the year 1750 (drawing by Gregor Nagler, 2020).

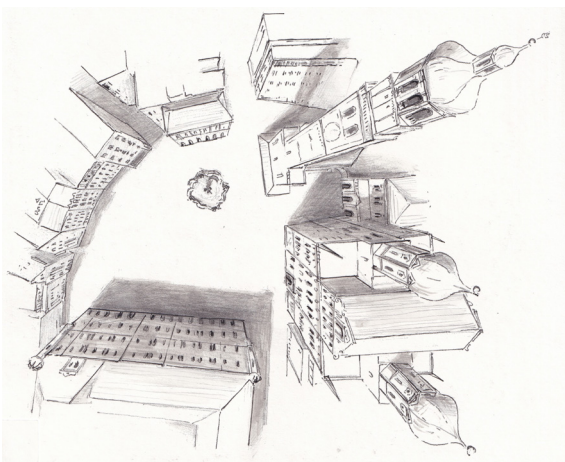


Fig. 2 Rathausplatz (city hall square) without the stock exchange in its current form (drawing by Gregor Nagler, 2020).



Fig. 3.1 and 3.2 Test subjects wearing AR-glasses on the Rathausplatz in Augsburg (Schweiger, 2021).

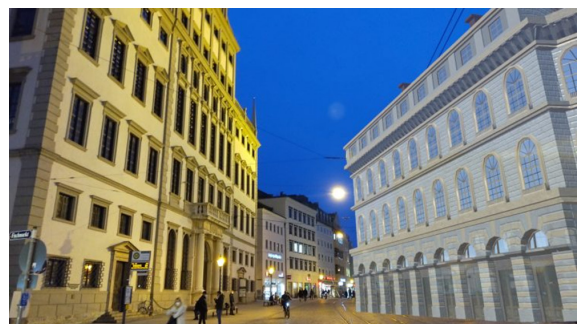


Fig. 4 Holographic animation of the Augsburg stock exchange (right), with the city hall on the opposite (left) (Schweiger, 2021).

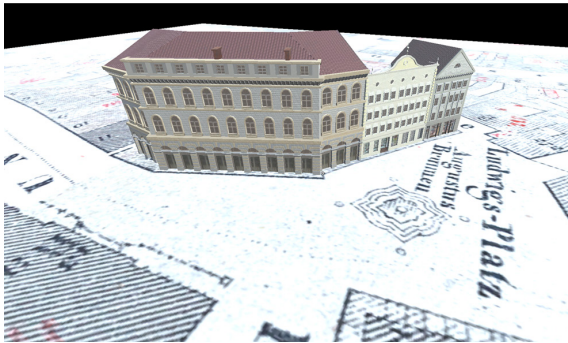


Fig. 5 Holographic animation of the Augsburg stock exchange on its original site (Schlagowski, 2021).

3. Theoretical background and research questions

3.1 Spatial dimensions and levels of analysis

To answer the question of how the holographic animation of the Augsburg stock exchange influences the experience of urban space, it is first necessary to consider the different levels of analysis of space. In everyday life, people connect with their surroundings in various different ways. As a result of the so-called spatial turn – the emphasis on place and space in social sciences – communication and media studies have increased their focus on how physical space and spatial conditions influence people’s communicative and media reality (Warf & Arias, 2008). In this context, several levels of analysis or dimensions can be identified in current research on how this connection to space can be established: Firstly, the sensual perception of space (Löw, 2008), and secondly, the symbolic meaning that certain places have for people (Gustafson, 2001).³

These two spatial dimensions – which will be referred to as spatial perception and spatial meaning – can be found in urban studies. The starting point is always the question of whether the city is to be analysed as a sensually perceptible or symbolically significant space of investigation (Lossau, 2012, p. 191–195). When dealing with “augmented space” (Aurigi & Cindio, 2008), the overlaying of urban space with holographic animations, it is important to consider these two spatial dimensions in the study design. Otherwise, the researcher runs the risk of neglecting fundamental characteristics of this genuinely spatial form of AR.

The question that arises is how spatial perception or meaning that is augmented by holographic animations can be conceptualised. It is striking that most AR studies focus on specific applications (cf. the smartphone app Layar, Liao & Humphreys, 2015), specific forms of perception, specific content or places (cf. the analysis of place satisfaction through AR in heritage tourism sites, Tsai 2020). Consequently, the categories are also derived (deductively) or formed (inductively) from highly specific theoretical frameworks. The aim of this study is to investigate AR and its influence on spatial experience regardless of location and content. For this purpose, it was necessary to find theoretical concepts that have a sufficiently high level of abstraction to holistically capture spatial perception or meaning.

With the help of semantic differentials, a specific type rating scale which applies two polar adjectives, the spatial perception of virtual (and physical) environments can be conceptualized and visualized regardless of content and location (e.g. “simple - complex”). A good example is provided by Kuliga *et al.* (2014). In order to measure the spatial perception of two identical buildings in virtual and real set-ups buildings, they created a polarity profile from 20 polarities, or 40 attributes

³ In addition, a third dimension can be identified in the current research, which describes the formative power of space on human behaviour (de Certeau 1985). Spaces are thus given meaning by individuals, which suggest or suppress certain spatial practices such as patterns of movement. Due to the focus of this article on the perception and meaning of space, however, this third dimension shall be left out in the following.

based on the theoretical considerations of De Kort et al. (2003), Westerdahl et al. (2006) and Franz & Wiener (2007) (Fig. 6).

| | |
|--------------|-------------|
| Boring | Interesting |
| Cold | Warm |
| Uninviting | Inviting |
| Bare | Decorated |
| Monotone | Varied |
| Simple | Complex |
| Unattractive | Attractive |
| Narrow | Spacious |
| Novel | Familiar |
| Inaccessible | Accessible |
| Illegible | Legible |
| Unclear | Clear |
| Arousing | Calming |
| Scary | Relaxing |
| Ugly | Beautiful |
| Coherent | Incoherent |
| Light | Dark |
| Closed | Open |
| Unpleasant | Pleasant |
| Private | Public |

Fig. 6 Semantic differential consisting of 20 polarity items by Kuliga et al. (2014, p. 368)

To represent augmented spatial meaning, the three-pole model by Gustafson (2001) can be used (Fig. 7). He conceptualises spatial meaning in relation to the self, others and environment and assigns different attributes to each of these

three poles. For example, the significance of places is shown by personal experiences (self), a certain clientele (others) or institutions (environment) that people associate with a particular place. In addition to these three poles, Gustafson also assigns the different aspects of spatial meaning along three axes he describes as self-others, others-environment and self-environment (2001, pp. 9-12). An overview of the attributes of spatial meaning that Gustafson derived from exploratory, guideline interviews on the perception of a wide variety of places can be found in figure 6. Although never before applied in the context of virtual environments, Gustafson's (2001) three-pole model of spatial meaning also lends itself to the analysis of holographically augmented spaces due to its high degree of abstraction and its holistic, location-independent perspective.

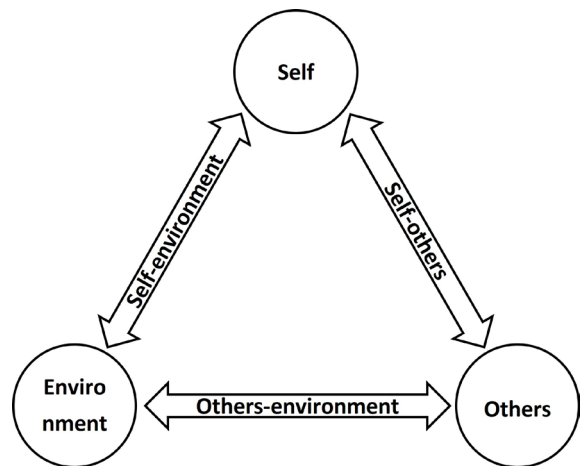


Fig. 7 The three-pole model of spatial meaning following Gustafson (2001, p. 10)

3.2 Research questions

In view of this historical and theoretical background, we differentiated our guiding research question into two specific research questions in order to examine the extent to which

the holographic animation of the Augsburg stock exchange might influence the experience of space on the level of the two spatial dimensions. The first question aims to find out in which way holograms of buildings with a historical reference influence the sensual perception of urban space – in this case the central square of the city centre. For this, we focus on the sensual-aesthetic aspects of architectural conditions and their holographic alteration:

RQ1: To what extent does the holographic animation of a historical building through AR influence the spatial perception of a city square?

With the second research question, we hope to investigate the extent to which the meaning of a central city square for its inhabitants can be changed by historical holograms. Specifically, we are interested in what personal memories or relations are associated with the Rathausplatz by city dwellers and to what extent the holographic animation of the stock exchange can influence them:

RQ2: To what extent does the holographic animation of a historical building through AR influence the spatial meaning of a city square?

4. Method

4.1 Recruitment

The survey took place between February and March 2021. Due to lockdowns and contact restrictions as a result of the Coronavirus pandemic, we had to deal with considerable recruitment difficulties in some cases. As older city dwellers did not want to participate in the study for fear of infection,

the average age of our sample is only 24 years (minimum: 18 years, maximum: 54 years).

For the development of a personal connection to urban space, however, it is not so much age as length of residence that is decisive, since the meaning of specific places (such as the Rathausplatz) is formed primarily through personal memories and experiences (Gustafson 2001). For this reason, participants who have lived in Augsburg or the surrounding area for less than three years were excluded from the study; the average length of residence is eleven years (minimum: three years, maximum: 39 years).

The study participants were recruited via third parties and selected based on their place of residence and length of residence in Augsburg (or the district of Augsburg). In addition, we ensured an even gender distribution. A total of 78 Augsburg residents (40 women, 38 men) took part in the study. No further sampling criteria were applied due to the difficulties in recruitment caused by the pandemic.

4.2 Empirical tools for capturing spatial dimensions

For the empirical assessment of augmented spatial perception and spatial meaning, we used a mixed-method design and combined quantitative and qualitative methods.

4.2.1 Capturing augmented spatial perception

To make the results more comparable, a factor analysis⁴ was then calculated to reduce the 20 polarities to a few factors. Two items were excluded from the analysis due to double or too small factor loadings. This resulted in the following five factors of augmented spatial perception consisting of 18

4 For the factor analyses, principal axis analyses with oblique rotation (oblimin, delta = 0) were calculated in each case, since the factors are latent constructs, and the assumption is that they correlate with each other. After a first analysis without factor number specification, a second analysis was calculated in which the factor numbers were specified, taking the elbow criterion into account. The pattern matrix was then interpreted.

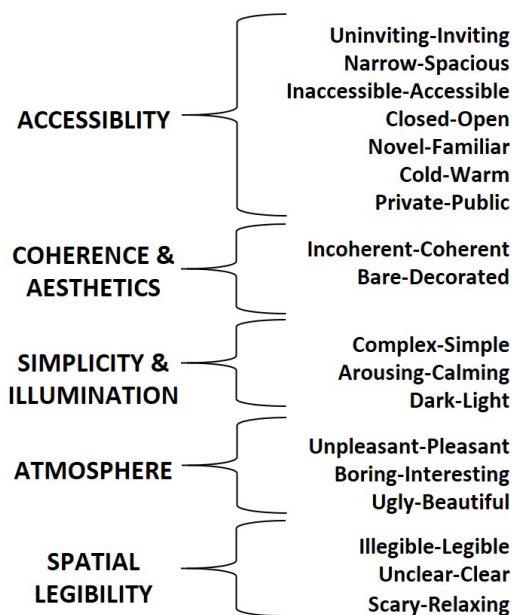


Fig. 8 Five factors of augmented spatial perception (Schweiger et al., 2021).

different polarities: accessibility (seven polarities), coherence and aesthetics (two polarities), simplicity (three polarities), atmosphere (three polarities), legibility (three polarities) (Fig. 8).

In addition, we used thinking-aloud protocols to obtain spontaneous associations, subjective impressions and more detailed insights alongside the standardised data. For this, the participants were guided to speak out everything that came to their mind (for a detailed explanation of the method, Wirth et al. 2004) – especially how the building would change the Rathausplatz in their eyes. Through this guided thinking-aloud, the interviewers were able to direct the conversation towards the sensual-aesthetic perception of space and avoid statements irrelevant to our research interest (e.g. regarding the usability or low weight of the AR glasses). The statements, gaze directions and gestures of the participants

were recorded using the integrated video function of the AR glasses, then transcribed and analysed for content. To this end, we assigned the qualitative statements to the individual factors and marked key quotations that validly depict the augmented spatial perception. Thus, they do not represent a complement to the questionnaire but an independent analysis, since we had to fall back exclusively on the open statements and associations of the participants in the case of contradictory, quantitative results in particular.

4.2.1 Capturing augmented spatial meaning

To quantitatively measure spatial meaning, we used the three-pole model by Gustafson (2001). The elements of spatial meaning and attributes associated with them (Fig. 7) were formulated into 56 questionnaire items in a preliminary study. After evaluating an online survey (n = 181) by means of a factor analysis⁴, a total of 30 attributes could be assigned to capture the significance of space in relation to the six elements of spatial meaning: self, others, environment, self-others, self-environment and others-environment. The test subjects rated this catalogue of questions before and after viewing the hologram using a 5-point Likert scale (1 = “strongly disagree” to 5 = “strongly agree”). This allowed us to determine the importance of the Rathausplatz for the people of Augsburg and how this importance would change as a result of the stock exchange. The difference between the before and after questionnaires resulted in a profile of an augmented spatial meaning for each participant. A factor analysis⁴ was then calculated using the difference value, whereby four items were excluded from the analysis due to double or too small factor loadings. An overview of the factors and items can be found in fig. 9. Using comparisons of means in connected samples, we tested the augmented spatial significance for statistical significance.

Again, we use additional thinking-aloud protocols to enrich the standardised results with qualitative insights. However,

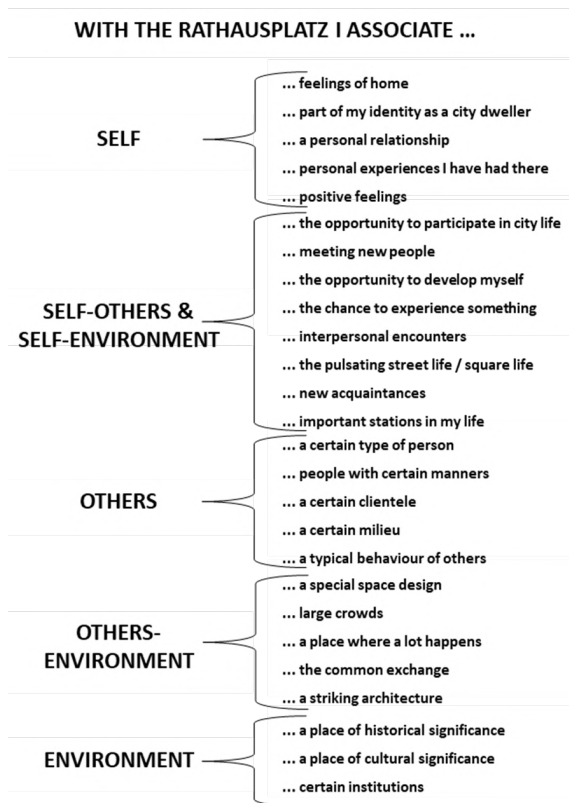


Fig. 9 Five factors of augmented spatial meaning (Schweiger et al., 2021).

thinking-aloud about the meaning of the Rathausplatz was carried out only after viewing the hologram. For this, the participants were presented with the video recordings of their AR glasses on a laptop immediately after their AR experience in an interview room. They were asked to speak out everything they personally associate with the Rathausplatz and how this would change through the stock exchange. The statements were recorded by voice recorder and then assigned to and interpreted in the context of the factors of augmented spatial meaning.

5. Results

5.1 Augmented spatial perception (RQ1)

The holographic animation of the stock exchange significantly influences the perception of the Rathausplatz. Differences can be found in the perceived accessibility (2.01⁵), simplicity and lighting (-1.08), atmosphere (-0.51) and spatial legibility (-0.61), but not in the perceived coherence and aesthetics (-0.03) (Fig. 10). This shows that the augmented Rathausplatz is perceived as less accessible, simplistic, atmospheric and spatially legible than the non-augmented Rathausplatz.

However, this does not mean that the stock exchange is fundamentally perceived as negative, as the comparison of the augmented (grey graph) and non-augmented (black graph) spatial perception illustrates (Fig. 11). Here, the average values of the polarities are shown on a scale from 1 to 6. It can be seen that the square with the stock exchange is definitely associated with positively connoted attributes in terms of its coherence and aesthetics, atmosphere and legibility (right half of the diagram) but is at the same time also perceived as predominantly inaccessible and complex (left half of the diagram). On average, the participants perceive the augmented square as rather negative in nine out of 18 polarities, while they consistently assign rather positive attributes to the non-augmented square.

In the following, we would like to take a closer look at the five factors of augmented spatial perception. In each case, the statistical results of the before-and-after questionnaires are first presented and then enriched by the more differentiated perspective of qualitative thinking-aloud statements.

5 The spatial perception was measured on a semantic differential scale with 6 points (value on the far left = 1, value on the far right = 6). The numbers show the average deviation from the centre of the scale (= 3.5) and thus describe the change or tendency in spatial perception. The greatest possible positive change is thus the value 3.5, the greatest possible negative change is the value -3.5.

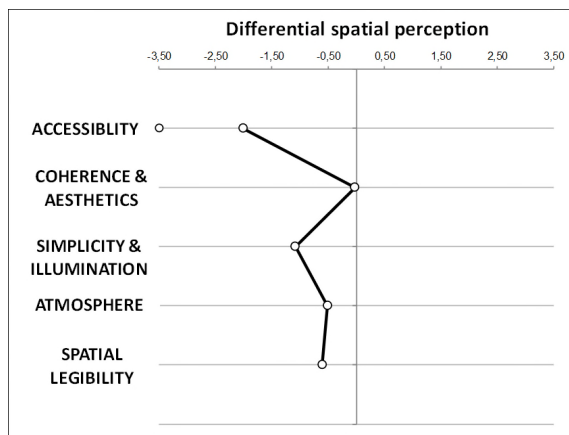


Fig. 10 Differential spatial perception (Schweiger et al., 2021).

5.1.1 Augmented accessibility

The Rathausplatz is one of the most prominent and expansive squares in the city centre, significantly characterised by its open space and the unmediated view of the front façade of the city hall. With this in mind, it is hardly surprising that the holographic animation of the stock exchange – which takes up almost two-thirds of the space – negatively affects the previously perceived accessibility of the square. This applies to both its physical and its sensual-emotional accessibility. The participants perceive the augmented Rathausplatz as rather “uninviting” (3.242), “narrow” (2.4), “inaccessible” (3.15), “closed” (1.96), “novel” (2.74), “cold” (3.14) and “public” (3.46) (Fig. 11). The mean comparison to the non-augmented town hall square, which is consistently perceived as accessible, proves to be significant for all polarities.

This perceived inaccessibility of the augmented Rathausplatz is also reflected in the qualitative statements of the participants. One Augsburg resident, for example, finds it “constricting, narrower and very bulky” (No.: 52, female, age: 50, length of residence: 25). Another city dweller sees the “square character” of the Rathausplatz as lost, the space now seeming more like a large boulevard (No.: 71, male, age: 26, length of

residence: 26). This impression is also described by a participant who has only lived in Augsburg for just over three years: “But there would no longer be such openness if the building were here. It would no longer be so free and accessible, it would just be built in. I associate that with ‘cold’ and ‘less spontaneous.’” (No.: 66, female, age: 24) These statements make it clear that even people with a short period of residence can establish a sensual connection to urban space that influences their perception.

In addition to these mainly negative impressions, there are also a few participants who evaluate the holographic animation positively and describe the non-augmented town hall square as a “concrete desert” (No.: 40, male, age: 26, length of residence: 5). This would be upgraded by the stock exchange, as one participant aptly describes: “Well, I actually think it makes the square smaller, cosier, which is what I would expect from the old town area. This large open space that we have here doesn’t really fit into the cityscape, including the side streets. And it always feels rather empty and windy and draughty to me. And this smaller setting, I actually find it quite nice.” (No.: 58, male, age: 40, length of residence: 4)

5.1.2 Augmented coherence and aesthetics

Due to its historical development, the Rathausplatz in its current form is architecturally characterised both by magnificent historical buildings and by plain, post-war buildings dating from the 1950s and 1960s (chapter 2.1). With this in mind, it is reasonable to assume that the holographic animation of the stock exchange enriches the coherence and aesthetics of the Rathausplatz and influences the inhabitants’ perception of the space accordingly. This assumption is reflected in the qualitative, but not in the quantitative results of our study. The participants perceive the augmented square as slightly less “coherent” (4.10 vs. 4.45), but more “decorated” (4.23 vs. 3.96) than the non-augmented square. The mean comparisons between the two variants, however, did not prove to be significant.

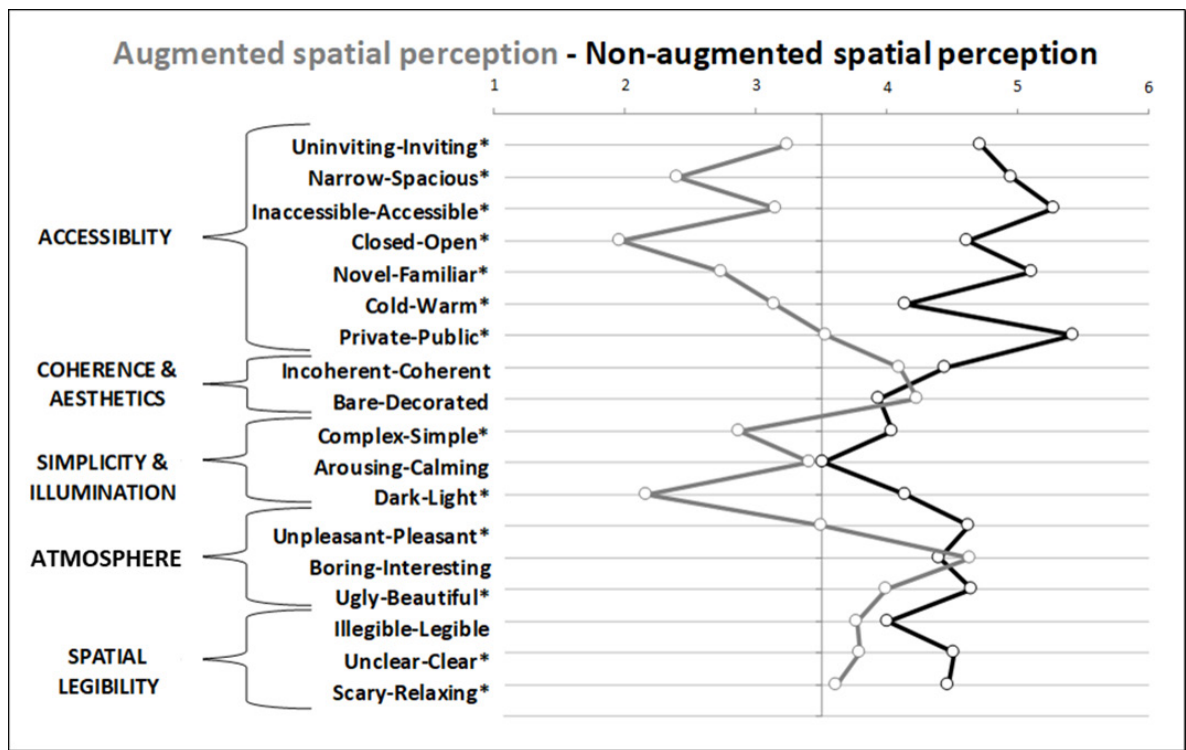


Fig. 11 Augmented and non-augmented spatial perception (Schweiger et al., 2021).

Despite insignificant quantitative results, tendencies can be discerned in the participants' thinking-aloud about the extent to which the hologram changes the coherence and aesthetics of the Rathausplatz. For example, a woman from Augsburg describes the interplay between the town hall and the stock exchange as "a beautiful unity, (...) like components that belong together." (No.: 63, female, age: 25, length of residence: 5) Another city resident considers the stock exchange to be "a very beautiful, magnificent building" which makes the town hall square "more coherent in itself" (No. 40, male, age: 26, length of residence: 5). This heightened aesthetic is sometimes only perceived on closer inspection of the hologram: "From a distance it looks like a real block, but when you go closer, it actually fits into the Augsburg cityscape in any case. These decorations are simply reminiscent of the old

Augsburg" (No.: 48, male, age: 20, length of residence: 20). One participant welcomes the fact that, thanks to the hologram, "this façade from the 1950s that is back there, which actually represents such a stark contrast to the town hall, is now hidden. Admittedly, I always think it looks pretty ugly." (No.: 58, male, age: 40, length of residence: 4).

5.1.3 Augmented simplicity and illumination

Another factor in the perception of space is the simplicity and illumination of the Rathausplatz, which is due mainly to the simple post-war buildings with low construction heights that bathe the square in sunlight until the evening hours. The participants tend to perceive the non-augmented square as "simple" (4.04) and "light" (4.14), while they perceive it in its

augmented form as “complex” (2.87) and “dark” (2.17). While these mean differences are significant, no significant differences can be identified with regard to the polarity “arousing-calming”.

The holographic animation of the stock exchange thus makes the Rathausplatz and its urban space appear darker and more complex, which is also partly reflected in the qualitative statements. For example, one city resident states that the stock exchange “really does something to the shape of the city. Now it is clearly arranged with the Kö[nigsplatz] and the Rathausplatz. With the building it is more unclear because you don’t see directly ‘This is the Rathausplatz’ but you only see a building when you come from Kö[nigsplatz].” (No.: 53, female, age: 19, length of residence: 19) Another resident of Augsburg believes that “it also gets very gloomy here, it gets really dark in the summer. Because the sun comes from over here and the building blocks everything. It gets totally gloomy and uncomfortable here.” (No. 12, female, age: 47, length of residence: 39)

5.1.4 Augmented atmosphere

Closely related to simplicity and illumination is the perceived atmosphere of the square, which in its non-augmented form is characterised by leisure activities and events. In contrast, the atmosphere at the augmented square is perceived as significantly less “pleasant” (3.50 vs. 4.63) and significantly less “beautiful” than in the non-augmented square (4.00 vs. 4.65), but slightly more “interesting” (4.64 vs. 4.40). The latter difference in mean value, however, is not significant.

Some of these tendencies are also reflected in the participants’ open statements. For example, city residents describe the atmosphere at the augmented Rathausplatz as “more hectic” (No.: 56, age: 20, length of residence: 20) and “more serious” (No.: 38, female, age: 20, length of residence: 19). Others believe that the stock exchange would “simply lose its flair” (No.: 34, female, age: 22, length of residence: 4) and

“take away a bit of the quality of life” (No.: 50, male, age: 28, length of residence: 4). However, some city residents also see the stock exchange as “a great enhancement for such a city”, as it could give the central square a business-like aura and raise the city’s reputation. (No.: 61, male, age: 54, length of residence: 5) This atmosphere changed by the stock exchange “also makes it more like a big city. Because it is unusual in big cities to have such a large square.” (No.: 10, female, age: 25, length of residence: 2).

5.1.5 Augmented spatial legibility

The trend that the augmented Rathausplatz is perceived less positively than the non-augmented one also continues when it comes to spatial legibility. The participants perceive the square with the stock exchange as less “legible” (3.77 vs. 4.01), less “clear” (3.79 vs. 4.51) and less “relaxing” (3.62 vs. 4.47). However, only the mean differences of the last two polarities proved to be significant.

The holographic animation of the stock exchange thus makes it more difficult for the citizens of Augsburg to read or perceive the spatial relations of the Rathausplatz. The factor thus shows similarities to “coherence and aesthetics”. While the latter, however, refers to the architectural-aesthetic interplay of individual buildings, spatial legibility describes the way in which the Rathausplatz as a whole fits into the downtown cityscape.

Its justification or right to exist is diminished by the stock exchange, as one participant aptly describes: “I just think it takes away a bit of the heart of the city somehow. Because I think the Rathausplatz is somehow justified by the fact that it is such a central point, that it is so big and just gives a bit of breathing space in the middle of the city between all the houses” (No.: 20, female, age: 22, length of residence: 3). Another woman from Augsburg says: “The way I know the Rathausplatz, everything is always nice and open. Everything is always so orderly. And this is a huge building with different

parts, and also really high. So, I can understand why they said, no, we don't want to rebuild it." (No. 65, female, age: 27, length of residence: 8)

5.2 Augmented spatial meaning (RQ2)

In addition to spatial perception, the holographic animation of the stock exchange also changes the meaning of the Rathausplatz. By this we mean what the city dwellers associate with the square and follow the three-pole model of spatial meaning according to Gustafson (2001). Comparing the meaning of the augmented and the non-augmented Rathausplatz, significant differences can be found in relation to self (-0.94⁶), self-others and self-environment (-0.87), others-environment (-0.54) and environment (-0.69). No significant change can be found with regard to the importance of others (Fig. 12).

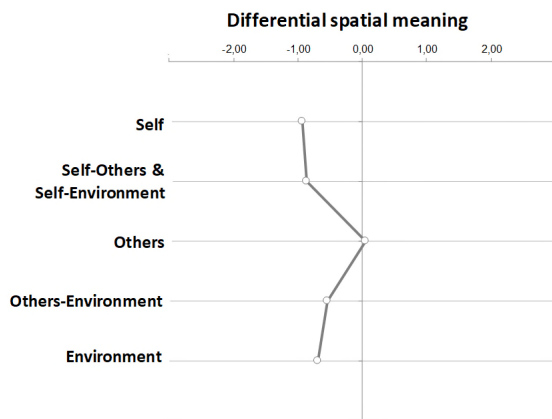


Fig. 12 Differential spatial meaning (Schweiger et al., 2021).

Figure 13 shows the individual attributes of spatial meaning and their average agreement values from "strongly agree" (value 5) to "strongly disagree" (value 1). It is striking that in its non-augmented form the Rathausplatz is of moderate

significance in the lives of the city dwellers (black graph). Some attributes can be found that the participants tend to agree with and that they personally associate with the square, e.g., "personal experiences" (3.92), "positive feelings" (3.91), "the opportunity to participate in city life" (4.06), "interpersonal encounters" (4.06), "the pulsating street life / square life" (4.00) or "large crowds" (4.00). With regard to other attributes of meaning, however, they feel rather neutral towards it.

With the stock exchange, the significance of the Rathausplatz would decrease in the eyes of the residents (grey graph) – 18 of 26 attributes have a lower approval rating than for the Rathausplatz without the stock exchange. Only with regard to its "striking architecture" do they assign a certain relevance to the augmented square (3.72), which even slightly exceeds that of the non-augmented square (3.65). All other attributes have average approval ratings of below 3.5, which indicates that they account for only a neutral to low relevance for the augmented Town Hall Square.

In the following, we take a closer look at the five factors of augmented spatial meaning. The statistical results of the before and after questionnaires are presented in detail and then expanded by the participants' open statements.

5.2.1 Augmented meaning regarding the self

Under the term self, Gustafson describes the significance that places take on in relation to one's own life path and are therefore strongly influenced by memories, emotions and individual activities. They contribute to people identifying with (private or public) places or linking certain aspects of their lives or personalities to them (2001: 10). This form of spatial meaning can also be found in the case of the Rathausplatz. Citizens associate the non-augmented square in part with

6 The spatial meaning was measured on a 5-point Likert scale ("completely disagree" = 1, "completely agree" = 5). The numbers in each case show the average deviation from the centre of the scale (= 3) and thus describe the change or tendency in spatial meaning. The greatest possible positive change is thus the value 3, the greatest possible negative change is the value -3.

Augmented spatial meaning - Non-augmented spatial meaning

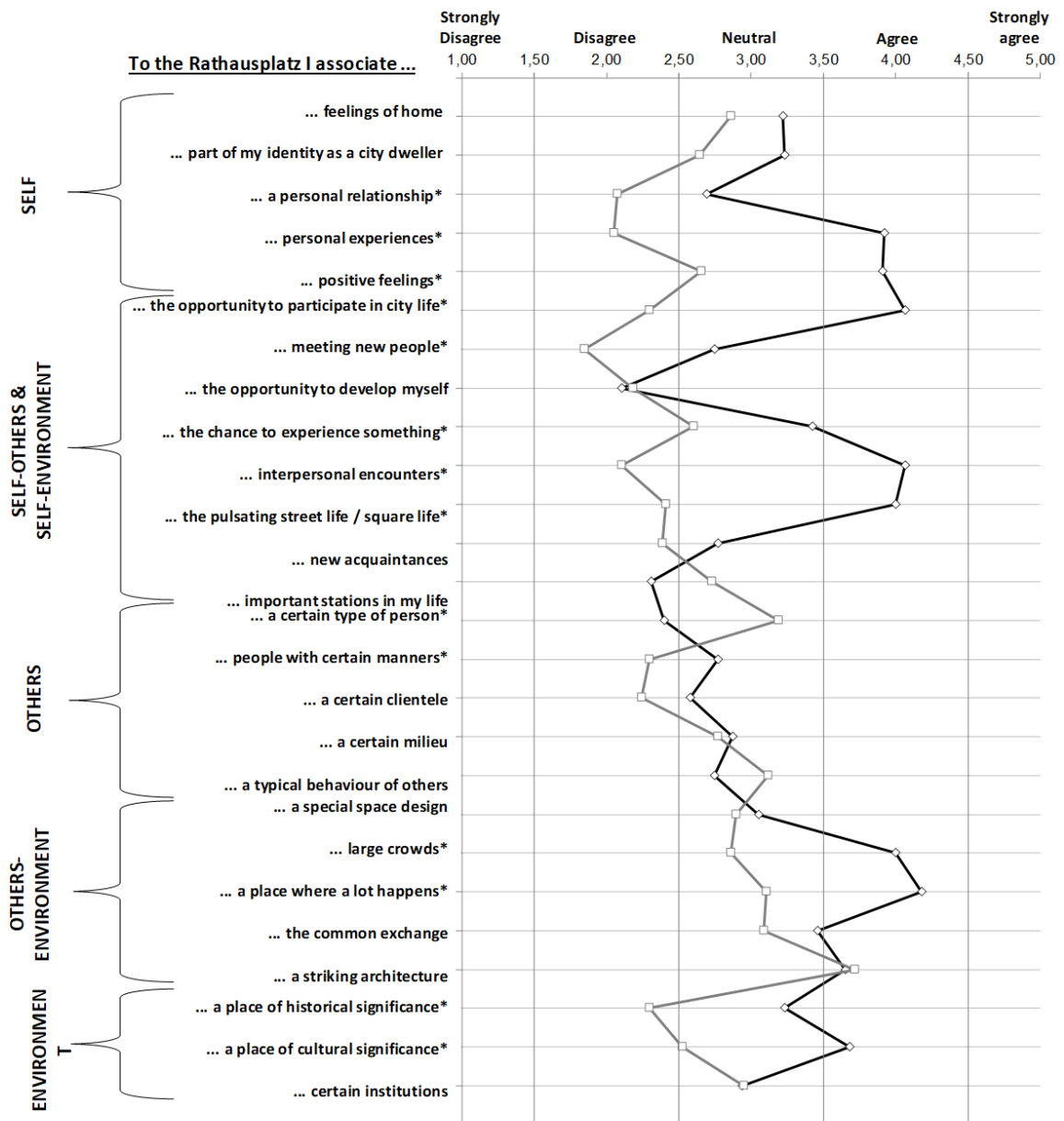


Fig. 13 Augmented and non-augmented spatial meaning (Schweiger et al., 2021).

“feelings of home” (3.22), “part of my identity as an Augsburg citizen” (3.23) and to a greater extent with “personal experiences” (3.91) and “positive feelings” (3.91). This relevance for one’s self would strongly decrease due to the stock exchange – all five attributes show mean differences for the augmented town hall square, three of them are significant.⁷

The changed meaning of the space in relation to the self is also reflected in the statements of some participants who associate formative experiences with the Rathausplatz that would not have been possible in its augmented form:

“I think that it would definitely change my relationship to this square or would have changed if it had been there. (...) I went to school here, there in [anonymised], that’s not far away, we often sat here ourselves in the summer and I think it would definitely have changed my relationship to the city centre.” (No: 72, female, age: 25, length of residence: 20)

In some cases, experiences of success are also associated with the Rathausplatz, which clarify the personal relationship with regard to self-identification:

“I had enormous difficulties looking for a flat here when I moved here, and I drove all the way from Bamberg again with my best buddy for a single flat-sharing viewing, and we sat back there and drank another beer. When the viewing ended successfully, we sat on one of those benches. It was also very beautiful because you could look at the town hall and it was also very impressive with its spaciousness. You can just watch everyone walking around and getting off the tram, it would be different if the stock exchange was there.” (No: 50, male, age: 21, length of stay: 3)

Another city dweller associates her individual lifestyle with the Rathausplatz, which she would like to maintain in this form: “Here you can just go and relax, spend more time. Just chill out a bit (laughs). And get a coffee or a beer or something (...) And there is this colourful, random mixture, I’d say. Which I personally find cooler than if it was like this (with the stock exchange).” (No.: 39, female, age: 21, length of residence: 3)

5.2.2 Augmented meaning regarding self-others & self-environment

Gustafson (2001: 9) defines self-others as the meaning that places have for us because of friends and acquaintances we associate with them and “the sense of community that such social relations create.” Meaning at the level of the self-environment, on the other hand, results from the connection of the self to physical-material space and the opportunities it offers. Gustafson defines this as “opportunities to perform certain activities, to feel or experience something desirable, opportunities for personal development” (ibid.: 11). As a result of the factor analysis, the attributes of self-others and self-environment were combined into one factor, as they load similarly on each other, i.e. measure the same construct. This shows that self-others and self-environment partly overlap and are analytically more difficult to separate than the other elements of spatial meaning, as Gustafson also states in his study (ibid.). With the non-augmented Rathausplatz, the residents associate “the opportunity to participate in city life” (4.06), “interpersonal encounters” (4.06), “the pulsating street life / square life” (4.00) and partly also “meeting new people” (2.74), while they tend to reject these attributes in relation to the augmented square (average agreement < 2.5). It is striking that they associate “important stations in my life” (2.73) more with the augmented place than with the non-augmented place (2.31). However, this difference in mean value is not significant and thus cannot be interpreted.

⁷ Significant after p-value correction: $p = 0,05 / 26 = 0,0019$ (Napierala 2012).

The changed meaning of space that participants associate with self-others is also expressed in the thinking-aloud statements. For example, one resident describes in detail the sense of community on the Rathausplatz that would be lost through the stock exchange:

“Well, I remember on the Rathausplatz itself in the summer we used to sit on these black and white paving stones. People met friends there or simply chose it as a meeting place. We just sat there together on the ground and spent time together and everyone bought something to drink. That would not be possible now because there is a huge building right there.” (No.: 48, male, age: 20, length of residence: 20)

Another participant describes this loss of opportunities, which in addition to the sense of community also relates to individual experiences at the Rathausplatz, as follows:

“When I think during summertime, I want a coffee now and I want to go out because the sun is shining, then I think of the Rathausplatz. I go there because it’s an open square, (...) the sun is shining, I get every ray of sunlight, and when the building [the stock exchange] is there, it naturally casts a lot of shade. Then it is somehow illogical to sit there.” (No. 33, female, age: 23, length of residence: 23)

5.2.3 *Augmented meaning regarding others*

Furthermore, places gain in meaning through the typical groups of people or stereotypes that we associate with them (= others). In contrast to self-others, however, these are not friends or acquaintances but strangers to whom we suggest a supposedly typical appearance and behaviour and associate them specifically with this place (Gustafson 2001: 10). Here, the lowest spatial significance can be found – neither for the non-augmented nor for the augmented Rathausplatz one can find attributes with an agreement of more than 3.5

(= tendency to “agree”). These differences in spatial meaning are also contradictory and do not allow for a clear conclusion.

By contrast, the evaluation of the qualitative statements provides more detailed insights. The partly contradictory results of the questionnaire can be ascribed to the fact that typical groups of people are not more strongly or less strongly associated with the augmented Rathausplatz. Instead, different stereotypes are associated with both versions of the Rathausplatz, as one city dweller aptly puts it:

“There would be a lot more businesspeople on the street and not so many young people who just spend their free time here and drink on the floor, I would say. And yes, that would then inevitably shift somewhere else, which would make the atmosphere quite different, I guess. Then, according to my feeling, it would no longer be so colourful and mixed.” (No. 39, female, age: 21, length of residence: 3)

Some participants see this as a loss of the openness and diversity of cultures that make up the Rathausplatz in their eyes (No. 73, female, age: 19, length of residence: 19). As a result, the supposedly typical behaviour of the people at the Rathausplatz would also change:

“But it would be a bit more hectic, closer, louder, you wouldn’t really have this community among each other, this interpersonality. It would be a bit more aggressive; I could imagine that. But I couldn’t imagine this sense of community where people can talk to each other, comfortably, where they can walk to each other, I can’t imagine that at all if the building were still there.” (No.: 70, male, age: 25, length of residence: 5).

5.2.4 *Augmented meaning regarding others-environment*

Others-environment describes a form of spatial meaning that results from a certain spatial atmosphere, street life or flair

and is thus linked to both the physical-material and the social characteristics of a place. Attributes of both the environment and others can thus be assigned to it. Gustafson (2001) defines this factor as “properties of the inhabitants that come to characterise the urban environment itself”, but also calls it “somewhat difficult to categorise” (10). According to our analysis, Augsburg residents associate the non-augmented Rathausplatz primarily with “large crowds” (4.00) and “a place where a lot happens” (4.18), whereas they associate this only partially with the augmented square (2.86 and 3.01 = “neutral”). These mean differences prove to be significant.

The augmented spatial meaning at the level of the self-other is also reflected in the participants’ open statements. For example, a city resident describes how the stock exchange would not only change street life at the Rathausplatz but also the city centre:

“It wouldn’t be the same. Especially in summer. I think there would be less people in the city, or there would be fewer real gatherings. There would no longer be this central square, it would all evaporate, people would be in smaller cafés or at some lakes or rivers, but there would no longer be this big square where everyone likes to sit. (...) Life in the city and meeting friends in the city would be less spontaneous.” (No. 7, female, age: 20, length of residence: 13)

5.2.5 Augmented meaning regarding the environment

We use the term environment to refer to the meaning that results exclusively from the environmental conditions of a place but is not bound to social aspects. Gustafson (2001) includes physical and material conditions and characteristics, as well as events, historical events or political and economic institutions that people associate with a place (10). The participants associate the non-augmented Rathausplatz with “a place of cultural significance” (3.68) and partly also with “a place of historical significance” (3.23), whereas they are more

neutral towards the augmented square with regard to these attributes (2.29 and 2.5). This difference between the mean values proved to be significant.

It can be deduced from the qualitative statements that the Rathausplatz is associated mainly with traditional leisure events: “The Christmas market, the summer nights, the [anonymised], they probably wouldn’t even exist. (...) I don’t know where else.” (No.: 48, male, age: 20, length of residence: 20) Above all the Christmas market is firmly associated with the Rathausplatz:

“And that would also be a thing with the stock exchange, the Christmas market would not be possible like that, or it would have been in a different place. I think that the Rathausplatz and the Christmas market [...], they simply belong together for me. I couldn’t imagine the Christmas market in any other place.” (No.: 45, female, age: 31, length of residence: 31).

Some participants also describe a feeling of security that comes from the large open space of the square that would be lost through the stock exchange:

“That’s the cool thing about the Rathausplatz, you’re in a square and you see everything. You have such a full overview and also feel fully connected to the people and they can also see you. That’s what makes it so safe. If the building was there, it wouldn’t be like that. Even more alleys and you don’t know what’s behind the next wall.” (No.: 53, female, age: 19, length of residence: 19)

6. Conclusion

The holographic overlay of virtual objects on physical space is a development that will have a lasting impact on the cityscapes of the future. While research in communication and media studies is increasingly looking at the possibilities of

small-scale, generic AR content, little is known about the extent to which large-scale, historically significant building holograms can change the personal connection to urban space. With this in mind, we asked to what extent the holographic animation of a building destroyed during the Second World War could influence the spatial experience of a central city square. While our first research question dealt with the extent to which the holographic animation changed the perception of space, our second research question focused on the extent to which it influenced the meaning of space. For this purpose, we reconstructed a building destroyed during the Second World War as a hologram and used a mixed-method design to descriptively investigate the augmented spatial perception or meaning through before-and-after questionnaires and thinking-aloud protocols.

The quantitative and qualitative results show that holographically animated buildings can significantly change the sensual-aesthetic perception and personal meaning of a place. For example, the augmented square is perceived as "inaccessible", "complex", "dark" and as less "pleasant" and "legible" than the non-augmented square. Its spatial meaning in the everyday lives of the city's inhabitants would also change fundamentally. For example, the people of Augsburg associate a different lifestyle (= self), other groups of people (= others) and other possibilities and opportunities (= self-others & self-environment) with the augmented town hall square. These statements indicate that people relate to urban space on a more abstract level and associate it with certain emotions, memories or people in their daily lives. They also show how holographic animations can influence this personal connection to urban space. For example, during thinking-aloud, participants almost consistently spoke of "the building" instead of referring to it as a "hologram". Many of them also tried to touch the hologram with their hands. This "perceptual illusion of non-mediation" (Lombard & Ditton 1997), referred to in media effects research as "presence" (Wirth *et al.* 2004), proves that people can briefly perceive holographic content as real objects. The perceived "presence" of holographically animated buildings

now promotes a kind of hypothetical "what-if"-thinking that makes city dwellers aware of, and possibly even reinforces, their special connection to urban space. This shows the potential of AR as virtual tool for city planning, allowing architects to visualize building models at a very early stage and illustrate them within their final surroundings. Aside from a higher planning security, this virtual planning tool could also enhance civic participation, as they motivate city dwellers to become more aware of and involved with urban construction projects in their neighbourhood (e.g. Reinwald *et al.*, 2014).

The results of this work point to new fields of study in the sociology of space in general and urban research in particular. For example, with regard to an increasing "augmented space" (Aurigi & Cindio 2008), the question that arises is to what extent the meaning of a smart city on the physical level can be differentiated from its significance on a virtual level. Since future cities will be characterised both by physical and holographic buildings, how will this multi-dimensional appearance influence daily life in the city? With the current developments in mind, it is safe to assume that tourism will be the first urban practice to be changed fundamentally through AR, followed by city planning and administration. Imagine three persons wearing AR-glasses on the Rathausplatz in Augsburg in the near future: While the first one is a tourist experiencing the holographic reconstruction of the stock exchange, the second is a long-term city dweller, evaluating (and maybe even voting against) the holographic building model of a new concert hall to be built on the Rathausplatz in the next years. The third one is a new resident applying for a registration card in the holographic extension of the town hall, avoiding physical queues in the real building. While all three of them are physically present on the same square, they are experiencing the cityscape in totally different ways.

This poses further questions and will lead to future discussions about the remaining, not (yet) augmented urban space, guided by the conflict of interests of different urban actors (e.g. tourist or city administrations, local heritage societies,

city dwellers). Who will decide about the holographic use of urban space? Which administrative or historic buildings should be holographically constructed or preserved for posterity? Almost all of our participants believed that it was the right decision not to rebuild the stock exchange in the 1960s. However, what about placing the stock exchange permanently as a holographic landmark on the Rathausplatz when it will already be occupied by large-scale holograms (e.g. the building model, the extension of the town hall)? Will it be necessary to establish special usage periods for different AR-content or -users to avoid collision in the physical space (e.g. the tourist, the long-term city dweller, the new resident)? These hypothetical questions about the design of augmented space could become crucial for urban planners and researchers in the not-too-distant future.

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