Virtual Animals as Diegetic Attention Guidance Mechanisms in 360-Degree Experiences

Nahal Norouzi, *Student Member, IEEE*, Gerd Bruder, *Member, IEEE*, Austin Erickson, *Student Member, IEEE*, Kangsoo Kim, *Member, IEEE*, Jeremy Bailenson, Pamela Wisniewski, Charlie Hughes, *Senior Member, IEEE*, and Greg Welch, *Senior Member, IEEE*

Fig. 1. Illustrations of the attention guidance mechanisms for the 360-degree experiences we compared and evaluated in this paper, from left to right: no guide, arrow, bird, and dog.

Abstract—360-degree experiences such as cinematic virtual reality and 360-degree videos are becoming increasingly popular. In most examples, viewers can freely explore the content by changing their orientation. However, in some cases, this increased freedom may lead to viewers missing important events within such experiences. Thus, a recent research thrust has focused on studying mechanisms for guiding viewers' attention while maintaining their sense of presence and fostering a positive user experience. One approach is the utilization of diegetic mechanisms, characterized by an internal consistency with respect to the narrative and the environment, for attention guidance. While such mechanisms are highly attractive, their uses and potential implementations are still not well understood. Additionally, acknowledging the user in 360-degree experiences has been linked to a higher sense of presence and connection. However, less is known when acknowledging behaviors are carried out by attention guiding mechanisms. To close these gaps, we conducted a within-subjects user study with five conditions of no guide and virtual arrows, birds, dogs, and dogs that acknowledge the user and the environment. Through our mixed-methods analysis, we found that the diegetic virtual animals resulted in a more positive user experience, all of which were at least as effective as the non-diegetic arrow in guiding users towards target events. The acknowledging dog received the most positive responses from our participants in terms of preference and user experience and significantly improved their sense of presence compared to the non-diegetic arrow. Lastly, three themes emerged from a qualitative analysis of our participants' feedback, indicating the importance of the guide's blending in, its acknowledging behavior, and participants' positive associations as the main factors for our participants' preferences.

Index Terms—Virtual Reality, 360-Degree Experiences, Attention Guidance, Diegetic Cues, Virtual Animals

1 Introduction

The experiences afforded by a traditional movie theater are clearly not interactive: while the content is purposefully curated and controlled by the creators, it is designed for "users" (the cinema patrons) who are seated in front of a fixed screen. By contrast, the experiences afforded by typical augmented reality (AR) and virtual reality (VR) systems are relatively interactive: the content is purposefully curated and designed to allow individuals to control the experience, for example by physically or virtually moving and looking around as they please.

- *Nahal Norouzi, Gerd Bruder, Austin Erickson, Pamela Wisniewski, Charlie Hughes, and Greg Welch are with the University of Central Florida. E-mail: nahal.norouzi@knights.ucf.edu., {Gerd.Bruder | Ericksona | Pamela.Wisniewski | charles.hughes | welch}@ucf.edu.*
- *Kangsoo Kim is with University of Calgary. E-mail: kkim.ucalgary@gmail.com.*
- *Jeremy Bailenson is with Stanford University. E-mail: bailenso@stanford.edu.*

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360-degree experiences can be representative of a wide range of media content. While the typical AR/VR content comprises 3D computer graphics models, recently there has been a marked increase in the availability of interactive *360-degree experiences* comprising real-world content, e.g., experiences curated from 360° or "immersive" video captured from omnidirectional cameras or camera clusters [28, 33]. For example, BlackRhinoVR (Nairobi, Kenya) has been creating award-winning 360-degree experiences, including award-winning films [1].

In a typical AR/VR experience, a viewer can freely explore the content by both translating and rotating in the 3D space. In many 360 experiences, a viewer can freely explore the content through 4π steradians of rotation, without the option to translate, such as *cinematic virtual reality* [42, 45], which usually refers to an immersive VR experience where the content is either a 360-video or a 360 virtual environment [29, 30]. For some of these experiences, this added freedom of exploration introduces the potential problem that viewers might miss aspects of the experience that are not in their field of view (FoV) at any given moment. This can lead to missed opportunities, and potentially result in confusion (e.g., a key event happening behind the viewer) [42].

Given these attention-related problems in 360-degree experiences, there has been a considerable amount of research aimed at identifying effective attention guidance mechanisms [9, 34, 42–44, 47, 52, 56, 58]. Recently, Several taxonomies categorized the characteristics of different attention guidance mechanisms, their effectiveness in successfully guiding the users, and their influence on user experience [34,42,52]. One particular appearance and behavior characteristic of attention guidance mechanisms is that of *diegesis*, a characteristic commonly considered in literature and film theory [12, 13, 51]. In the context of attention guidance, *diegetic* mechanisms are those that are part of the narrative or the environment, such as utilizing the movements of the characters within that experience [42, 52], with virtual animals/insects more recently utilized as attention guidance mechanisms in video games and 360 VR experiences [9, 34, 40, 54, 58]. On the other hand, mechanisms that are external to the story or the environment, such as arrows, or the forced rotation of the viewer towards a new direction, are considered non-diegetic [34, 42, 52]. Compared to non-diegetic mechanisms, diegetic mechanisms are thought to yield an enhanced sense of presence and user experience factors, albeit with a higher chance of going unnoticed [9, 34, 42], This would seem to make sense, as diegetic mechanisms could be perceived as more plausible than non-diegetic mechanisms, thus producing higher *plausibility illusion* measures [48]. However, past findings have not always been conclusive on the advantages and disadvantages commonly associated with non-diegetic and diegetic mechanisms inlcluding virtual animals [9, 34, 52].

Previous research also suggests that *acknowledgment* of the viewer's existence in 360 experiences by virtual characters can enhance the users' sense of connection with those characters and increase their sense of presence and enjoyment [8, 47]. This would seem to make sense, as self-relevance is considered a positive moderating factor of social influence [4, 5]. In fact, one might suppose that the combination of acknowledgement (self relevance) by a diegetic mechanism (place relevance) could produce higher *place illusion* measures [48]. Similar notions exist in AR interactions where responsiveness to and acknowledgement of the physical world by virtual characters has been shown to positively effect the users' sense of co-presence and quality of experience [17, 18, 20, 25, 36]. However, less is known about the influences of attention guidance mechanisms that can both acknowledge and show awareness of the user and its environment. This ability could be important, as it could provide the opportunity for increasing the users' sense of presence while simultaneously guiding their attention.

Thus, two primary research questions remain unanswered:

- **[RQ1]** Are virtual animals a suitable **diegetic** realization for attention guidance mechanisms compared to non-diegetic ones in terms of user experience factors?
- **[RQ2]** Are virtual animals that **acknowledge** the user and its environment more effective than those without acknowledging behaviors in terms of user experience factors?

To answer these research questions, we designed a within-subjects user study where participants were immersed in a virtual neighborhood and were told that they can freely explore while experiencing five different conditions, each containing five events placed randomly behind the user in the scene. The five conditions contained diegetic and non-diegetic guides as well as acknowledging and non-acknowledging behaviors. These conditions were embodied as: no guide, a virtual arrow, a virtual bird, a virtual dog, and a virtual dog with an acknowledging behavior. Our results show that the acknowledging behavior of the diegetic dog improved our participants' sense of presence and contributed to a significantly more positive user experience compared to the non-acknowledging and non-diegetic mechanisms. Our behavioral data analysis revealed that all of the attention guidance mechanisms were successful at directing our participants towards the target events, resulting in lower levels of concern and confusion captured in their subjective ratings. The qualitative analysis of our participants' post-study interview responses revealed themes detailing the positive influences of attention guidance mechanisms that are diegetic and show acknowledging behaviors towards the user and the environment.

Through this work we make the following contributions: to our knowledge, this is the first comparison between (a) diegetic and non-diegetic attention guidance mechanisms where a similar motion pattern is utilized for both mechanisms and the user's exploration freedom is maintained during the guidance period, and (b) the acknowledging behavior of diegetic attention guidance mechanisms versus non-acknowledging mechanisms and non-diegetic mechanisms.

The remainder of this paper is structured as follows. Section 2 describes the related work in the scope of our user study. Section 3 presents the details of our experiment. Section 4 describes our findings which are discussed in Section 5 and Section 6 concludes our work.

2 Related Work

In this section, we discuss the concept of 360-degree experiences and prior research on attention guidance and virtual animals while addressing the focus of our research in this paper.

2.1 360 Virtual Experience and Attention Guidance

Recent advances in VR technologies allow users to have more immersive and realistic virtual experiences, for example 360 virtual experiences where the users can have a full 360-degree field of regard (FOR) while navigating or staying at a fixed position in a virtual environment. The majority of 360 virtual experiences involve users being presented with 2D images and videos of real places projected on a virtual sphere around them or a computer-generated 3D virtual environment [26]. The former, with recorded images/videos of the real world can provide immersive experiences with a high sense of realism to users. However, the recorded scenes inherently lack interactivity, e.g., persons in the video cannot natively react to the viewer [49] unless specifically planned [47]. The latter, with 3D computer graphics models can provide such an interactivity with interactive virtual models, and it allows the users to freely move and rotate within the virtual environment. However, rendering high-quality virtual models can be computationally expensive [28].

The need to guide viewers' attention has been addressed in 2D media, such as Hollywood style movies, through the use of techniques like motion and framing manipulation, and increased cuts [27]. Utilizing such techniques leads to a very high *attentional synchrony*—"most viewers look at the same things at the same time." [27]. However such attention guidance approaches may not always work in 360 virtual experiences, where users have the freedom to explore the environment with relatively unrestricted orientation [42, 53]. This freedom can increase the perceptual load, e.g., via necessitating visual searches, and the chance of missing elements or information in the scene or the story [42]. Such information loss could lead viewers to a wrong place in the scene/story (contrary to the desires of the content creators), and in some cases can cause a phenomenon called *"Fear of Missing out"* (FoMo), which is a social anxiety that one might miss or already have missed important parts of the story [29, 32, 42].

In response to such issues and inspired by previous research [42], in this paper, we investigate the influence of alternate mechanisms for guiding users' attention, e.g., via arrows (overt and non-diegetic) or birds (subtle and diegetic), and study the influences of each mechanism on user experience factors, including the potential for diminished fear and confusion.

2.2 Diegetic and Non-diegetic Attentional Mechanisms

Researchers, particularly in cinematic VR film-making, have focused on different techniques to guide viewers' attention and devised taxonomies that studies the characteristics of these techniques and their effects on user experiences [34, 42, 52]. One of the characteristics identified in the taxonomies mentioned above is *diegesis*, which is adopted from film theory [51]. In the context of attention guidance, *diegetic* mechanisms are those that are part of the narrative or the environment, such as utilizing the movements of the characters within that experience [42, 52]. One of the advantages of utilizing characters' motion and other non-verbal behaviors for guidance is that viewers naturally know where to orient based on such cues, and are inclined to follow a character's target of attention [11]. Such methods have been used in film to support *attentional continuity* through multiple cuts [50]. On the other hand, *non-diegetic* mechanisms such as arrows are external to the scene or story, and typically their only function is to guide users' attention to a specific point or direction in the scene or story [42]. The ability of diegetic mechanisms to become part of the experience, compared to non-diegetic ones, has been associated with improvements in user experience, increases in the sense of presence, and higher user preference [9, 34, 52].

In this area, Nielsen et al. conducted a study that compared a non-diegetic attention guidance approach, which controlled the viewer's body orientation, with a diegetic approach that used a firefly to attract the viewer's attention, and the participants reported that the firefly was perceived as more helpful in their story-oriented experience [34]. Cao et al. proposed an automatic method to generate attention guidance metaphors including non-diegetic arrows and diegetic birds [9], and the conducted study utilizing story-oriented content showed that the diegetic guidance encouraged a higher sense of immersion and easily redirected the viewers to the events of interest, compared with the static graphical guidance. Speicher et al. described different attention guidance methods, and conducted a study to investigate the effects of the methods on task performance and user preferences in a virtual environment with 360 videos [52]. Interestingly, they found success with both non-diegetic (object to follow method) and diegetic mechanisms (person to follow method) in terms of user experience and performance.

To summarize, although these results are promising, it is not clear whether diegetic mechanisms are effective in attention guidance compared to non-diegetic mechanisms, such as commonly used graphical symbols like arrows, due to various factors, e.g., differences in the motion patterns of the diegetic and non-diegetic mechanisms [9], absence of comparison with non-diegetic mechanisms that retain user's control of their orientation during the guidance period (i.e., methods that do not enforce the user to rotate towards the target) [34, 58], and not utilizing a fully diegetic flying animal [56]. Thus, in this paper, we investigate diegetic and non-diegetic mechanisms, through controlling the mechanisms' motion patterns and user's control over their orientation. Our overall goal is to develop new knowledge about the characteristics that can lead to advantages and disadvantages of each mechanism.

2.3 Virtual Animals and Environment Acknowledgment

Using virtual animals is common and popular in various VR application scenarios from gaming to therapy and social studies [15, 36, 37]. In the context of attention guidance in 360 virtual experiences, virtual animals are appropriate and useful as attractors and/or distractors of attention because their appearances may not be obtrusive, but naturally absorbed in the virtual experience settings, such as birds, fireflies, and butterflies in nature or urban environments. Due to this advantage, prior research has used virtual animals as attention guides, and investigated the effects on the viewer's user experience in different 360 virtual experiences [9, 34, 38, 54, 56, 58].

Virtual animals are particularly beneficial to involve viewers into the virtual experience scenario through their interactive and acknowledging behaviors towards the viewers and the environment—e.g., looking at the viewer or changing the gaze to the target of interest in the environment as diegetic mechanisms. Such acknowledging behaviors have been introduced in many real–virtual human interactions to improve the user's sense of presence in the virtual environment or social presence with a virtual human. Sheikh et al. investigated how different attention-directing techniques influence the viewer's sense of presence in 360 panoramic videos through a user study [47]. The results showed that a character's behavior acknowledging the viewer positively influenced the participants' sense of presence, enjoyment, and immersion. In AR settings, Lee et al. developed a physical-virtual wobbly table, which spans from the user's physical space to a virtual human's virtual space, using a projection screen [24]. They studied how the virtual human's environment-aware behavior towards the user and the wobbly table event, and found effects on the sense of presence and attentional allocation in the interaction. Kim et al. also conducted a user study with a virtual human acknowledging a physical obstacle on her way and asking for help from the participants [19], resulting in a higher social presence and perceived intelligence of the virtual human. Norouzi et al. pointed out that this kind of environment acknowledging behavior is an important factor to affect the user's perception and behavior in human-agent interactions [36].

To summarize, since viewers' sense of presence in 360 virtual experiences would be reduced when there is no sensation of a (tangible) relationship with the surrounding environment, called the *Swazy Effect* [8], based on the aforementioned research, we study the use of virtual animals in 360 virtual experiences with environment acknowledging behaviors and assess their effectivness for guiding the viewer's attention while maintaining or improving their sense of place or plausibility illusion and improving their experience [47, 48, 54].

3 Experiment

In this section, we describe the experiment we conducted to understand and compare the effectiveness and influence of attention guidance mechanisms in 360-degree immersive experiences.

3.1 Participants

We recruited 28 participants (10 male, 18 female, age 18–28, $M = 21.21$, $SD = 2.84$) affiliated with our university. Our experimental protocol was approved by the Institutional Review Board of our university. All of our participants had normal hearing and normal or corrected vision with glasses or lenses. 17 participants were single/multi pet owners, with 13 dog owners, 6 cat owners and 3 mice/hamster owners. At the end of the study, using a 7-point scale (1 = novice/not familiar, 7 = expert/very familiar), we asked our participants to rate their expertise with computers ($M = 4.96$, $SD = 1.34$), VR ($M = 4.32$, $SD = 2.17$), AR ($M = 4.14$, $SD = 2.17$), virtual humans ($M = 5.32$, $SD = 1.80$), and virtual animals ($M = 4.78$, $SD = 1.91$). Among the participants who had experience with virtual animals in video games, 18 of them mentioned that they experienced them in companionship or pet-like roles, three in guiding roles, and one in enemy/hunting roles. Participants were screened for dog and bird phobias before arrival.

3.2 Materials

Here, we present the details of our physical setup for our 360 VR experience, the virtual environment, the virtual events designed as attention guidance targets, and the different attention guidance mechanisms.

3.2.1 Experimental Setup

In our experiment, participants were seated and immersed in a virtual neighborhood via an HTC Vive Pro HMD (refresh rate: 90 Hz, resolution: 1440×1600 pixels, FoV 110°) which was connected to a workstation (Intel Xeon 2.4 GHz processors comprising 16 cores, 32 GB of main memory and two Nvidia Geforce GTX 980 Ti graphics cards). We used a separate computer for participants to answer questionnaires. We used Unity version 2019.2.13f1 for all of our development. Participants were told that they can freely explore the virtual neighborhood by changing their orientation and without the ability to translate to observe the life of its inhabitants, while in some trials they may see a virtual entity guiding them towards events, which may or may not interest them. Due to the free exploration nature of the study they could choose to ignore or follow the guide.

3.2.2 Virtual Environment

We used an urban neighborhood scene by Art Equilibrium that is available through the Unity Asset Store[1]. To create the illusion of a real neighborhood, we populated the scene with 13 simulated sentient characters with idle behaviors, such as walking and talking. See for example Figure 2. We acquired the idle characters and their animations from Adobe Mixamo[2] and the Unity Asset Store[3]. All the walking virtual humans had spatial footstep sounds from Fesliyan Studios[4] and we played an urban distant ambient sound through the headphones, provided by ZapSplat[5].

3.2.3 Attention Guidance Mechanisms

In our experiment we investigated the effectiveness of four different attention guidance mechanisms, comparing them with each other and a

[1]https://assetstore.unity.com/packages/3d/environments/urban/japanese-street-170162

[2]https://www.mixamo.com/#/

[3]https://assetstore.unity.com/packages/3d/characters/animals/animal-pack-deluxe-v2-144071

[4]https://www.fesliyanstudios.com/royalty-free-sound-effects-download/footsteps-31

[5]https://www.zapsplat.com/

Fig. 2. Screenshots showing examples of some of the idle characters present in the virtual neighborhood.

no-guide condition. Our attention guidance mechanisms illustrated in Figures 1 and 3 were either a virtual arrow, a virtual bird, a virtual dog, or a virtual dog with acknowledging behavior. Each mechanism started its guidance routine 10–12 seconds after the start of the condition or after the end of each event. This guidance routine was repeated five times for each condition.

The first three mechanisms only directed the user to a target event and were not programmed to have any acknowledging behaviors towards the user or the environment. Therefore, we will refer to these three together as *non-acknowledging* mechanisms. For the non-acknowledging mechanisms, the guiding routine consisted of a mechanism spawning at 90 degrees to the left of the user's forward vector and travelling on an arc path around the user with the radius of 2.5 meters (i.e., within social space range [14]) at the speed of 30 degrees per frame. After arriving at their target event, all non-acknowledging mechanisms turned towards the event, after which they faded away.

We modeled the virtual bird[6] after a Blue Jay with a flying animation, and scaled it to be close to a real one [2] (30 cm head to tail, 52 cm wing to wing). We scaled the virtual arrow[7] to have the same length as the Blue Jay (i.e., 30 cm), with its widest and tallest part at 11 cm and 18 cm, respectively. Both the arrow and the bird traveled at one meter above the ground (i.e., roughly the vertical center of the FoV), which is similar to previous examples of flying arrows and animals/insects [9,45]. We modeled the virtual dog [8] after a beagle, and scaled it to be close to a real beagle (30 cm shoulder height, 18 cm wide, 50 cm long) [10]. The non-acknowledging virtual dog was animated to run towards its target event, where it turned idle and faded away. Although fading away is not a natural behavior for animals, to maintain consistency among the non-acknowledging mechanisms, we used the same means of leaving the experience for these entities, in line with related work on fading in attention guidance [45, 56]. Also, in pilot tests we observed that any extra movement/behavior by these mechanisms, such as moving out of the user's FoV, moving towards the horizon or towards the user would unintentionally induce the impression that the user is still being guided, which can be avoided with the fading mechanism.

We used the same 3D model for the *acknowledging* dog; however we randomized the color of the dogs between dark brown and light brown throughout the study. We programmed the acknowledging dog to stay 1 meter away from the user (i.e., within personal space range [14]) facing forward, and cycled it through idle animations of looking around while wagging its tail and scratching its ears. The presence of this dog close to the user was the first indication that this dog acknowledges the user as if it is *with* the user. We also programmed the acknowledging dog to remain in the user's FoV, and to walk towards its initial position when the user turned. For this mechanism, the guidance routine consisted of the dog leaving its position next to the user, sniffing the ground while walking 2.5 meters forward (i.e., acknowledging the environment), then fully turning clockwise and looking back at the user (i.e., acknowledging the user). With the acknowledging dog positioned on the arc path, similar to the non-acknowledging mechanisms, it ran on that path towards the position of a target event and turned towards the event after arrival. Unlike the non-acknowledging mechanisms, it sat down and observed the target event (i.e., acknowledging the environment). After the target event ended (see Section 3.2.4), the acknowledging dog turned and walked back towards the user (i.e., acknowledging the user) and turned again to its initial orientation facing the environment.

[6]`https://assetstore.unity.com/packages/3d/characters/animals/birds/living-birds-15649`
[7]`https://assetstore.unity.com/packages/tools/particles-effects/arrow-waypointer-22642`
[8]`https://assetstore.unity.com/packages/3d/characters/animals/mammals/dog-beagle-70832`

3.2.4 Target Events

In addition to the idle characters in the virtual neighborhood we implemented different target events that were intended to be more distinct and salient compared to the interactions of the idle characters. The events were programmed to be in one of the categories of a single person exercising, two people exercising, two people dancing, 5 people dancing, and three children playing/miming. As we wanted to maintain the similarity of the events within each category while ensuring that participants are not seeing the same characters(s) doing the same thing(s) every time, we implemented five different events for each category that are conceptually similar. This resulted in 25 events in total. For instance, for the single person exercising category, different virtual characters were programmed to do five different exercise routines (e.g., jumping jacks and boxing exercises). Figure 4 illustrates one example of each of the event categories. The event characters and their animations were acquired from Adobe Mixamo.

In the experiment, we randomly placed all target events six meters (i.e., within public space range [14]) directly behind the participants in a randomized range of ± 20 degrees. We set the *beginning* of the event animation (e.g., dancing) to start 5.8 seconds after it appeared, and the *ending* 10 seconds later. It took all guidance mechanisms roughly 5.8 seconds to arrive at the event, using about the same basic arc path, traversal speed and angles around the user (see for example Figure 1), while the acknowledging dog used the idle time before, during, and after the events for its supplemental diegetic acknowledging behaviors.

3.3 Methods

In this section, we present the details of our experimental design and procedure, our hypotheses inspired by previous literature, and our quantitative and qualitative measures.

3.3.1 Study Design

We utilized a within-subjects design for our experiment with one factor (5 levels). We chose attention guidance mechanism as our independent variable (see Figure 1), which was realized in the following conditions:

- **No Guide [None]**: control
- **Arrow:** non-diegetic and non-acknowledging
- **Bird:** diegetic and non-acknowledging
- **Dog:** diegetic and non-acknowledging
- **Acknowledging Dog [Ack-Dog]:** diegetic and acknowledging

All participants experienced all five conditions and all five event categories (see Figure 4) within each condition. To account for order effects, Latin Square was used to randomize our study conditions, and although our event categories and the dog colors were designed to be comparable, we further randomized them between conditions to ensure no event category and no dog color is always seen with a specific condition.

3.3.2 Procedure

After the participants read the consent form, and provided their informed consent, we assigned them a participant ID and asked them to complete the Simulator Sickness Questionnaire [16]. We then briefed the participants on the general structure of the experiment and the free exploration nature of the study (see Section 3.2.1). We asked them to

Fig. 3. Screenshots showing the different diegetic behaviors and stages of the acknowledging dog's attention guidance mechanism.

Fig. 4. Screenshots of example target events from each of the five event categories, from left to right: single person exercising, two people exercising, two people dancing, a group of people dancing, kids playing.

take a seat on a rotating chair in the middle of the experimental space, and helped them don the HMD. All of the participants started with a one-minute familiarization session during which they were immersed in the same virtual neighborhood that was used for the experimental conditions. Only the idle characters were present during this session. After confirming that they were ready, we started the first random condition assigned to the participant's ID. The beginning and end of each condition was communicated both with a beep sound heard through the HMD's headphones and was also verbalized by the experimenter. After each condition, we had the participant place the HMD on the chair and then answer several questionnaires on a computer. Participants completed the demographics and familiarity with technology questionnaires last. Afterward, participants took part in a post-study interview followed by monetary compensation.

3.3.3 Hypotheses

Here, we present our hypotheses focusing on the effectiveness of presence/absence of different attention guidance mechanisms and their influence on user experience, fear of missing out, and sense of presence. Our hypotheses are grounded in previous literature borrowing from findings on the use of attention guidance in 360 virtual experiences, and notions of diegesis and acknowledgment.

- **H1:** *Overt nature* of the non-diegetic arrow and the *acknowledgement* of the ack-dog will influence participants' behavior. (See Sections 2.1 and 2.3.)
  - **H1a:** The ratio of event visibility will be higher with the non-diegetic arrow, followed by the diegetic mechanisms and the no guide condition.
  - **H1b:** The ratio of mechanism visibility will be higher with the the acknowledging dog during the attention guidance period compared to the other mechanisms.
- **H2:** Utilizing the diegetic mechanisms will lead to a more positive *user experience* compared to the non-diegetic arrow and the no guide conditions. (See Section 2.2.)
- **H3:** Utilizing the acknowledging mechanism will lead to a more positive *user experience* compared to the non-acknowledging and no guide conditions. (See Section 2.3.)
- **H4:** The diegetic acknowledging mechanism will lead to a higher *sense of presence* and *user preference*, followed by diegetic mechanisms and the no guide, and the non-diegetic mechanism. (See Sections 2.2 and 2.3.)
- **H5:** Absence of any attention guidance mechanism will lead to higher levels of *fear of missing out*. (See Section 2.1.)

3.3.4 Measures

To assess the effectiveness of the different attention guidance mechanisms and investigate their influence on user experience and preferences we utilized objective behavioral data, subjective questionnaires, and a post-study interview which are detailed in this section.

Objective Measures For each trial, we recorded the duration of time where the attention guidance mechanisms and the events where present in the participant's FoV at different stages resulting in the measures below:

- **Mechanism Visibility Ratio:** We calculated the duration the attention guidance mechanisms were in participants' FoV over the total duration of the guidance period (see Section 3.2.4). For non-acknowledging mechanisms, this duration started the moment they entered the participant's FoV. For the acknowledging dog, it started the moment it began running on the arc path towards the target event. For all mechanism the end of this duration was marked by the moment a guide arrived at the target event.
- **Event Start:** We marked whether the moment the events began were (e.g., characters started dancing) within participants' FoV. (See Section 3.2.4.)
- **Event Visibility Ratio:** We calculated the ratio of time an event was within participants' FoV over its total duration (i.e., 10 seconds), which indicates whether participants arrived at the event on time and/or how long they continued to observe the event.

Subjective Measures We utilized multiple questionnaires to assess the influence of the attention guidance mechanisms on participants' subjective experience as detailed below.

Table 1. Attention Guide Questionnaire (AGQ). The sub-scales are: *Utility* (2 items), *Affect* (4 items), *Behavioral Influence* (2 items), and *Place & Plausibility Illusion* (5 items). Each question is assessed on a 7-point scale (1=not at all, 7=very much). Scales with an * are inverted for the analysis.

Sub-Scale	Item
Utility	1*) I found the presence of this guide to be *distracting*. 2*) I found the presence of this guide to be *disruptive*.
Affect	3*) I found the presence of this guide to be *annoying*. 4) I found the presence of this guide to be *pleasing*. 5) I felt *encouraged to explore* the environment with this guide. 6) I felt like I had a *guiding companion*.
Behavioral Influence	7*) I *felt forced* to explore the environment with this guide. 8*) I *felt rushed* to explore the environment with this guide.
Place & Plausibility Illusion	9) This guide made me feel like I was *part of the experience*. 10) This guide was *aware of the environment*. 11) This guide was *aware of me*. 12) It felt as if the guide was *responding to me*. 13) The presence of this guide seemed *plausible* to the environment I was in.

- **Quality of Experience:** We utilized the short version of the User Experience Questionnaire (UEQ) [46] and an Attention Guide Questionnaire (AGQ) devised by the authors to assess the influence of the attention guidance mechanisms on the participants' quality of experience.
  - **User Experience Questionnaire (UEQ):** The UEQ-Short consists of eight items (semantic differentials). This questionnaire provides a *Total* user experience score and two sub-scales of *Hedonic* and *Pragmatic* qualities for all five conditions.
  - **Attention Guide Questionnaire (AGQ):** Table 1 shows the 13-item *Attention Guide Questionnaire* we devised to assess the effectiveness of the four diegetic and non-diegetic attention guidance mechanisms. The items of this questionnaire were inspired by related work on instruments to assess guidance mechanisms [34, 42, 47, 48]. The AGQ has four sub-scales of *Utility*, *Affect*, *Behavioral Influence*, and *Place & Plausibility Illusion*.
- **Presence:** We utilized the Slater-Usoh-Steed Presence Questionnaire [55] to assess participants' sense of *being there* in the virtual neighborhood.
- **Fear of Missing out:** To assess the notion of *Fear of Missing out* [32], we utilized the questionnaire devised by MacQuarrie and Steed [29]. This questionnaire consisted of two sightly adjusted statements which are: (1) "At times, I was worried I was missing something," and (2) "My concern about missing something impacted my enjoyment of the experience." They were assessed on a 7-point Likert scale (1=strongly disagree, 7=strongly agree).
- **Preference:** We utilized a Preference Questionnaire devised by Wallgrun et al. [56] with slight adjustments. In the resulting questionnaire, participants were asked to order the five conditions according to six factors which were: (1) comfortable working with mechanism, (2) aesthetic appeal, (3) overall preference for future use, (4) recommend to others, (5) easy to learn and use, (6) least distracting.

Post-Study Interview After the end of the experiment, we conducted a post-study interview to gain a better understanding of how the attention guidance mechanisms affected participants' perceptions and decisions. Specifically, participants were asked to describe which mechanisms were more or less comfortable to work with, aesthetically appealing, easy to understand, and distracting.

Table 2. Summary of the main effects we observed for the different objective and subjective measures.

Measure	Main Effect
Objective Measures:	
Mechanism Visibility	$F(3,69) = 5.14$, $\boldsymbol{p = 0.003}$, $\eta_p^2 = 0.18$
Event Visibility	$F(4,92) = 11.81$, $\boldsymbol{p < 0.001}$, $\eta_p^2 = 0.34$
Event Start	$F(4,92) = 13.44$, $\boldsymbol{p < 0.001}$, $\eta_p^2 = 0.37$
UEQ:	
Total	$F(4,108) = 7.08$, $\boldsymbol{p < 0.001}$, $\eta_p^2 = 0.20$
Hedonic	$F(2.71,73.28) = 9.43$, $\boldsymbol{p < 0.001}$, $\eta_p^2 = 0.25$
Pragmatic	$F(2.76,74.53) = 4.38$, $\boldsymbol{p = 0.008}$, $\eta_p^2 = 0.14$
AGQ (Crobach α):	
Total (0.90)	$F(1.86,50.47) = 28.65$, $\boldsymbol{p < 0.001}$, $\eta_p^2 = 0.66$
Utility (0.84)	$F(1.94,52.42) = 8.47$, $\boldsymbol{p = 0.001}$, $\eta_p^2 = 0.23$
Affect (0.85)	$F(2.18,58.86) = 22.68$, $\boldsymbol{p < 0.001}$, $\eta_p^2 = 0.45$
Behavioral Influence (0.84)	$F(2.63,71.19) = 7.78$, $\boldsymbol{p < 0.001}$, $\eta_p^2 = 0.22$
Place & Plausibility Illusion (0.79)	$F(3,81) = 30.04$, $\boldsymbol{p < 0.001}$, $\eta_p^2 = 0.52$
Presence	$F(4,108) = 5.94$, $\boldsymbol{p < 0.001}$, $\eta_p^2 = 0.18$
Fear of Missing out	$F(2.88,77.99) = 8.01$, $\boldsymbol{p < 0.001}$, $\eta_p^2 = 0.23$
Preference:	
Comfortable Working with	$\chi^2 = 40.68$, $\boldsymbol{p < 0.001}$
Aesthetic Appeal	$\chi^2 = 51.34$, $\boldsymbol{p < 0.001}$
Future Use	$\chi^2 = 42.31$, $\boldsymbol{p < 0.001}$
Recommend to Others	$\chi^2 = 40.91$, $\boldsymbol{p < 0.001}$
Least Distracting	$\chi^2 = 36.08$, $\boldsymbol{p < 0.001}$
Easy to Learn and Use	$\chi^2 = 38.22$, $\boldsymbol{p < 0.001}$

4 RESULTS

We used a mixed-methods approach for the analysis of our results, which are detailed in this section. We used repeated measures ANOVAs at the 5% significance level for the analysis of most of our subjective and objective quantitative results in line with the ongoing discussion in the field of psychology indicating that parametric statistics can be a valid and informative method for the analysis of combined experimental questionnaire scales [21, 22, 31, 35]. We used paired sample t-tests with Bonferroni correction for the pairwise comparisons. This correction was applied to the p-values instead of adjusting the α level from 0.05. We confirmed the normality of the results using QQ plots and a Shapiro–Wilk test at the 5% level. Degrees of freedom were corrected using Greenhouse-Geisser and Huynh-Feldt estimates of sphericity when Mauchly's test indicated that the assumption of sphericity had been violated. Friedman tests were used to analyze the single item preference scores at the 5% significance level with Wilcoxon signed rank tests with Bonferroni correction for the pairwise comparisons.

Table 2 summarizes the main effects of the experimental conditions on our objective and subjective quantitative measures. The post-hoc tests are shown in Figure 5 and discussed below.

4.1 Objective Measures

The results for the objective measures are shown in Figure 5(a). Due to technical issues with behavioral data recording in one of the conditions, the data of four participants was excluded from the objective measures analysis, leaving a total of 24 valid data sets. A summary of the main effects we found is shown in Table 2. We found significant main effects of the attention guidance mechanisms on all objective measures.

4.1.1 Mechanism Visibility Ratio

For the mechanism visibility ratio, we found a significant differences between the dog and ack-dog conditions (***p=0.011***), indicating that the ack-dog was in participants' field of view for a significantly longer duration during the attention guidance period.

4.1.2 Event Start

For the event start measure, we found significant differences between the no guide condition and all other conditions (all $p<0.01$). This indicates that the start of events were significantly less often in participants FoV in the no guide condition compared to all other conditions.

4.1.3 Event Visibility Ratio

For the event visibility ratio, we found significant differences between the no guide condition and all other conditions (all $p<0.01$), indicating that the events were in participants FoV for significantly longer periods with all the other conditions compared to no guide. We also found a significant difference ($p = 0.04$) between the arrow condition and the ack-dog condition, indicating that events were in participants' FoV for a significantly longer period compared with the arrow than the ack-dog.

4.2 Subjective Measures

In this section, we report our results from the different subjective measures described in Section 3.3.4. A summary of the main effects can be found in Table 2. We found significant main effects of the attention guidance mechanisms on all subjective measures.

4.2.1 Quality of Experience

User Experience Questionnaire (UEQ): Figure 5(b) shows the results for the UEQ-Short questionnaire, specifically the total scores as well as hedonic and pragmatic sub-scales.

Pairwise comparisons between the *Total* scores revealed significant differences between the ack-dog and the arrow and no guide conditions (both $p < 0.02$). These results suggest that overall, the ack-dog led to an improved user experience compared to the arrow and the no guide.

Pairwise comparisons between the *Hedonic* scores revealed significant differences between the arrow condition and the bird, the dog, and the ack-dog conditions (all $p < 0.04$). Additionally, the ack-dog condition was significantly different from the no guide and the dog conditions (both $p < 0.02$). These findings suggest that the ack-dog resulted in a more pleasant experience than the arrow, dog, and no guide conditions. The arrow resulted in the least pleasant experience.

Pairwise comparisons between the *Pragmatic* scores only revealed a significant difference between the ack-dog and the no guide conditions ($p=0.03$). The results suggest that all mechanism were similar in terms of pragmatic qualities except the ack-dog being perceived as more pragmatic compared to the no guide condition.

Attention Guide Questionnaire (AGQ): Figure 5(d) shows the results for the AGQ with its total score and four sub-scales. The scores were calculated by computing the means of the corresponding items after reversing the negative ones. Cronbach's alpha indicated a high internal consistency for the total scale and the sub-scales (see Table 2).

For the *Total* score, pairwise comparison indicated significant differences between the arrow condition and the bird, the dog, and the ack-dog (all $p < 0.001$). Also, the ack-dog condition was significantly different from the bird and the dog conditions (both $p < 0.01$). These results suggest that the non-diegetic arrow was perceived more negatively compared to the other conditions while the ack-dog was perceived more positively in its role as a guide.

For the *Utility* sub-scale, pairwise comparisons indicated significant differences between the arrow condition and the dog and ack-dog conditions (both $p < 0.02$). These findings suggest that the diegetic mechanisms realized as dogs had a higher utility.

For the *Affect* sub-scale, pairwise comparisons indicated significant differences between the arrow condition and the bird, the dog, and the ack-dog (all $p < 0.001$). These results suggest that the diegetic mechanisms resulted in more positive emotions compared to the non-diegetic arrow.

For the *Behavioral Influence* sub-scale, pairwise comparisons indicated significant differences between the arrow condition and the bird, the dog, and the ack-dog conditions (all $p < 0.01$). These findings suggest that the non-diegetic arrow had a negative influence on participants' behavior in terms of feeling rushed and forced.

For the *Place and Plausibility Illusion* sub-scale, pairwise comparisons revealed significant differences between the arrow condition, and the bird, the dog, and the ack-dog (all $p < 0.001$). Also, significant differences were found between the ack-dog, and the dog and the bird conditions (both $p < 0.01$). These findings suggest that the arrow was perceived as the least plausible guide compared to all the other conditions while the ack-dog was perceived as the most plausible guide.

4.2.2 Fear of Missing out and Presence

Figure 5(c) shows the results for Fear of Missing out and Presence.

For *Fear of Missing out*, pairwise comparisons indicated significant differences between the no guide condition and the arrow, dog, and the ack-dog (all $p < 0.05$). Overall, this suggests that having no guide introduced some level of concern with regards to missing the events.

For participants' sense of *Presence*, pairwise comparisons revealed that participants had a stronger sense of *being there* with the ack-dog compared to the arrow ($p=0.001$).

4.2.3 Subjective Preference

Figure 5(e) shows the results for the subjective preference ratings. To calculate the scores for each preference factor introduced in Section 3.3.4, participants' preferences were transformed into ranking data by associating a score of five to their first choice, the score of four to their second choice and so on.

Pairwise comparisons for the *Comfortable Working with Mechanism* factor revealed significant differences between the ack-dog condition and the arrow, bird, dog, and the no guide conditions (all $p < 0.005$). These findings suggest an overall high preference to work with the acknowledging diegetic mechanism realized as a dog compared to other alternatives.

Pairwise comparisons for the *Aesthetic Appeal* factor revealed significant differences between the ack-dog condition and the arrow, the bird, the dog, and the no guide conditions (all $p < 0.05$). Additionally, we observed significant differences between the arrow condition and the bird, the dog, and the no guide conditions (all $p < 0.05$). These results suggest that the acknowledging diegetic guide presented a more appealing experience compared to the others while the non-diegetic arrow was perceived as the least aesthetically appealing.

Pairwise comparisons for the *Overall Preference for Future Use* factor revealed that the ack-dog condition was significantly different than the arrow, the bird, the dog, and the no guide conditions (all $p < 0.001$). These findings suggest that participants had a stronger preference to use the acknowledging diegetic mechanism in the future compared to the others.

Pairwise comparisons for the *Recommend to Others* factor revealed significant differences between the ack-dog condition and the arrow, the bird, the dog, and the no guide conditions (all $p < 0.01$). Additionally, we found a significant difference between the dog and the arrow conditions ($p=0.01$). These findings suggest that participants were more willing to recommend the acknowledging diegetic mechanism to others compared the rest of the conditions with a preference for the diegetic dog over the non-diegetic arrow.

Pairwise comparisons for the *Easy to Learn and Use* factor revealed significant differences between the ack-dog condition and the dog and no guide conditions (both $p < 0.02$). Also, we found significant differences between the arrow and the dog and no guide conditions (both $p < 0.02$). These findings suggest that participants perceived both the ack-dog and the arrow mechanisms as more understandable compared to the dog and the no guide conditions.

Pairwise comparisons for the *Least Distracting* factor revealed significant differences between the no guide condition, and the arrow, the bird, the dog, and the ack-dog conditions (all $p < 0.02$). These findings suggest that compared to not having a guide, the addition of the four

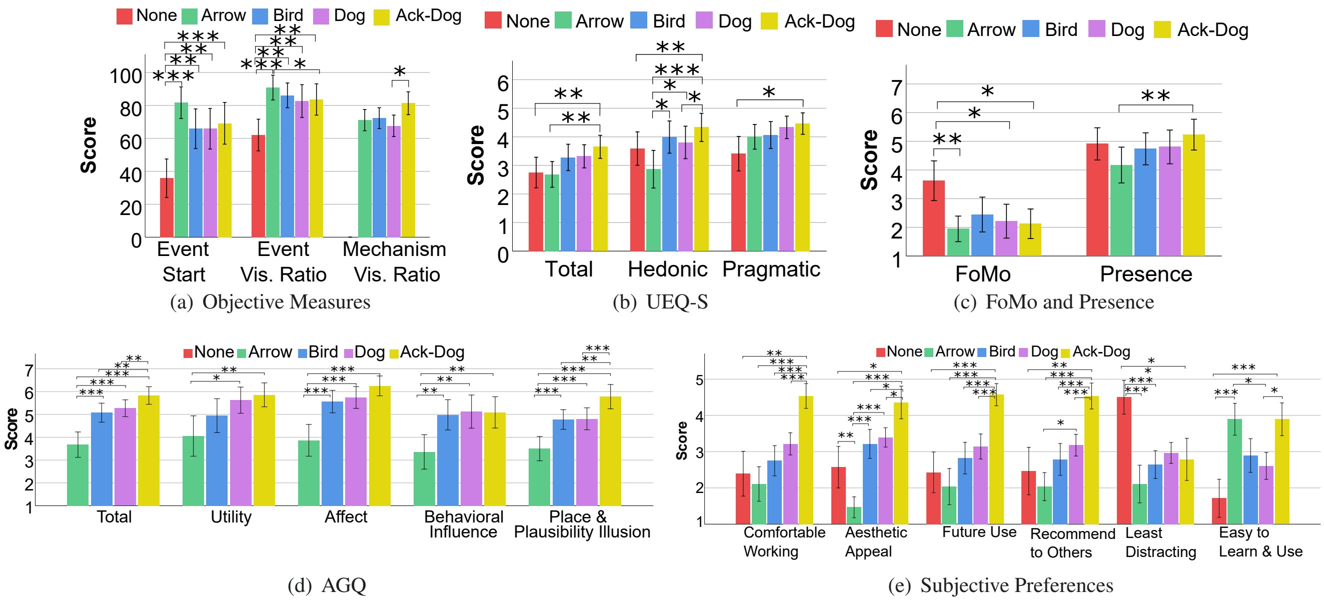

Fig. 5. Objective and subjective results: (a) Objective Measures, (b) UEQ-S, (c) FoMo and Presence, (d) AGQ, and (e) Subjective Preferences. Bars indicate the mean score for each measure and error bars indicate 95% CI. Statistical significance: *** ($p<0.001$), ** ($p<0.01$), * ($p<0.05$).

remaining mechanisms, regardless of their characteristics, distracted our participants.

4.3 Qualitative Results

In this section, we present the qualitative results of our participants' post-study interview responses. We used the thematic analysis approach devised by Braun and Clarke [7]. This analysis was conducted by the first author of this manuscript. The analysis consisted of transcriptions of post-study interview responses, iterative steps of data familiarization, identification of code words, conceptual grouping of code words into themes and refining the themes. The analysis revealed three themes and the effect of each theme on the quality of our participants' experience.

4.3.1 Blending in with the Environment Matters

18 of our participants (64%) described the notion of a guide blending in with the environment (i.e., being diegetic) as one of the main factors for preferring a mechanism over another. For instance, the non-diegetic arrow was described as unnatural, out of place, or forced reminding participants that the experience is not real, while the diegetic guides that *blended in* were described as more pleasing and less distracting. For instance, two participants stated:

> *P5: "... the dog that was with me the whole time, it was more aesthetically appealing because it seemed like it fit into the environment, more like a dog would really be there in that type of city and it made me feel more comfortable because it was there..."*

> *P24: "...how much it fits into the environment like the dog and bird ... with the animal guides they were still guiding me but it wasn't like I was on a leash with it, the arrow felt a little more force kind of like this where you need to go kind of format..."*

Additionally, the behaviors that defied the ability of a guide to blend in the environment played a role in their decisions. Although, the diegetic animals were preferred more, their disappearance, which can be considered a non-diegetic behavior, negatively influenced the experience of some of our participants (61%) either in terms of distracting them, reminding them that the experience is not real, or that they are not present in the virtual neighborhood. One participant remarked:

> *P20: "... I rated the arrow the lowest cause it kind of just reminded me that yeah I'm in a simulation something that shouldn't be here normally the animal companion ones were nice but when they disappeared they had the same sense of oh right I'm inside a simulated environment that fade out kind of pulled me out of things..."*

4.3.2 Acknowledgment Led to a More Positive Experience

Our participants preferences were positively influenced by the acknowledging behavior of the diegetic dog and many of our participants (61%) noted that the the dog's behaviors towards them and the environment seemed natural and made them feel like they are actually there, introducing feelings of reassurance, companionship, and a sense of connection and communication. Two participants stated:

> *P9: "...I really enjoyed the dog who just stayed the entire time because he seemed more lifelike he would sit down look at it like a real puppy dog would do in reality and I really enjoyed that cause it made me feel connected to the space so it made me feel like oh this is realistic..."*

> *P19:"... it both moving around and yet kind of still feeling like a dog just kind of felt like okay it's a light little situation not anything to be worried about at all... it would catch my attention and yet still feel natural at the same time..."*

4.3.3 Positive Associations with the Guide Matters

20 of our participants (71%) noted that their affinity towards and familiarity with the animal guides affected their preference as they found them more appealing, cute, or elegant compared to the non-diegetic arrow even though the arrow was considered as more direct and easier to understand by many of our participants (60%). A participant noted:

> *P18: "... I really liked the bird I just thought it was pretty like as soon as I saw it I was like whow like I'm gonna go where ever that bird is going...I'm just familiar with having dogs around me and it makes me more comfortable having it there, like I wasn't alone I was with the dog even before I noticed that it was the guide..."*

5 Discussion

In this section, we present our main findings and discuss the implications of utilizing attention guidance mechanisms that are diegetic and/or acknowledging on user experience and behavior.

5.1 Virtual Animals are Effective as Diegetic Attention Guidance Mechanisms (RQ1)

Primarily, our findings indicate the potential of virtual animals as diegetic attention guidance mechanisms compared to the non-diegetic arrow in enhancing participants' user experience. For instance, the

UEQ results indicated an overall less positive experience with the non-diegetic arrow compared to the ack-dog, with the arrow receiving the lowest hedonic quality scores compared to all the other conditions. Also, we did not find any support for the arrow enhancing participants' experience compared to the no guide condition. These findings are also aligned with our devised attention guidance questionnaire (AGQ). Compared to the diegetic mechanisms, the non-diegetic arrow received the lowest total score, was perceived as most distracting/disruptive (i.e., the utility sub-scale), reduced positive affect and place and plausibility illusion, and was perceived as more forced (i.e., the behavioral influence sub-scale). These findings partly support our Hypothesis **H2** and indicate the potential benefits of utilizing diegetic mechanisms. Although the non-diegetic arrow was perceived as the most direct by many of our participants, making it a top candidate for fast and efficient guidance, it was evaluated very negatively. We speculate that participants' appreciation of the mechanisms that blended in with the environment and seemed more natural may have affected the evaluation of the non-diegetic arrow, especially in the presence of multiple sentient and interactive characters, exacerbating its lack of diegesis.

We did not find significant effects supporting that all of our diegetic attention guidance mechanisms can lead to a higher sense of presence compared to the non-diegetic arrow, not supporting parts of Hypothesis **H4**. Based on the qualitative analysis of our participants' post-study interview responses, we speculate that this is caused by the non-diegetic behavior of disappearance exhibited by two of our diegetic conditions, as participants characterized the disappearance of animals as unnatural.

Focusing on our participants' preference scores, the diegetic ack-dog was highly preferred for the majority of the factors which is discussed in Section 5.2 in more detail. A few exceptions were observed in the *Aesthetic Appeal* and *Recommend to Others* factors, as our participants chose the non-diegetic arrow as the least aesthetically appealing condition and preferred to recommend the diegetic dog compared to the non-diegetic arrow significantly more. These findings are aligned with previous positive perceptions of virtual animal/insect attention guides [9, 34], partially supporting our Hypothesis **H4**. As noted above, we speculate that the disappearance of the two diegetic virtual animals influenced their desirability and we propose further exploration for diegetic behaviors of such mechanism to successfully indicate the end of the guidance period without negatively influencing users' experience.

Aligned with Hypothesis **H1a**, all of the attention guidance mechanisms were found to be effective as their presence led to increased event visibility ratio and mean event start scores. This was also reflected in our participants' *Fear of Missing out* ratings, where the arrow, dog, and ack-dog mechanisms were evaluated more positively compared to the no guide condition. From this, we accept Hypothesis **H5**. However, we can only partially accept hypothesis **H1a**. Our expectation was that the overt nature of the arrow would make the presence of a target event more explicit to our participants. However, we only found a significant difference in visibility ratio between the non-diegetic arrow and the ack-dog. Also, the findings from the AGQ behavioral influence sub-scale show that the ack-dog was perceived as less forced compared to the arrow, which may have resulted in more exploration freedom with the ack-dog; hence, the lower event visibility ratio. However, we do not see a similar pattern with the other non-acknowledging diegetic conditions, which may have been influenced by their disappearance or their non-acknowledging behavior, requiring future investigations to pinpoint the exact cause.

5.2 Influence of Acknowledging Behavior for Attention Guidance Mechanisms (RQ2)

Overall, the ack-dog, which exhibited acknowledging behaviors towards the participants and the environment, resulted in a more positive experience compared to the no guide and the non-acknowledging guidance mechanisms which is aligned with previous exploration on this topic suggesting the potential for an increased sense of presence, enjoyment, and connection [8, 47]. Focusing on quality of experience, UEQ scores indicated an overall increased positive perception of the ack-dog over the no guide and non-diegetic arrow, with a hedonic advantage over all conditions but the bird, and a pragmatic advantage over the no guide condition. The total score as well as the place and plausibility sub-scales of the AGQ revealed a significant advantage over all the other conditions, and the ack-dog was perceived as less disruptive/distracting (i.e., the behavioral influence sub-scale) compared to the arrow. Also, the ack-dog resulted in a significantly higher sense of presence compared to the non-diegetic arrow. These findings partly support Hypotheses **H3** and **H4**. We speculate that the increased place and plausibility illusion [48] induced by the ack-dog's behaviors and its continuous presence, which was deemed natural by our participants, increased the participants' perception of self-relevance and the ack-dog's social influence [4, 5], resulting in our participants' experience of a higher sense of presence, companionship, and connection captured in their subjective ratings and their interview responses. Additionally, these findings can explain why the ack-dog was significantly preferred more in many of the preference factors compared to all other conditions, such as *Comfortable Working with Mechanism*, *Aesthetic Appeal*, *Future Use*, or *Recommend to Others*, while only significantly different than the no guide and the diegetic dog in the *Easy to Learn and Use* factors partly supporting our Hypothesis **H4**.

Our expectation for hypothesis **H1b** was that the acknowledging behavior of the ack-dog might communicate that the ack-dog is aware of the goings-on in the environment, and with real dogs being more common in guiding roles [39, 57], participants may feel more encouraged to follow it more closely, leading to higher mechanism visibility ratios. However, while we see a trend for a higher mechanism visibility ratio for ack-dog compared to all other condition, this effect is only significant between the ack-dog and the non-acknowledging dog condition. For future studies, we think that using eye tracking can better distinguish the differences between the effectiveness of our attention guidance mechanisms, for instance by analyzing gaze fixation data.

5.3 Limitation

Our study has certain limitations. First, similar to many previous AR/VR attention guidance research, we adopted a holistic view of each attention guidance mechanism, where the defining characteristics of the mechanisms are not varied or studied consistently and are compared as a whole in favor of mechanism practicality [3, 6, 23, 34, 41, 45, 52]. We think that future research will benefit from adopting factorial design approaches to better narrow down on the impact of each characteristic which can augment the current more practical findings and lead to more systematic design decisions. Second, we did not explore various content types and we believe that there is a lot of opportunity in exploring the influence of content type on users' guidance mechanisms preferences and overall experience (e.g., entertainment vs. educational).

6 Conclusion

In this paper we presented a within-subjects user study in which we compared the effectiveness of virtual animals as diegetic attention guidance mechanisms and the role of acknowledging behavior on participants' experience in 360-degree experiences. Our results indicate that diegetic mechanisms can positively influence participants' quality of user experience and effectively guide them towards target events. Additionally, the inclusion of acknowledging behaviors resulted in a higher sense of presence with participants preferring the diegetic acknowledging mechanism. A qualitative analysis of our participants' post-study interview responses further revealed three main themes influencing participants' preferences: blending in, acknowledging behaviors, and positive associations.

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