

Examining semantic coupling in augmented reality

Nina Rosa, Wageningen University and Research, nina.rosa-dejong@wur.nl

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Abstract

Augmented reality (AR) requires the real environment to be part of the experience. Semantic coupling, the degree of connection between the physical and the virtual, has been explored as a way to create more immersive AR experiences. Studies that have investigated semantic coupling have used AR in a very specific way, leading to a possible misinterpretation of when semantic coupling can be used, and how to design for it. In this position paper, I examine the literature on semantic coupling, place and aura, and describe which types of places future AR studies studying or applying semantic coupling should consider, how to create semantic coupling without the need for a complex narrative, and how to ensure and verify a degree of connection in semantic coupling experiments.

Keywords: Augmented Reality, Mixed Reality, Semantic Coupling, Place, Aura, Experience, Immersion

1 Introduction

Augmented reality (AR) research from the 1990s and 2000s saw a large interest in improving technology, and there was less attention for user experience; there were still few guidelines on how to create ‘good’ AR experiences. Now, there are aspects which are consistently considered important, such as immersion, presence, and engagement, but it is still not agreed upon what a ‘good’ AR experience is. More recently we are seeing the anticipated research interest in evaluating user experience [2] and designing for certain experiences [7]. Design guidelines for AR applications for specific contexts are also increasingly being developed [12, 39].

One interesting factor that AR introduces that may influence user experience is the actual place in which the experience occurs, since the real environment is always part of the of the experience. Some AR applications integrate unique aspects of the real surroundings into the experience, while others do not [38]. In this position paper, I zoom in on this particular concept of semantic coupling.

Semantic coupling can be defined as the degree of connection between the AR application and the physical space in which it is experienced [38, 14]. This concept reportedly first emerged in 2005 by Reid et al. under the phenomenon “magic moments” in the context of location-based audio AR [31]. One particular type of magic moment would occur when aspects from the physical and virtual worlds would unexpectedly collide [31]. Since then others have studied semantic coupling and similar concepts, but there is no agreed upon terminology, and the phrases ‘semantic’ and/or ‘coupling’ only appear sporadically. Moreover, due to the history of AR research, semantic coupling has become locked within location-based research, while it could be equally relevant for the experience of non-mobile applications. Lastly, while there are a number of empirical studies on semantic coupling, there is no predefined method with which one could state that a given physical world is strongly or loosely coupled to a given virtual one.

The purpose of this position paper is to examine the concept of semantic coupling in order to delineate its role and use in future AR research. First, an overview of literature that has discussed or applied the concept of semantic coupling is provided. Second, expressions of the importance of places from HCI and AR literature are discussed. Third, a discussion is presented

based on tendencies in past semantic coupling research and shows what potential future research that focuses on designing for immersive experiences could entail. Finally, suggestions for the design of semantic coupling experiments are provided.

In this paper, a broad notion of AR is used: everything can be augmented, and the virtual augments that to which it relates [35]. Similarly, augmentation can occur across modalities [33]. This means that works labeled as location-based, mixed reality (MR), and pervasive games are included. It is also worth noting that Georgiou and Kyza previously provided an overview on semantic coupling studies [14]. While they focused on empirical studies on narrative coupling, here those and more studies are presented in more detail to understand how semantic coupling in general was achieved and how it was experienced.

2 Literature on semantic coupling in AR

2.1 Magic moments

The works by Reid et al. are typically referenced as the first mention of a meaningful connection between real and virtual content [31]. The authors studied situated mediascapes: mobile, location-based narrative experiences. In the analysis of their mediascape *Riot! 1831*, they found that participants experienced what the authors called magic moments: memorable moments that people valued and enjoyed. There were four types of these moments, one in particular being “unexpected connections between physical and virtual worlds” [31, sect. 3.2] such as a hearing a virtual seagull cry and then seeing a real one fly over. The high ratings of enjoyment, immersion, and history coming alive are attributed by the authors to magic moments. Reid et al. also showed that there were positive correlations between these ratings, and they inferred that immersion was a positive determinant for enjoyment and vice versa, and that history coming alive was a special form of immersion [30].

In a different mediascape, *Scape the Hood*, the authors gave special attention to collecting sounds from the real location, in order to create magic moments [29]. Similar to before, they found high ratings of, amongst others, enjoyment, immersion, and importance of listening to the stories in the exact location. Participants commented that the close connection between what you see and what you hear positively affected the experience.

Reid et al. also published experience design guidelines for situated mediascapes, with one section devoted to “meaningfulness of the place” [28]. There, they differentiate between three types of places that can be chosen depending on how important the location is for the mediascape: arbitrary linkage (any place of certain size), physicality (place with certain characteristics that are important but actual geography is not), particular location (actual location and physical artifacts are significant and meaningful to the mediascape) [28].

Lastly, Reid presented a spectrum concerning the relevance of place for location-based games [27], from neutral (the place is used for solely the spatial properties) to high (place has a strong association in terms of its significance, meaning and integration within the narrative of the game), reflecting the arbitrary linkage and particular location definitions from the previous design guidelines [28].

Interestingly, this collection of works by Reid et al. is not the first mention of connecting real places to virtual narratives. In the context of what pervasive games should look like, Ericsson expressed his opinion that, just like roleplaying games, pervasive games require that the narrative of the game be consistent with the real world [11]. Stories should essentially be set in the modern world, and things like magic can be included but should be hidden or integrated with day-to-day existence. Ericsson uses quotes from other works to reflect how artifacts, actors, and visual and sound effects (i.e. magic moments) are required.

2.2 Levels of semantic coupling and types of connections

Wetzel et al. also noted the importance of semantic location context, and it became one of three dimensions in the categorization of mobile AR games [38]. The game can be location independent (the location is not relevant for the game), loosely coupled (played with very little relation to enclosing places), or contextual (the game has a strong narrative relation to the location they are played in). Krüger describes levels of contextuality, not as a scale, but by looking at whether there is thematic relevance between an AR application’s context and the physical environment and/or anchors (markers), and whether the environment and/or anchors are fully visible despite virtual elements [18, table 3].

A different interpretation of coupling is given by Schraffenberger2014everything and Van der Heide [35]. There, the authors investigate what is real and what is augmented in AR, and state that the virtual content augments that to which it relates, which can concern a spatial relation and/or a content-based relation. Similarly, Ellenburg2023spatiality present a two-dimensional design space for overall perceived unity in a mixed reality environment. The dimensions are spatial coupling and semantic coupling, of which the latter they define as “a contextual connection and relation of virtual content items with [...] real world objects.” [10, sect. 3.2]. They highlight that a binary definition (i.e. something is or is not coupled) is insufficient to differentiate contextual connections in detail.

2.3 Empirical studies

The works by Reid et al. use an empirical approach, and other studies have followed the same approach. Paay et al. argue that humans are drawn to fiction when it interweaves historical fact and real places we may be familiar with [24]. The location-based fiction *Who killed Hanna Holmgaard?* was developed, where factual and fictitious events in the city of Aalborg take place. The designers combine digital components with real locations and objects such as the use of digitally altered photographs in order to create fuzzy boundaries between story and environment. Audio was appreciated by participants as something that created an atmosphere that blended with the real city and made the story come to life, and participants who were residents claimed that they had learned new things about their city.

In a series of studies, the location-aware AR game *Time Warp* was developed where participants travel to different time periods in the same city [22, 38]. In the first version, the main element of semantic coupling is the story being based on the historic tale of elves in Cologne. Participants could see the elves and virtual elements visually overlaid on portable see-through displays. The evaluation found peaks and drops in immersion, and the potential solution provided for the drops is to integrate real people and objects into the game, e.g. to make real use of street ambiance, coinciding with Reid et al.’s description on how to create magic moments. In *Time Warp 2.0*, the elves were traded in for robot-elves to better match the time travelling theme, and virtual elements were planned to more carefully match the content of the real world, such as a virtual wedding by a real church [38]. Based on the evaluations of both versions, mobile AR game design guidelines are provided, such as adding atmospheric scenery objects, sounds and smells to help the player immerse themselves into a narrative place.

Rossitto et al. analyzed the location-based audio theater drama, *Maryam*, designed around loose coupling [34]. They found that immersion in the narrative contributed to the particular sense of place “being at the theater”, and also the wandering contributed to their imagination of being transported somewhere else, in the time and place where the main character lived. Participants mentioned wanting more connections, i.e. wanting more magic moments, yet they also described enjoying using their imagination to create the associations to make sense of the ambiguity. Associations could be physical or activity-based, and being familiar with the neighborhood played a role in how the connections were made. The authors argue that loosely coupled designs can offer enjoyable, engaging and immersive experiences.

Raeburn created the location-based AR story experience *MapStory* that can be experienced anywhere [26]. The story uses buildings and places of meaning, such as a school and a church,

that are usually present in cities, and when they do not exist, a visual overlay is created on a smartphone screen in an open space. Virtual clues were added to the scenes that players needed to interact with. The evaluation showed, amongst others, that when comparing real sites to AR sites participants experienced less match between the visited site and the one described, and found it harder to imagine the story events playing out at the site. Comments showed that being familiar with the area made it harder to think about it in terms of a new story, and that AR could have given more chances to immerse. Comments also suggested deeper immersion only happened when aspects of the story temporarily paralleled something in the real world environment, i.e. during magic moments.

Similarly, Li et al. designed a method to automatically adapt stories to real-world locations based on contextual compatibility using an optimization-based approach [20]. In one of the user studies, the authors evaluated the player experience regarding the compatibility between event and location, by comparing a condition where the optimization used compatibility, walking distance, and equal distribution of walking as costs, and a condition where only the latter two were costs. Location compatibility was rated significantly higher in the compatibility condition than in the no compatibility condition, and all users agreed that the compatibility condition led to a more reasonable storytelling.

While these experiences and games were evaluated by the general public, some experiences are specifically catered to tourists. Ballagas et al. created a game *REXplorer* with a dramatic narrative and some historical facts, not as a replacement for tour guides, but to help tourists become interested in the history of Regensburg [3]. By “casting spells” (using a device as a wand) the system provided the players with fictitious stories based on the true events. The system would save recordings and images that were later blogged for the users to share with friends. Some users became very immersed, as illustrated by neglect of safety precautions. Participants had a hard time remembering facts, but they did build important connections to history, which combined with the personalized weblog could result in new knowledge.

Lastly, Weerasinghe et al. studied whether learning vocabulary in context could be enhanced by means of AR. Their application, *VocabuLARY*, visually annotates objects in AR with corresponding first and second language words (written and audio), a keyword (mnemonic) and its visualisation [37]. The authors compared AR with keywords, AR with keywords and visualisation, non-AR with keywords, and non-AR with keywords and associations. In the non-AR case users saw a virtual kitchen or office scene with matching virtual objects via a tablet while seated in an empty real room, while in the AR case users were seated in a kitchen or office with real objects. Results showed that AR scored better than non-AR in terms of mental effort and task-completion time, and visualization scored better than just keywords in terms of immediate and delayed recall, learning efficiency, mental effort and task-completion time. This indicated that showing keywords and visualisations in context of immediate surroundings (i.e. AR with semantic coupling) resulted in better learning than showing them in a virtual scene (i.e. non-AR).

2.4 Systematic studies

There are a few studies that have investigated semantic coupling systematically. Karapanos et al. performed an experiment with tourists using a location-aware narrative in Funchal, *iLand*, where participants would stand at a specific (stationary) location in the city, and watch a video that either took place in that original location, a location with the same atmosphere, or an arbitrary location [17], following the distinction by Reid et al. [28]. Results showed that experiencing a narrative in the original location led to increased immersion and heightened imagery compared to the control condition. In the same atmosphere location, there was also heightened immersion but not heightened imagery, i.e. no experienced magic moments, possibly due to confusion and disengagement arising when searching for connections in the same atmosphere location but not finding them.

In a series of studies, Georgiou and Kyza investigated the relation between immersion and learning, by creating two educational location-based AR games, *Mystery at the lake* on eutrophication and bioaccumulation [13, 19], and *Mysterious disease* on microbes and pathogens [14]. An

evaluation of the first game showed there were improvements to be made in interface, content, locality and context. With respect to locality, students reported that investigating an environmental case where it had unfolded positively contributed to their sense of immersion; yet, they still needed greater coupling [13, 19]. Therefore in the redesign they also let students engage with both the real and virtual worlds, e.g. test real water from the lake. Especially props in the second iteration enhanced immersion since it created connections, i.e. students experienced magic moments. Regarding learning, the second iteration (with other improvements besides locality) led to more engagement with the activity and more engagement in obtaining information.

For the second game, semantic coupling was specifically of interest [14]. The authors expected that with stronger semantic coupling, there would be greater immersion and better learning outcomes. The game was set in a university building where a disease outbreak had taken place, and the authors compared a strong coupling condition (QR codes in related rooms, and props) to a loose coupling condition (QR codes in unrelated rooms, no props). Children in the strong coupling condition reported more immersion and achieved better learning scores than children in the loose coupling condition. Moreover, there were numerous positive correlations between the immersion and learning measures for the strong coupling condition, which were mostly absent in the loose coupling condition. According to the interviews, reasons for the differences in experienced realism included the purposeful placement of the QR codes and the props.

Wu et al. performed an experiment where participants were shown a virtual butterfly on top of their real hand using a smartphone. The authors examined three forms of relations between real and virtual on, amongst other measures, realism and presence [40]. The relations were contextual (e.g. location related to butterflies, following Wetzel et al. [38]), physical (e.g. gravity), and interactive (e.g. natural). Note the absence of narrative in this application. For the contextual relation specifically, they found increased realism, but not increased presence, possibly due to the novelty factor of AR, yet the general conclusion was to always include contextual relationships in AR experiences, so the user's focus is not only on the virtual content.

Lastly, Cheng et al. present their application, *SemanticAdapt*, which creates MR layouts of offices such that object placement takes semantic connections between objects (real and/or virtual) into account, for example by preferring when elements and objects which share semantic associations are placed in close proximity [8]. This application was tested against a control application without semantic requirements, and it was found that *SemanticAdapt* resulted in a reduction of required adjustments by the user after seeing the initial layout, and a reduction of misplaced items, both by approximately 35%. The authors suggested that future studies also take into account depth of semantic associations; for example, a PDF could be associated with 'reading' and 'article', or more deeply by the topic of its content. This is similar to the case made by Ellenburg [10].

While these studies are primarily based on a system having 'built-in' relations, there are also applications that let the user decide whether to create relations or not. One highlighted here is the study by Mcgookin et al., where participants created digital location-based graffiti that others could view, as a form of social network [23]. The authors expected participants to create primarily place-related tags, but only 60-80% of tags were intended to relate to the place they were created, and only 20-60% of tags were interpreted as having a relationship with the environment. The authors explain that the relationships were of two types: physical and semantic, which echoes the spatial and content-based relationships defined by Schraffenberger and Van der Heide [35].

2.5 Overarching themes

Looking at the discussed studies, there are two notable overarching themes. Firstly, most studies are on mobile location-based applications, where large spaces serve as locations that people have to traverse, likely a product of the technological abilities of the 1990s and 2000s. These spaces are generally parts of cities that are already considered meaningful because they contain history. Secondly, the coupling typically happens through narrative, i.e. the story concerns the location in which the experience takes place. Again, it can be seen that stories are developed around characters that live in or wander the city. In the next section, we discuss the importance of place

in different types of experiences.

3 Space, place and aura

Discussions on what makes a certain place meaningful have been ongoing for decades. Here, one of the most influential notions of place is highlighted before discussing notions specific to HCI and AR. In his book, Relph takes a phenomenological approach to describe how we experience spaces [32]. Very generally speaking, a space is of geographical nature, while a place has some added meaning from an experiential perspective. The identity of a place is defined by the setting, the activities that happen there, and meaning, and lies in large part in the experience of an “inside” that is distinctive from an “outside”, reflecting familiarity with and belonging to a place. Then, authentic place-making occurs when there is sensitivity to the significance of place in everyday life. Placelessness occurs when meanings and identities of places are ignored or lacking.

Within HCI, Harrison and Dourish discuss the differences between space and place in the context of collaborative (office) systems [16]. They argue that designers are seeking a sense of place rather than space: appropriate behavioral framing rooted in cultural understandings about behavior and action. Places are spaces that are valued, and the sense of place must be forged by the users over time. Collaborative systems need to be designed to support the duality of space and place [16].

While these concepts have provided significant guidance for research, they do not explain why different places create different responses from users. This problem was noticed by MacIntyre et al. [21]. To measure the user’s sense of emotional engagement, rather than relying on presence (in terms of “being there”), they propose the concept of aura. This concept is derived from Benjamin’s notion of aura in the humanities [4], where aura is the “unique phenomenon of a distance, no matter how near.” MacIntyre et al. define aura of an object or place as “the combination of its cultural and personal significance for a user or group of users” [21, sect. 2]. Places of cultural significance have placeness, or a sense of place following Harrison and Dourish, but these places can also have other special personal significance, creating aura. Technology can leverage aura to improve the experience by bringing the place/object “closer” to the user, and technology can enhance aura by increasing the connection between the place/object and user. The authors argue that aura also bears an important relationship to space and place, where embodiment is a key aspect. They state that “just as place was developed to supplement the concept of space, [...] place now needs to be supplemented with the concept of aura” [21, sect. 5]. There is a strange relationship between VR’s presence (in the sense of non-mediation) and aura, which is further examined in later works [6, 5]. In these works, they also explain why aura enhancement occurs in MR. Where a VR reproduction of a place or object may diminish aura, or only give a “memory of aura”, in MR the experience is both immediate and mediated [6, 5]. The physical presence should enhance aura, and the medium could further enhance aura by building a sense of distance-through-proximity [6, 5].

Note that these works were published around the same time as the collection of works by Reid et al. Since then the majority of works have referenced magic moments or semantic coupling; the concept of place is not frequently mentioned (from the above works only in [27, 22, 34, 23]), let alone the concept of aura. One recent study that successfully brought these related, yet until now quite isolated, concepts together was Sharma et al. [36]. The authors performed a systematic literature review to find the salient variables that MR play designers need to consider when selecting space, and how these variables impact the experiences. A brief description is provided on related concepts, including MR, AR, space, place, and aura. The result was a framework for selecting space based on two dimensions: continuity (individual, isolated, continuous, ubiquitous spaces) and specificity requirements (open, templated, place). Here, place is a templated space with added aura. Note that the specificity categories coincide with the levels defined by Reid et al. [28]. One of the main conclusions is that the continuity of space drives the need for virtual data that is linked to a physical world location [36].

Lastly, in a recent work Pitman explores how motion-sensitive but not locative technologies can help create aura in common places, for generating environmental affect [25]. The case game

Sin Sol is a green art game on ecological collapse. It shows plants overlaid on the camera feed of a smartphone, and in order to interact with visible but far away plants, the user must walk up to them. This requires players to play the game outside in large open spaces such as parks, which in turn may allow the user to compare their own positionality and surroundings with that of the avatar and the collapse the avatar describes. This comparison helps players be aware of signs of climate breakdown, and appreciate the natural world more deeply. Playing the game in an already auratic area such as the Ilkley Moor showed virtual forests that were absent in real life, as vegetation is kept to a minimum for raising and shooting grouse, creating a very provocative scene. The author explains that the avatar offers the player a way of reading the environment that imbues it with aura, and the game contrives to restore the aura of the environment [25].

4 Discussion

Based on the works discussed in Sections 2 and 3, the gathered insights are combined, and a number of questions are posed. These are based on the two overarching themes: large culturally relevant locations being used, and semantic coupling occurring through narrative.

4.1 Large locations and aura

Looking at works categorized by Sharma et al. as “in place” (i.e. the locations have aura) [36], it is clear that mostly parts of cities have been explored, but also cemeteries and archeological sites. There are undoubtedly many more types of large spaces that are culturally and personally significant. One question that arises is whether semantic coupling can only happen in large spaces, since so far this has been the setting for the majority of studies. Sharma et al. explicitly state that although they found no combination of “individual” “place-based” AR game systems, they noted that there is no reason these systems should not exist. In Section 2, there were few non-mobile “individual” cases, i.e. where the user was not required to walk [17, 40, 10, 8, 37]; these found that semantic coupling contributed positively to immersion, presence, perceived unity, layout or learning. Looking at magic moments of type “unexpected connections between real and virtual” specifically, they do not require walking or large areas; multiple magic moments can happen in a single location. While the magic moment design checklist [27] was intended for mediascapes in large spaces, many of the aspects are easily translatable to small meaningful spaces.

Another question that arises is whether there needs to be a specific balance between cultural and personal significance of places in order for them to have aura and consequently enhance the AR experience. Section 2 showed that familiarity generally creates deeper immersion [31, 24, 34], except when it clashes with your understanding of a place [26]. Would these moments of immersion have been stronger if the familiar places had been even more personally significant, such as one’s own workplace, school, or home, or weaker because it clashes with the role of that place in your own life? On the other hand, it is imaginable that AR experiences that are semantically coupled to any of these more personal locations could be more emotionally engaging. For example, one could argue that for the average person the most personally significant place is home. Although at first glance an individual’s home does not have cultural significance, Relph argues that homes are not just the foundation of our own identity as individuals, but also of our identity as members of a community [32]. Moreover, there are examples of experiences that are transformed through AR simply by bringing them into homes, such as *Mario Kart Live: Home Circuit* [1]. Although I do not propose aura as a requirement for AR, it may help researchers understand the types of significance that matter.

4.2 Narrative

In the discussed studies, there were different types of relations and connections between real and virtual content. Schraffenberger and Van der Heide defined real and virtual having spatial or content-based relationships [35], which is reflected in the location independent AR games described

by Wetzel et al. [38]: each game only focuses on spatial relationships, and they lack content-based relationships. Even though these games had narratives, the narratives occurred only on the virtual side of the games. On the other hand, one could argue that the narrative used for semantic coupling is an example of the content-based relationships. In most of the works described in Section 2, the intended connection between virtual and real is through narrative, yet intended or desired magic moments concern a blending of content-based and spatial relations. That is, generally, objects or events are mentioned in the narrative, but are not the core of the narrative, and are designed to create ambiance and coincidences, such as seagulls [31], stairs [34], and weddings [38]. Similarly, for loose coupling, Rossitto et al. found only two types of associations: physical or activity-based, both of which help the setting, but not the main story, as designed.

Narrative has been the go-to way to create semantic coupling in AR. Narrative-based learning specifically has been shown to be effective in enhancing and holding interest in topics [15], thus for such a context using a narrative is logical. Karapanos et al. explains how narrative alone could arguably be immersive by itself, as demonstrated by the “book problem”, by tapping into psychological immersion as opposed to perceptual immersion [17]. But even this does not mean that complex narratives are necessary for semantic coupling or even immersive experiences in general. What if the main focus of the application is not necessarily to learn, but just to experience or feel or think about (non-)fiction? This was demonstrated by Wu et al. and Weerasinghe et al., who use a more abstract (or arguably, more basic) type of semantics: placing virtual content in an environment that makes sense [40, 37]. Reusing the home example from earlier, one could imagine food-related AR experiences to be most immersive in the kitchen, and plant-related AR experiences to be most immersive in the garden. The experience could revolve around play, learning, or just becoming emotionally engaged with a topic, like food-waste or biodiversity.

5 Designing experiments with semantic coupling

Now that considerations for future research on semantic coupling have been provided, how to study and apply the concept in an experiment is briefly addressed. In Section 2.4, studies that systematically investigate semantic coupling were described. While it is indisputable that the used conditions differ in relevance for each experience, it is still interesting to consider what alternatives could have been used, or how the specific choices were made; how does one go about choosing the locations? For example, while Reid et al. explain that three types of places could be used depending on if place is an integral element of the experience [28], how would one know beforehand whether a place is indeed significant or meaningful?

One way to approach ensuring the conditions are chosen well is to run a pilot study and ask potential participants what they would consider spaces that are and are not related or connected to a narrative or abstract concept. This was attempted in a recent thesis project on using AR to teach about waste separation rules, where potential participants were asked early in the design phase which locations they associated with waste separation, within the boundaries of a university [9, p. 12]. Then, to check whether the condition was experienced with the intended level of coupling, manipulation check questions were asked: “I often throw away waste in this type of space”, “I associate this type of space with waste separation”, “The physical space of the activity is connected to the waste separation theme of the activity”. Despite only finding small differences in presence, the results of the manipulation check showed that the locations were well chosen [9, p. 14]. For a similar result, Karapanos et al. asked participants whether they noticed any elements from the physical environment that surrounded them in the audio-visual narrative, and if they did, to point them out [17]. The most specific elements were reported in the strongly coupled condition, general atmosphere elements were reported in the loosely coupled condition, and none were reported in the control condition.

Georgiou and Kyza used both location aspects and props to create the largest difference between conditions [14], but arguably this would not have made sense in the study by Wu et al. [40]. While the use of props is facilitated by the narrative component, note it is still possible to include props in a scenario without narrative. Taking the kitchen example from before, one could

make use of props that are typically found in kitchens, such as cutlery, pots, a refrigerator and a waste bin. This was also seen in the work by Weerasinghe et al., where the office space contained objects like scissors, an envelope, and sticky notes [37].

Lastly, it is important to understand where semantic coupling should be placed in the greater context of AR experiences. Generally, AR applications serve a certain purpose, with learning outcomes being one of the most common desirable outcomes. Such outcomes are generally influenced by mediators such as immersion [14] or presence. In turn, these mediators are influenced by factors, which are for example used to design the conditions of experiments (e.g. low-immersion and high-immersion conditions). I argue that semantic coupling should be considered as such a factor. Therefore, achieving semantic coupling, and an experienced coincidence of real and virtual, is something that should be designed for. Reid et al. have published a work on exactly this for mediascapes [28].

6 Conclusion

In this position paper existing literature on semantic coupling and on the concepts of space, place and aura was investigated. There are a few main takeaways from the insights gathered from these studies. Firstly, aura has made apparent that AR with semantic coupling does not necessarily need large locations, just locations that are meaningful. The locations are meaningful when they are culturally and/or personally significant, but not necessarily both. Semantic coupling can therefore also be applied in small meaningful places. Future AR studies that aim to create immersive experiences that are emotionally engaging should consider the location in which the experience occurs. With the rise of AR head-mounted displays, which are still often tethered to a computer, it is possible a large portion of these future immersive experiences will be designed for small spaces. Secondly, narrative has been used to enable semantic coupling, but scenarios were described that demonstrate that narrative is not essential to semantic coupling. This is particularly interesting for experiences that for example do not have learning as a focus, but just the experience of (non-)fiction. Future AR studies could consider experiences that do not rely on narrative, by choosing spaces that are already relevant to the topic at hand. Lastly, suggestions were provided on how future AR studies could approach designing an experiment using semantic coupling, specifically, by estimating meaningfulness beforehand based on conversations with potential participants, and performing manipulation checks afterwards. Props can help amplify the difference between low and high coupling conditions, and ways to incorporate props in small meaningful locations without narrative were described. This position paper has illustrated in which ways semantic coupling can enhance AR experiences, and future researchers should consider semantic coupling when designing AR experiences and research.

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