FACILITATING PARTICIPATION IN ADULTS WITH AND WITHOUT VISION LOSS BY SUPPORTING EXHIBIT MOTIVATIONS THROUGH REAL-TIME DESCRIPTIVE MEDIATION

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FACILITATING PARTICIPATION IN ADULTS WITH AND WITHOUT VISION LOSS BY SUPPORTING EXHIBIT MOTIVATIONS THROUGH REAL-TIME DESCRIPTIVE MEDIATION

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DEDICATION

To the little girl who has successfully invaded my life and heart.

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This dissertation has been a challenging and rewarding process. Of course, I made it more difficult than it needed to be as a way of making it the hard-to-attain goal I always thought it was. This was the journey that I created, with all kinds of twists and turns, and prolongation. Now at the end of this journey, I have to gratefully acknowledge a number of people who braved the years with me. Beginning with David and Sophia. There are too many things that you both have dealt with and forgiven knowing that I needed to do this. I am not sure that I could ever explain how necessary this support was. Next, to my parents, who have never been big on pushing me towards anything, yet whose approval I expected and received. To Jon, you always knew you were a mentor because I anointed you, but I am still trying to convince you that you must have learned something from me after all this time. Bruce, you done good by being a listener, encouraging me to think, and bringing me down from the top of stress mountain. My friends in the HCC program, especially Betsy DiSalvo and Tae-Jun Yun. The Walkers and McDonalds, who are amazing neighbors with wonderfully positive outlooks on life and who gave me access to the woods, lake, and field for pondering all the information in my head. All of the people I have worked with over the years from the Georgia Aquarium, I know that you believe in this work. Special thanks to the research participants, Center for the Visually Impaired, Georgia Industries for the Blind, and many other aquariums, museums, science centers, and zoos. Thank you to the Accessible Aquarium team members near and far who helped shape this work through prototypes, discussions, demonstrations, evaluations, and everything else. And, many other people that played equally important roles despite not being mentioned by name. I did it.

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SUMMARY

Aquariums are unique community settings where people can participate in various exhibit-related activities intended to support *learning, entertainment, social,* and *restoration* motivations such as watching moving animals and talking to other visitors about what's going on in the exhibit [1-3]. However, visitors with vision loss have significant difficulty knowing what is on display and understanding the movement that is occurring in live exhibits [4, 5]. Existing exhibit mediation systems, such as docent presentations or audio tours, that could enable or enhance participation for visitors with vision loss do not adequately describe animal and habitat information in real-time for these visitors. Consequently, visitors with vision loss are seldom able to participate by addressing their learning, entertainment, social, and restoration motivations at live aquarium exhibits.

In my dissertation, I designed and evaluated real-time descriptive mediation (RTDM) for live aquarium exhibits that can facilitate participation of adults with and without vision loss through support for learning, entertainment, social, and restoration motivations at exhibits. This RTDM was evaluated by adults with and without vision loss and compared to traditional sound-based mediation (e.g., audio tour and docent presentation). The specific aims of this empirical work were to: 1) develop information design criteria for mediation that conveys real-time and descriptive details of an exhibit's visual scene to address participation-based exhibit motivations of adults with and without vision loss; 2) implement the information design criteria as speech-based, real-time descriptive mediation (RTDM) that supports participation-based exhibit motivations of adults with and without vision loss; and 3) evaluate the RTDM and compare it to

traditional exhibit mediation (i.e., docent presentation and asynchronous audio tour) to determine its impact on participation-based motivations in adults with and without vision loss. The main contributions of this work are in: 1) generating evidence-based information design criteria for mediation at live animal exhibits; 2) demonstrating feasibility of RTDM as a support for exhibit motivations and facilitator of participation for adults with and without vision loss; and 3) operationalized and validated participation as a design goal. The findings from this work show that the RTDM system was supportive of learning, entertainment, social, and restoration motivations in a majority of adult participants with and without vision loss. Compared to representative audio tour and docent mediation, the RTDM system was perceived to be more effective at supporting learning, social, and restoration motivations for most participants. Entertainment motivations, while adequately addressed by the RTDM, were reportedly better supported by traditional docent mediation. The real-time and descriptive design features were the intended and direct methods of support for exhibit motivations and largely confirmed as beneficial by participants with and without vision loss. The findings also revealed that the RTDM enabled equitable exhibit access which made it possible for participants to address their exhibit motivations and led to specific personal and social aspects of participation. These aspects include: *personal understanding of the exhibit; sharing the exhibit experience; independence*; and *belongingness.* The results of this study directly link design features and their impacts on exhibit motivations to participation.

CHAPTER 1

INTRODUCTION

Aquariums are unique community settings where visitor participation is supported through experiences that address *learning*, *entertainment*, *restorative*, and *social* motivations such as viewing a wall of colorful fish and talking to other visitors about what's going on in an exhibit [1-3]. Addressing these participation-based motivations at live exhibits often depends on the visitor's ability to see the habitat and observe animal behaviors and locations. However, consistent with the World Health Organization's International Classification of Functioning, Disability and Health (ICF) model [6], simply providing sensory access (i.e., vision and auditory) to exhibit-related activities, such as viewing live animals, only provides an opportunity for participation, but does not guarantee it. Impaired access to exhibit-related activities, such as a person with vision loss would experience at a visual display of live animals, results in problems fulfilling exhibit motivations and barriers to participation.

Despite legislation and technological advances, visitors with vision loss have the lowest level of exhibit accessibility [7], including difficulty locating an exhibit, knowing what is on display, and understanding the movement that is occurring in live exhibits [4, 5]. Thus, it is difficult (if not impossible) for these visitors to address exhibit motivations and consequently, their participation is restricted without effective exhibit mediation. However, traditional exhibit mediation strategies, such as docent presentations and asynchronous audio tours, do not adequately convey the real-time and descriptive details about animals and their habitats for visitors with vision loss. **This work examines the effects of real-time descriptive mediation designed to facilitate participation by**

supporting learning, entertainment, social, and restoration motivations in adults with and without vision loss.

For the 25 million adults with vision loss in the United States [8], participation by addressing learning, entertainment, social, and restoration needs is significantly impaired at live aquarium exhibits due to the overwhelming emphasis on the visual experience and conveyance of information primarily through visual methods such as animals in tanks and text-based signs. Existing information strategies, such as docent presentations or audio tours, that mediate the exhibit experience by discussing animals facts provide auditory information relevant to the visual scene, but typically do not adequately describe exhibit details in real-time for visitors with vision loss to provide effective access or support participation. Furthermore, partners without vision impairment may provide description of the exhibit to compensate for inadequate or nonexistent auditory information strategies offered at an exhibit. Unfortunately, most partners are unfamiliar with the specialized details of an exhibit, not trained to describe effectively, and likely unaware of the need to address motivations other than learning. Support for participation should enable visitors with vision loss to successfully address their visit goals; whether it be learning animal facts, visualizing animal movements, relaxing after a tough week, or reminiscing with their partner about a similar experience.

During the past several decades there have been numerous efforts by various entities including the U.S. Federal Government [9-11], Smithsonian [12], National Endowment for the Arts [13], and American Association of Museums (AAM) [14] to promote improved exhibit accessibility for individuals with disabilities, including those with vision loss. However, none of these efforts has directly addressed access to live

aquarium exhibits for visitors with vision loss—a necessity for providing the opportunity to participate. Furthermore, although participation is explicitly mentioned as an outcome in legislation, guidelines, and resources relevant to exhibit accessibility [9-11, 13, 15, 16], it has not been consistently defined or adequately operationalized to inform design of exhibits or improve exhibit evaluation. This lack of guidance on developing specific participation constructs makes it difficult to effectively design exhibits that facilitate participation by all visitors, including those with vision loss. More importantly, there is no advisement on designing exhibit mediation systems, such as audio tours or docent presentations that could support participation of visitors with vision loss by enabling them to meet their learning, entertainment, restorative, and social goals.

An insufficient understanding and application of participation as the outcome of an aquarium visit for individuals with vision loss has led to the design of exhibit mediation systems that inadequately compensate for access barriers. In fact, mediation systems, such as audio tours and docent presentations, that augment the exhibit experience for sighted visitors are designed based on the assumption that the visitor can see the artifacts or animals being discussed. Yet, these are the systems that are frequently used to create an "accessible" experience for visitors with vision loss. Moreover, research and development on audio tours has largely been directed at providing information on stationary displays such as framed art, sculptures, or artifacts and primarily focused on the system hardware and software, with little mention of effective content design [17-21]. For live displays with dynamic information, such as an aquarium exhibit, pre-recorded audio tours cannot convey or translate the real-time dynamics of the visual scene. Conversely, docent presentations do occur in real-time, but are fundamentally less

descriptive as they are designed to supplement the visual scene that the audience can see. **To more effectively support the exhibit motivations and participation of visitors with vision loss at live aquarium exhibits, a mediation system should provide a comprehensive description of the visual scene and convey associated exhibit facts in real-time.**

1.1 Thesis and Research Questions

Perhaps the most significant limitation of the majority of accessibility efforts in the exhibit design field, particularly for visitors with vision loss, is the emphasis on practices that have little to no empirical evidence base. Central to this issue is the limited conceptual understanding of the relationship between the exhibit and a visitor as a basis for designing to facilitate participation. For example, what are the interaction issues for live aquarium exhibits and visitors with vision loss? There is an obligation for exhibit designers to recognize and manage these visitor-exhibit (V-E) interaction issues that impact participation and create an experience that meets learning, entertainment, social, and restoration needs of all visitors. By operationalizing the construct of participation for visitors with vision loss in the context of live aquarium exhibits, a more sophisticated framework from which to base design and evaluation criteria for mediation at live aquarium exhibits can be developed. Further, by designing and evaluating real-time descriptive mediation with visitors who have vision loss and their familiar adult partners, it will be possible to inform the design of future mediation that facilitates visitor participation regardless of visual ability. The central question that motivates my research is**:**

What are the information design criteria of a mediation system for live aquarium exhibits that facilitates participation in adults with and without vision loss?

This work addresses my central research question by demonstrating the following: *"Speech-based mediation that incorporates real-time and descriptive design features for conveying visual scene information at live aquarium exhibits will facilitate participation of adults with and without vision loss by supporting their learning, entertainment, social, and restoration motivations."*

This work is also a portion of a larger program of research that links participation to exhibit design. As the concept of participation is operationalized in the context of live aquarium exhibits, a new understanding of the experience of visitors with vision loss has emerged and shaped ongoing development of real-time descriptive mediation for dynamic visual scenes. In order to evaluate my thesis statement, the following research questions were addressed through this work:

RQ1. What are the effects of conveying static descriptive details about the visible physical characteristics of animals and habitat elements in live aquarium exhibits intended to support exhibit motivations (i.e., learning, entertainment, social, and restoration) in adults with and without vision loss?

RQ2. What are the effects of conveying dynamic real-time characteristics (e.g., animal location and swimming behaviors) of live aquarium exhibits intended to support exhibit motivations (i.e., learning, entertainment, social, and restoration) in adults with and without vision loss?

RQ3. How does real-time descriptive mediation (RTDM) compare to typical sound-based mediation (i.e., asynchronous audio tour and docent presentation) for supporting exhibit motivations (i.e., learning, entertainment, social, and restoration) in adults with and without vision loss?

1.1.1 Research Question 1:

What are the effects of conveying static descriptive details about the visible physical characteristics of animals and habitat elements in live aquarium exhibits intended to support exhibit motivations (i.e., learning, entertainment, social, and restoration) in adults with and without vision loss?

Hypothesis 1.1. Conveying descriptive details will support the exhibit motivations of adults with and without vision loss by giving them a more robust understanding of the static components of the exhibit's visual scene; they will be better informed about visible details such as size, shape, length, color, and quantity.

Hypothesis 1.2. Detailed description of the visual scene will support the creation of more visually detailed mental imagery.

Hypothesis 1.3. Added description of visual details will complement and supplement what participants are able to see in the visual scene.

1.1.2 Research Question 2:

What are the effects of conveying dynamic real-time characteristics (e.g., animal location and swimming behaviors) of live aquarium exhibits intended to support exhibit motivations (i.e., learning, entertainment, social, and restoration) in adults with and without vision loss?

Hypothesis 2.1. Conveying information that is synchronous with the visual scene will support exhibit motivations of adults with and without vision loss by giving them a more robust understanding of the dynamic components of the exhibit's visual scene; they will be better informed about dynamic details such as location, direction of travel, and swimming behaviors that are related to exhibit dynamics.

Hypothesis 2.2. Real-time details about the visual scene will support the creation of mental imagery that incorporate location, direction of travel, and swimming behaviors

Hypothesis 2.3. Added description of real-time details will complement and supplement what participants are able to see in the visual scene as well as help direct their attention to what is being referenced.

1.1.3 Research Question 3:

How does RTDM compare to typical sound-based mediation (i.e., asynchronous audio tour and docent presentation) for supporting exhibit motivations (i.e., learning, entertainment, social, and restoration) in adults with vision loss and their adult partners without vision loss?

Hypothesis 3.1. RTDM will be more effective at supporting exhibit motivations and facilitating participation for adults with and without vision loss because it provides more specific and comprehensive information about real-time (e.g., dynamic) and descriptive (e.g., static) components of the exhibit's visual scene compared to typical sound-based mediation.

1.2 Contributions

The empirical work conducted through this dissertation intended to: 1) develop information design criteria for mediation that conveys real-time and descriptive details of an exhibit's visual scene to address participation-based exhibit motivations of adults with and without vision loss; 2) implement the information design criteria as speech-based, real-time descriptive mediation (RTDM) that supports participation-based exhibit motivations of adults with and without vision loss; and 3) evaluate the RTDM and compare it to traditional exhibit mediation (i.e., docent presentation and asynchronous audio tour) to determine its impact on participation-based motivations in adults with and without vision loss.

The task of building a real-time mediation system was part of a larger research effort, the Accessible Aquarium Project at Georgia Tech. The system is based on a computer vision technology that continuously detects animals in an exhibit, identifies the particular species, and assigns information, such as spoken description, for delivery to end-users. This real-time mediation system is also capable of delivering musical interpretations to aquarium visitors based on the real-time activity of the exhibit. However, this dissertation work does not directly address the design and delivery of musical mediation, but instead suggests a relevant and effective process for designing and evaluating sound-based mediation with adults who may have vision loss.

It is recognized that descriptive mediation is a complex combination of content, voice, and temporal aspects of information as well as heavily dependent upon the user interface and transmission protocols. These are all extremely challenging, yet important pieces of the puzzle in developing a successful mediation system. It is expected that user

interfaces and transmission protocols will vary across institutions and evolve quite rapidly in the next few years, making it less fruitful to develop a particular device that can be deployed later. In regards to the information, voice and temporal aspects are important to the user and do require research attention. However, in order to satisfactorily inform these areas, more extensive work on speech perception should be completed that was not within the scope of this current work.

The main contributions of this work are in: 1) generating evidence-based information design criteria for mediation at live animal exhibits; 2) demonstrating feasibility of RTDM as a support for exhibit motivations and facilitator of participation for adults with and without vision loss; and 3) operationalized and validated participation as a design goal.

1.3 Document Overview

This introduction gave a brief overview of the motivation for this work and presented the thesis, research questions, and contributions of the research. **Chapter 2** describes related work dealing with access and participation in aquariums, including visitor-exhibit (V-E) interaction models that can be used to inform design processes and products. **Chapter 3** provides an overview of the completed work that guided the development of this dissertation. **Chapters 4 and 5** explain the development and evaluation of RTDM. **Chapter 6** presents the results of the evaluation of RTDM in comparison to typical sound-based mediation (e.g., docent presentation and audio tour). **Chapter 7** discusses the findings from this research in terms of the relationship among mediation design features, equitable exhibit access, and specific personal and social

aspects of participation. Future work is also mentioned in this chapter. **Chapter 8** concludes this dissertation by describing successful contributions that resulted from the systematic design and evaluation activities of this work.

CHAPTER 2

BACKGROUND AND RELATED WORK

In this chapter, I review the access and participation issues that are common in aquariums and other informal learning environments (ILEs) for visitors with vision loss. I also discuss the potential for exhibit mediation to enable and enhance the exhibit experience for individuals with vision loss and describe the insufficiencies with current mediation systems. Next, I summarize the literature from the ILE field that can inform the operationalization of participation in the aquarium context. While this summary does not provide an exact taxonomy of participation, key aspects (learning, entertainment, restoration, and social) of visitor-exhibit (V-E) interaction that are relevant to participation are examined. Further, I provide an overview of several V-E interaction models, including the Bruce and Walker [22] framework that makes mediation an explicit component of the V-E interaction.

2.1 Aquarium Access and Participation

Aquariums, as informal learning environments (ILEs), are designed to support free-choice learning through semi-structured visitor-exhibit (V-E) interactions. Exhibits are designed to attract visitors and provide opportunities for them to engage in learning, entertainment, restorative, and social goals. The focus is on watching animals that have diverse physical characteristics and behaviors. Visual features and attributes of exhibits such as movement, lighting, shapes, color, and contrast are part of the experience. This primary emphasis on the visual experience through living, moving exhibits creates

significant access barriers and participation restrictions for visitors with vision loss. These visitors have difficulty addressing their learning, entertainment, restorative, and social goals in these settings and are unable to fully participate.

Participation as an outcome of V-E interaction at aquarium exhibits requires more than simply getting in the door, moving around the space, and looking at displays. Historically, physical and information barriers in ILEs have been addressed through accessible design efforts mandated by legal requirements enacted by the Americans with Disabilities Act (ADA), Architectural Barriers Act (ABA), and Section 504 of the Rehabilitation Act for making public accommodations. For visitors with vision loss, exhibit design considerations in the current standards and guidelines focus primarily on increasing visual aspects of exhibits including labels, lighting, signage, and contrast. In addition, field-developed guidelines do consider tactile and audio components as mediation strategies for conveying exhibit content for visitors with more significant vision loss [13, 14, 23], but they do not provide specific design recommendations that could guide an ILE professional in developing exhibit materials. Thus, mediation that could relay vital exhibit content to visitors is often created with limited guidance towards enabling access or facilitating participation.

2.1.1 Tactile-Based Mediation

Despite a lack of evidence-based practice or guidance on mediation design for visitors with vision loss, exhibit designers develop and use tactile and sound-based mediation to provide access to visitors with vision loss. In the case of tactile mediation, visitors can touch replicas, models, or actual artifacts in an effort to build a mental model or imagery of exhibit contents. It is easier to do this when the exhibit contents are static

or move very little and the primary benefit is to get a sense of characteristics that can be felt such as shape, texture, size, and temperature. Some aquariums provide touchable access through artifacts such as animal bones or pelts as well as through live animal encounters. However, not all exhibit contents can be handled due to their delicate or rare nature, visitor safety or health issues, and costs associated with creation or maintenance. Furthermore, it can be difficult to convey size or make size comparisons through scaled representations of animals or habitats. While a live animal encounter can enable a visitor with vision loss to explore the "real thing", not everyone may be comfortable touching a living animal and there is some controversy about animal health and well-being when they are involved in interactive exhibits [24].

2.1.2 Tactile with Recorded Sound-Based Mediation

Beyond the considerations discussed above, tactile mediation may have little benefit when the touch experience is not accompanied by text or spoken information that identifies what is being touched. Quite often, tactile mediation requires that a visitor with vision loss be dependent on someone else to tell them what he/she is touching. A few exceptions to this issue include the talking maps developed by Landau [25] to assist visitors with vision loss in exhibit wayfinding at ILEs, the talking fish sculptures work carried out by Fuller and Watkins [26] at the North Carolina Aquarium at Pine Knoll Shores (see Figure 1), and an interactive dolphin statue created in association with this dissertation (see Figure 2). While those projects combined tactile and sound-based mediation, the latter two were more relevant to the current work given their focus on aquarium exhibit mediation. The talking fish sculptures were created through a grant-funded project to develop guidelines for the design and fabrication of tactile exhibits with

Figure 1. Talking Fish Sculpture by Fuller and Watkins.

Figure 2. The Georgia Tech Interactive Dolphin Sculpture.

an audio component (see Figure 1). The fish sculptures were fabricated to scale and their tactile features were designed through an empirical study with individuals with vision loss. The sculptures were mounted near related live displays, yet considered to be the core of the exhibit. Each fish had its own sound-based mediation track that could be activated by touching the sculpture. The sound-based mediation guided the visitor in feeling the features of the sculpture and provided basic feature descriptions and animal facts. This system of mediation was innovative for providing improved access and possibly enhancing participation in aquarium settings for visitors with vision loss. However, they were static representations of animals and only provided one loop of recorded information. Although these sculptures gave more specific details about the

physical appearance of an animal, they did not talk about animal movement and had a limited message repertoire.

The interactive dolphin statue was inspired by the talking fish work and developed through a joint project among students, the Georgia Aquarium, a local artist, and the Georgia Radio Reading Service (see Figure 2). The statue was donated by the Georgia Aquarium and, while it was not a full-scale replica of an adult dolphin, it did represent the main features of a dolphin. It was modified to include touch-activated sensors that triggered recorded messages about dolphins. The system design was informed by and informally evaluated with members of the local community who had vision impairment. Similar to the talking fish sculptures, the dolphin statue was intended as a static, stand-alone exhibit. It was an important step in understanding the value of sound-based mediation for aquarium exhibits because people with vision impairment gave input about the information they wanted to know. However, since it was a static sculpture conveying static animal facts, it could not convey the real-time and dynamic features of live exhibits and provided little guidance towards designing for those features.

2.1.3 Recorded Sound-Based Mediation

Audio technologies have been used as mediation in ILEs for over 50 years to provide basic access to visitors with vision loss [20]. These technologies range from simple talking buttons to wayfinding beacons that help a visitor with vision loss get from one exhibit to the another [27]. While audio technologies are mentioned in the accessibility guidelines and resources from the field, there is a lack of empirically-based information that would help an ILE professional in understanding when audio information is appropriate, what form it should take, and what the content should sound

like. Consequently, there is a broad range of practices relative to audio technologies not based on any formal evidence.

Audio tours, as a type of audio technology, have become more popular with the growth in cell phone use and the advent of MP3 and podcasting technologies, making it much easier for facilities to develop their own tours. Audio tours can be structured to provide a range of description depth from a repeat of label copy or sign content to a listener-controlled branching of seemingly endless information. However, audio tours are asynchronous in that they are generally limited to pre-produced narration of exhibit signage or explanations of fixed artifacts through recorded information and cannot be used for interpreting the real-time activities of live aquarium exhibits.

Although non-specialized audio tours designed for the general visitor population are not typically effective at meeting the needs of people with vision loss, a considerable amount of research has been conducted on their development and use. The majority of the related literature does not address visitors with vision loss, aquariums, or live exhibits as the context of interest or as potential research space to be explored. However, the literature contains valuable information about the impact of mediating technologies on attention [28], meaning-making [29], social interactions [18, 30], and other outcomes that are related to participation.

One of the more compelling pieces of literature reports on a study of mediating device properties and visitor attention to the source of mediation, their companions, and the exhibit environment. Woodruff and colleagues [28] found that visitors appropriated the technology, successfully navigating the physical and social environment through a mediated experience. The visitors were able to use the technology to share the

experience with their partners and preferred the audio feature to enable visitors to listen to the information together or eavesdrop on their partner's mediation. This research finding is evidence that a mediating technology can enable and enhance a shared context between visitors, perhaps making it much easier to discuss artifacts or events together and leading to increased participation. The researchers also discussed supporting conversation as a way to facilitate learning and suggested that the mediation content can be specifically designed to structure and reinforce social interaction. This point is significant as it highlights the need to 'design' content for particular purposes (e.g., conversational structure) and perhaps, specific needs (e.g., conveying information about the visual scene in a way to support social interactions).

2.1.4 Live Sound-Based Mediation

The traditional approach to real-time information delivery in ILEs is through interpretive staff members or volunteers who commentate as activity happens in the exhibit. They are able to provide both "canned" facts about the exhibit contents (e.g., the average size and lifespan of a species such as hammerhead sharks) as well as just-in-time information about animal movements and behaviors (e.g., an explanation of why that hammerhead shark seems to be leaning to one side as it swims past the viewing window). These individuals are not likely to be trained to provide interpretation that meets the needs of visitors who have vision loss as it has been reported that docents often lack even the more general training on pedagogy, learning theory and communication skills [31]. While they may be able to discuss exhibit activities in a way that most people understand, these descriptions are based on the visitor being able to see the same thing the docent is seeing. For example, locational information may often be presented in ways that rely on

the visitor being able to see, using basic deictic words like, “over there” and “here comes…”. For visitors with vision loss, this style of interpretation does not convey the salient characteristics in a way that makes the dynamics of the exhibit understandable. For example, these visitors need more explicit orientational and expanded contextual information such as, “now slowly entering our viewing area from the left” or “at the right side of the tank, up near the water surface”.

2.1.5 Audio Description in Recorded and Live Sound-Based Mediation

For over 30 years, audio description (AD) has been used in describing live theater performances, television programs, movies, museums, and outdoor venues for people with vision impairment [32, 33]. Descriptions can be vivid aural representations of visual characteristics such as colors, facial expressions, movements, and textures. Audio describers are trained to provide verbal accounts of the visual scene through formal techniques, yet they are rarely used in the design or delivery of exhibit mediation. When they are consulted, their input is typically given in the design of recorded sound-based mediation. Generally, audio describers do not have the domain-specific knowledge about aquarium animals and habitats that is required to comprehensively describe an exhibit in a live sound-based format.

Although AD has been shown to be effective in conveying visual information to people watching television programs and film [34, 35], there is very little empirical evidence on the design of audio description which makes it difficult to translate existing processes to a dynamic setting or event [36]. Guidelines for description have been developed through multiple organizations [37-39], but there is not a set of standards from an accrediting body responsible for description practices. Evidence of the practice-based

origin of these description resources can be seen in how one particular organization, the Audio Description Coalition, refers to their standards and code of conduct for describers as representing the "training and experience of audio describers and trainers from across the United States" [39]. Despite the lack of research in existing guidelines, common AD practices could be useful as a baseline for what to describe in a live aquarium exhibit and how best to describe it.

2.1.6 Limitations of Existing Sound-Based Mediation

Sound-based mediation such as audio tours and docent presentations can transform visual displays into perhaps more accessible auditory displays of information and potentially impact participation by visitors with vision loss. However, there is a lack of research-based design on meeting the needs of visitors with vision loss who are unable to see what is being referenced, often benefit from more specific descriptions, and may have preferences that differ from visitors without vision loss. Additionally, these existing methods do not adequately describe the real-time dynamic movements of individual animals, groups of animals, or an entire exhibit for visitors with vision loss [40]. Audio description that effectively conveys visual information to individuals with vision loss could be useful, but is not well-researched and rarely applied in aquarium mediation. Thus, the commonly used sound-based mediation techniques discussed here (recorded and live) cannot adequately support V-E interaction or, more importantly, facilitate participation of visitors with vision loss at live aquarium exhibits.

2.2 Informal Learning Environment Research Related to Participation

The term 'participation' is used in various ways in the ILE field, resulting in a diverse spectrum of definitions and characterizations. In some instances, participation means being able to afford going or to get to the institution [41] (p. 154), whereas in others it means being able interact with the exhibit [42]. Recently, Simon [43] described participation in ILEs as the basis of attempting to make "cultural institutions more dynamic, relevant, essential places" and a representation of the potential for co-created content among visitors and institutions. In this view, the ILE is seen as more than just a physical *space*; it is instead, a *place* where people can actively participate by collaborating with the ILE in constructing their experience. While it is commonly accepted that V-E interaction is the core of the exhibit experience, there is limited research that adequately characterizes participation and situates it as the primary outcome of the interaction.

Participation has been used interchangeably with interactivity and discussed as a social experience by some researchers in the ILE field [44-46]. This representation of participation brings it closer to being perceived as the outcome of V-E interaction, but does not provide explicit constructs related to visitor needs that could be useful in guiding exhibit design and evaluation. Other researchers have investigated visitors' learning, entertainment, restorative, and social goals which could be operationalized as participation, [1-3, 47], but have done so primarily as a means to more fully understand and design for learning.

A survey completed by the Association of Zoos and Aquariums and several other research partners [48] revealed that the top three reasons people visit aquariums are to see

animals, do something fun or enjoyable, and spend time with friends and family. Similarly, Falk and colleagues have discussed grouping visitors according to identity-related factors that closely parallel learning, entertainment, restorative, and social themes [49]. Packer's work specifically outlines learning, entertainment, restorative, and social goals as components that comprise motivational factors and help shape the ILE visit [2, 47, 50, 51].

In the informal science domain, visitor participation is frequently discussed in terms of involvement in the learning and "doing" of science. A report by the Center for the Advancement of Informal Science Education (CAISE) discussed how public participation in scientific research can increase scientific literacy among a wide range of people, including those who aren't typically interested in science-related activities [52]. They implicitly refer to participation as members of the public conducting scientific activities through contributory, collaborative, or co-created projects. Mentions of citizen science, community science, participatory action research, and volunteer monitoring further emphasize the performance of scientific work as a conduit for scientific understanding.

These various findings demonstrate that visitors' goals have an important influence on V-E interaction and should be acknowledged when designing and evaluating exhibit experiences. Additionally, these goals represent expected outcomes of the visit, much like participation is represented as the outcome of P-E interaction in the ICF model. Consequently, it is worth examining whether we can capitalize on this existing research and operationalize participation in the aquarium context through learning, entertainment, restorative, and social themes.

2.2.1 Learning as a Participation Construct

Historically, learning has been the most sought after outcome in ILEs and has been highlighted as a key process and product of the V-E interaction. While learning may not be the primary motivation for an ILE visit and is certainly not the only reason people go to ILEs, a considerable amount of research has been conducted in this area. Recent theory and practice advances in formal and informal educational settings have encouraged a deeper understanding of the factors that influence learning and diversity of learning evidence. However, this wealth of information has created some utility issues. As Leinhardt and Crowley [53] point out, learning is variably defined and examined among researchers, causing significant inconsistencies in outcome-driven research and practice. Despite these concerns, an appreciation of the way that learning is modeled and studied can help situate participation as a more comprehensive outcome that is useful to the ILE context for explaining V-E interactions.

Informal learning environment professionals draw on various resources to understand learning as an outcome of V-E interactions [47, 53-55]. One of the most comprehensive references of V-E interaction from the field is Falk and Dierking's *Conceptual Model of Learning* [56]. This model does not mention participation as a process or product of V-E interaction, but instead, describes learning in ILEs as an implied form of participation. Through this model, the authors acknowledge the complex nature of learning and posit that learning occurs as a result of an individual attempting to partake in contextual meaning-making. They attribute the V-E interaction to the association among personal, sociocultural, and physical contexts. These contexts are

susceptible to change over time and include 12 factors (denoted in italics in the following text) that are reportedly influential for learning in museums.

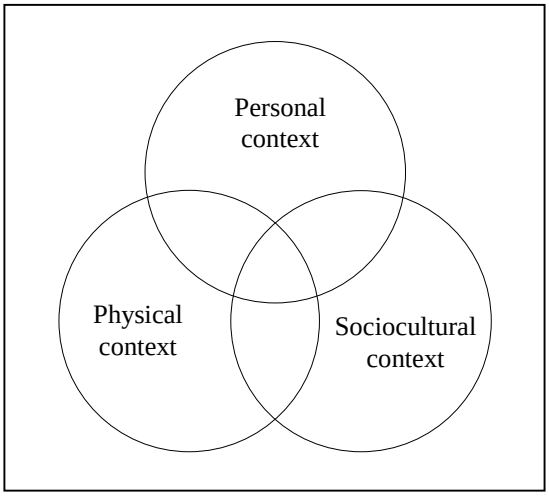


Figure 3. Intersecting Factors from the Contextual Model of Learning.

The Personal context (see Figure 3) is largely based on what the individual brings to the situation in terms of *motivation*, *interest*, *knowledge*, and *experience*. The authors suggest that these factors are to some degree based on innate characteristics, but are generally unique to each individual and each situation. Additionally, a person's ability to make *choices and control* her learning is another personal factor that impacts learning.

The Sociocultural context incorporates both *within-group social mediation* and *outside-of-group social mediation*. These concepts include not only the appreciation of free-choice learning, but also the cultural importance of museums to individuals and society. The importance of these factors lies in the concept of mediation, which highlights the value of the interactions that visitors have with one another or with educational staff when participating in learning experiences.

The Physical context is represented by a broad set of factors that consist of layout and constitution issues such as *architectural and large-scale environment, advance organizers, orientation to the physical space,* and *design and exposure to exhibits and programs.* The architectural factors refer to the features and attributes of the space such as the colors, sounds, and ambient conditions such as lighting and noise. The advance organizers and orientation describe the properties of the setting that help people familiarize themselves with the space and understand what to expect. For example, summaries of an exhibit that visitors receive ahead of time can be a form of advance organizer and maps or signage can serve to facilitate orientation. On a smaller scale, design and exposure to exhibits addresses the features and attributes of the exhibit itself including the display cases, shape and size of interactives, and type of artifact. Physical context also deals with the larger infrastructure for learning that exists beyond the museum walls and is known as the *subsequent reinforcing events and experiences outside of the museum.*

The authors and others [55] have acknowledged that this model is still a work in progress and often refer to it as a framework, rather than a full-fledged model, that has helped clarify some of the relationships among the contextual factors that can influence learning. Falk and Storksdieck [55] have attempted to design measures related to the key factors identified in the model and recognized that assessing learning through the model is complicated and not all-inclusive. They suggested that visitor learning is closely tied to "dimensions" of contextual factors. Although they make this point, they only apply it to segmenting visitors into specific subsamples (e.g., people with certain prior experiences or interests). They do not mention the potential importance of defining the

dimensions (or characteristics) of other factors including those that are ability-related (e.g., vision impairment) or exhibit-specific (e.g., the static or dynamic elements). This is not a deficiency of their work or the model, *per se*, but it points to the need to appreciate the effect of more precisely defining person and environment characteristics when assessing learning and participation.

Falk and Dierking's Conceptual Model of Learning [56] establishes the basis for investigating contextual factors that influence learning in museums and suggests that an attentiveness to these factors can lead to a better understanding of learning in museums and other informal learning settings such as aquariums. However, while the interaction of these factors provides a conceptual basis for improved exhibit design, the model does not link specific environmental or personal attributes to performance outcomes. Furthermore, although it addresses a wide range of personal factors that have been shown to affect learning, it ignores functional ability and its potential to impact learning. As a result, it does not provide explicit guidance for investigating visitor-exhibit interactions or directing participation-driven design relevant to visitors with vision loss.

2.2.2 Entertainment, Restoration, and Social Themes as Participation Constructs

The other potentially useful constructs for investigating participation—entertainment, restoration, and social interaction—are often subsumed as factors that can facilitate learning. However, Packer and Ballyntine [50] reported evidence from the field [57, 58] that people visit ILEs for "entertainment, social or restorative experiences as well as, or in preference to, a learning experience" and that "learning is no more than an optional extra" (p. 55). The research related to these non-educational themes

demonstrates a need to explore how these areas can be studied and how they contribute to participation.

For entertainment, ILE professionals have recognized the value of entertaining visitors as a way to attract their attention, even comparing their settings to other "entertainment venues" such as theme parks [59]. Some researchers have even used the term "edutainment" to describe their outcomes [60]. Moore [61] highlighted the importance of entertainment to learning saying, "you have to reach them to preach to them" and then suggested that there is often an imbalance between the two when he said, "many museums are stimulating a lot and educating little" (p. 17). Packer [2] also discussed entertainment as a potential personal goal for an ILE visit and defined it as "stimulation, novelty, escape from boredom" (p. 48). Visitors also reportedly perceive that aquarium visits are more entertaining than educational [47], validating that entertainment is an important V-E outcome to consider in studying participation at aquarium exhibits.

Restoration as an outcome of the V-E interaction is the least understood theme as it is an emerging area of inquiry for ILE research and practice. Packer [2] identified restoration as a motivational factor for an ILE visit stating that it represents "rest and relaxation, escape from everyday stress" (p. 48). Additionally, Packer and Bond [51] explored the restorative nature of ILEs more deeply and found that these settings have restorative qualities and benefits that are comparable to natural settings. Aquarium visitors, in particular, rate restoration goals as more important than museum and art gallery visitors [47]. However, it has been acknowledged that more research and theoretical development needs to be done to understand how restorative aspects impact

visitors' well-being and satisfaction during a visit. That extension of work is also necessary to understanding how best to support restoration to improve participation at aquarium exhibits.

Social themes are often linked to learning in the ILE literature and provide a strong basis for exhibit design that promotes interactivity and engagement [e.g., 44, 62, 63]. Collaborative learning, in particular, is a growing area that expresses the social nature of participation at ILE exhibits. Dierking and colleagues [64] have stated that "much of what people learn is mediated through group social interaction" (p. 1), and discussed how knowledge and understanding are constructed through the participants' shared conversation, observations, and past. This association is also apparent in the closely-related meaning making literature that discusses the "process of making sense of experience, of explaining or interpreting the world to ourselves and others" as part of social and learning interactions [65] (p. 12). Moreover, a few researchers have used the term "co-participation" to describe social interactions between visitors and discuss how design of exhibit components can encourage shared experiences [44-46, 63].

Despite the potential for learning, entertainment, restorative, and social goals to be operationalized as participation, they are still largely studied as individual or paired (i.e., learning/entertainment or learning/social) constructs. Although a few researchers [1-3, 47] have considered these four goals together in studying visitor behavior, they have done so only as a means to more fully understand and design for learning. Thus, there is an opportunity to leverage these recognized V-E interaction outcomes in understanding visitor needs and expectations and provide a field-informed means for investigating participation.

2.3 V-E Interaction and Disability

Whereas there are evident contributions from ILE research and practice towards an understanding of participation, the literature does not provide much information about how the needs of visitors with impairments are addressed. Reich and colleagues [66] discuss this omission in a comprehensive account of the state of practice in informal science education related to inclusion of people with disabilities. They target deficiencies in the way ILE experiences are designed, knowledge and attitudes of ILE professionals regarding inclusion, and how inclusion is generally characterized. They point out that there is a significant shortage of evidence-based work that is devoted to disability and inclusion. Further, their report highlights the lack of investigation into the potentially rich social interactions of groups that have a member with a disability and how that can impact the value of shared mediated exhibit experiences.

Design guidance, such as the ADA Accessibility Guidelines (ADAAG) [67], that could assist exhibit designers in minimizing V-E interaction barriers due to functional impairments is predominantly focused on overcoming performance issues such as physically moving around the exhibit or reading signs. However, these guidelines and others [9-11, 13, 15, 16] were not developed to provide sufficient detail for considering visitors' participation goals as design objectives. Thus, the primary resources that could guide exhibit designers in enabling positive exhibit experiences for visitors with impairments merely promote access through performance-based design objectives and do not provide participation-based criteria that support achievement of visit goals. As a result, there is an insufficient understanding of how to design to enable visitors with impairments, such as vision loss, to participate at exhibits by addressing their visit goals.

Without effective guidance from the field-relevant resources, it is useful to look to other fields that have examined person-environment (P-E) interaction and stress the importance of context to activity performance and participation. There are numerous models of P-E interaction that describe this contextual dependence, particularly in the fields of health and rehabilitation [6, 68-76], assistive technology [77], psychology [9, 12, 78], human factors [79], and museum studies [56]. These models suggest that performance outcomes are situational—the result of the interaction between person and environment factors. As a result, performance is viewed as an expression of the fit or *mis*fit between an individual and the environment. An environment that fits an individual will facilitate activity performance and result in positive participation outcomes. In contrast, an environment that does not fit an individual will result in performance deficits and negative participation outcomes or prevention of participation altogether.

2.3.1 International Classification of Functioning, Disability and Health (ICF)

Among the various P-E models that have been developed over the past three decades, one particular model—the World Health Organization's ICF [80]—is particularly important to investigating visitor participation at aquarium exhibits. The ICF is heavily focused on activity and participation as equally important goals of the P-E interaction and provides a framework for studying and measuring the contextual facilitators and barriers to performance. It also specifically defines participation as *involvement in a life situation*.

The ICF has been used primarily for health information systems evaluation [81-83], design of medical records systems [84], proposing assessments and interventions in rehabilitation [75, 85], and development of surveys for research [86, 87]. However, it

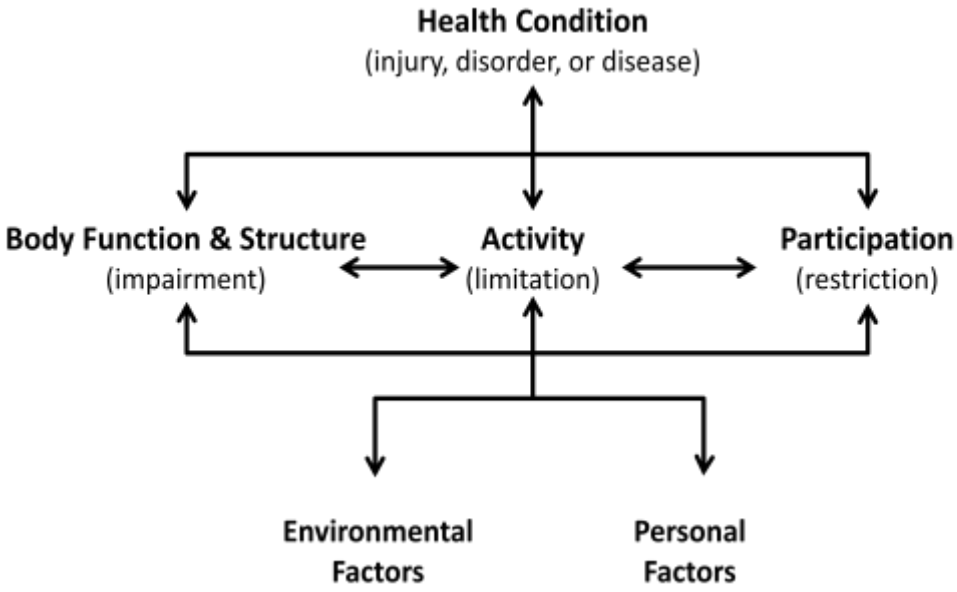


Figure 4. Interactions among ICF Components.

offers a potentially useful framework for understanding the impact of health and function (i.e., person factors) as well as exhibit design (i.e., environment factors) on activity and participation in aquariums. The ICF's taxonomy identifies a number of constructs that represent the essential components of P-E interaction, regardless of setting. These include *body structure*, *body function*, *activities*, *participation*, *environmental factors*, and *personal factors*. Each of these constructs has an associated nested taxonomy. Participation (and activity) is classified at its highest level as: learning and applying knowledge; general tasks and demands; communication; mobility; self-care; interpersonal interactions and relationships; domestic life; major life areas, and community, social, and civic life.

The ICF (see Figure 4) not only provides a model that describes participation as a result of the interaction between the environment and an individual's functional ability, it also recognizes that personal factors are associated with the context and also impact

participation. The environment is described through a taxonomy of features, organized in sequence from the individual's most immediate environment to the general environment, that may either facilitate or create barriers to activity and participation. However, the ICF leaves out certain environmental features that are central to aquarium exhibits such as living and non-living artifacts. Additionally, as Sanford and Bruce [85, 88] discuss, even if these features were included, the ICF limits environmental factors to categorical descriptions of what exists (e.g., a fish), rather than quantifiable, demand-producing attributes (e.g., the 2" long, brown speckled sea horse that is moving from branch to branch looking for food).

In contrast, the ICF doesn't provide a taxonomy for personal factors, but instead suggests that they are comprised of a variety of individual attributes, such as age, gender, education, coping style, and social background. This construct is where visitors' goals would be represented as they are personal factors that are contextually tied to the exhibit experience and interact with other constructs to result in participation. However, the lack of specificity in personal factors that is evident in the other constructs necessitates further work in understanding and employing personal factors as a useful component of V-E interaction.

The ICF's characterization of personal and environmental factors is important because as we investigate participation at exhibits, it is beneficial to examine how these factors interact with visitors' abilities and impact participation. For example, in studying the specific features in aquarium exhibits that are problematic for visitors with vision loss, it is critical to understand that the demands exerted by a particular feature (such as a fish) are not inherent properties of that feature (i.e., common to all fish), but rather, vary

with the attributes (e.g., the size, color, pattern, movement, behavior) of that feature [88]. Perhaps more importantly, visible exhibit dynamics can only be conveyed by describing features according to their attributes and not by simply mentioning the presence or absence of features. Furthermore, when we design exhibit mediation, we must be able to identify the salient features and attributes of the habitat and animals in order to effectively describe them. As a result, the degree to which a visitor with vision loss will be able to experience different aspects of live exhibits will be dependent on our understanding of specific demand-producing attributes that interact with a visitor's vision impairment and ability to effectively reduce those demands.

2.3.2 Limitations of Existing Models and Resources

The models and literature discussed in this section and Section 2.2 have limitations in their functionality to address the dynamic nature of live aquarium exhibits and the context-specific participation needs of visitors with vision loss. Specifically, the ICF and Contextual Model of Learning are V-E interaction models that provide a more comprehensive conceptual overview of the context, but are much broader in scope due to their intended uses. The Contextual Model of Learning contends that it is useful for understanding learning in museums and has been used to investigate visitors' experiences at specific exhibitions (a themed collection of exhibits) and entire institutions [49, 55, 56]. Conversely, the ICF is much more expansive and was designed to be used internationally to measure health and disability across all settings and populations. While both models emphasize the importance of the physical environment on learning and participation, neither scale down acceptably to effectively consider basic perceptual access to exhibit dynamics, identify barriers to accessing exhibit dynamics, provide

enough detail to develop design guidelines for conveying exhibit dynamics through mediating technologies, nor outline contextually-relevant themes for participation.

A more problematic issue with the existing models and resources is that mediation as a component of V-E interaction is not explicitly considered. Mediation, in this context, describes interventions that assist a visitor in engaging in the exhibit experience and can be particularly useful to visitors with impairments who have difficulty experiencing an exhibit in its intended format. For example, visitors with vision loss at live aquarium exhibits may not be able to see animal movements, colors, or shapes, and in some cases, may not be able to see anything at all. Without mediation, such as an audio tour or docent presentation, visitors with vision loss are restricted in their V-E interaction.

2.4 Mediating V-E Interaction

A more robust model of V-E interaction that incorporates mediation is necessary for understanding and providing for basic perceptual access to live exhibits is an essential component of an aquarium visit and should be explicitly addressed to ensure that visitors with vision loss can address their visit goals and participate. Bruce and Walker [22] developed a more precise understanding of V-E interactions that includes visitors with vision loss in aquariums and similar settings. Their framework has been refined and now includes a model of mediated V-E interaction that represents the critical factors that influence access to live exhibits (see Figure 5).

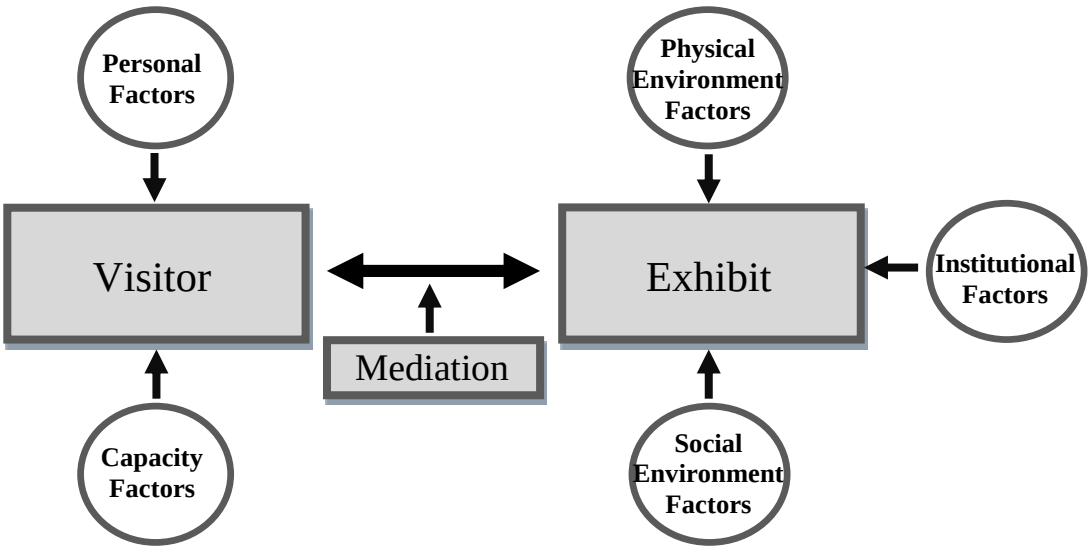


Figure 5. Model of Mediated Visitor-Exhibit Interaction.

Visitor factors are the characteristics that people come with to the ILE. This includes the capacity factors that represent the contextually independent abilities and the personal factors that are contextually relevant.

- *Capacity Factors* incorporate the constructs of body structure, body function, and their associated capacities (i.e., what an individual is capable of). These are the factors that directly interact with environmental factors to determine whether a person can access something or not. Body structures refer to the parts of the body such as the eyes, ears, fingers, arms, and legs; and body functions are the abilities of those structures including seeing, hearing, thinking, speaking, reaching, and walking. Capacities are the related measures of function. For example, seeing can be measured according to capacities such as acuity, depth of field, light sensitivity, and color reception.

- *Personal factors* differ from capacity factors in that they are typically not based on a person's abilities and are likely to change according to the context. These include preferences, values, experience, knowledge, cultural beliefs, motivation (visit goals), and interest. For example, a person may be interested in an aquarium visit to meet entertainment and restorative goals.

Exhibit factors are comprised of contextual factors that place demands on the visitor and contribute to participation. These factors are predominantly exhibit-specific and include:

- *Physical environment factors* consist of multiple aspects of the space. These include features and characteristics of habitats, animals, lighting, sounds, and signs (some signs are not considered mediators).
- *Social environment factors* include the expected behaviors, roles, and relationships for that setting. For example, a parent is expected to support their child in the exhibit experience, but may require mediation to facilitate participation.
- *Institutional factors* include the learning objectives for the exhibit(s), access policies and practices. In some instances, environmental factors can also be constrained by external forces such as legal guidance through the ADA and policies from accrediting organizations.
- *Mediation factors* are strategies for overcoming an access barrier between the visitor and exhibit. Mediation can be accomplished through a variety of people, strategies, products, and technologies in text, auditory, visual, olfactory, or tactile formats. For visitors with vision loss, this mediation is frequently achieved through

another person (e.g., interpretive staff, volunteers, or other visitors) or via audio technologies (e.g., audio tours, speakers, or sound domes). Less often, tactile representations such as live animals, models, or reference objects (i.e., actual or simulated animal parts) are used.

This framework recognizes that mediation can be crucial to V-E interaction and that the relationship between the visitor and mediation can be dynamic, enabling visitors to interact more effectively with an exhibit and other visitors. As a result, this framework differs from other models previously discussed in that it more actively addresses mediation and supports a "two-role" social interaction structure that includes (1) a visitor and (2) a mediator (which can be, for example, a docent, or even another visitor interacting with a docent, with signage, or with other interpretive information). Furthermore, the interpersonal interaction between visitors is variable, in terms of who plays which role, or the relationship between the "players". For example, as depicted in Figure 6a, a visitor with vision loss (V2) receives most information from a friend or family member (V1), who accesses the exhibit directly or interacts with a docent, audio tour, signage, etc. In another possible scenario, depicted in Figure 6b, a visitor with vision loss (V2) also interacts with the exhibit through mediation, making the exhibit more directly accessible. This enables a more level, two-way sharing between the visitors (V1 and V2). In yet another possible scenario, depicted in Figure 6c, social conditions may mean that the visitor with vision loss (V2) assumes the primary role for mediating (e.g., a parent with vision loss visiting the aquarium with a sighted child).

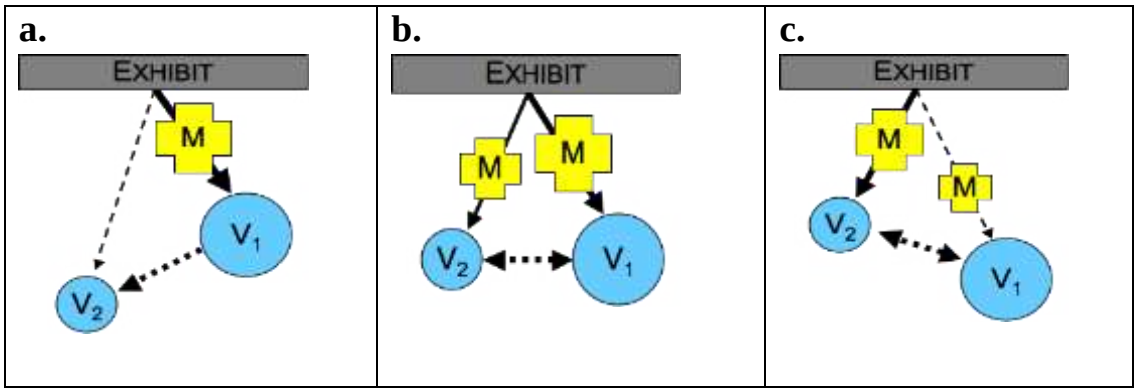


Figure 6. Mediation Variations. Information about the exhibit passes either directly to a visitor (V), or through a mediator (M), which can be technology or another person (e.g., a docent), or both. [22].

This framework provides a structure for studying and designing mediated exhibit experiences for visitors with vision loss. Although it does not contain the same taxonomic detail of the ICF, it satisfactorily represents the critical components of the mediated V-E interaction. The taxonomy from the ICF can be used as a companion to this framework to inform the level of detail required by the user. It also offers a context-relevant and flexible method for investigating exhibit design that can incorporate the dynamic nature of live aquarium exhibits and learning, entertainment, restorative, and social goals as contributors to participation.

2.5 Summary

The majority of design practice in aquariums and other ILEs has made it difficult to impossible for visitors with vision loss to address their visit goals and consequently, restricted their participation. Additionally, mediation research has not included people with vision loss nor focused on content design and impact, creating substantial gaps in our understanding of how best to support live exhibit experiences through mediation.

Moreover, much of the existing knowledge in the exhibit mediation domain is derived from practice-based evidence rather than evidence-based practice, resulting in minimal empirically-derived information.

In studying and designing exhibits and exhibit mediation, researchers have introduced several themes that can be useful to operationalizing participation in this context: **learning, entertainment, restoration, and social**. However, the field in general, relies heavily on learning as the outcome of V-E interactions. While this helps to bring educational worth and likely entices funding sources, it undervalues the full spectrum of participation by diminishing the potentially valuable contributions of the entertainment, restorative, and social aspects of the experience. Further, a majority of ILE research and practice does not consider visitors with vision loss as members of the target audience, so there is little familiarity with their particular visit goals or participation needs. It is important to leverage knowledge that can aid in the operationalization of participation for this context, but it is also important to recognize the limitations of current ILE resources as a way to understand the gaps that can be filled by the work of this dissertation.

In order to advance mediation research and practice, a comprehensive design approach that utilizes a participation-centered V-E interaction model that incorporates mediation should be enacted. Further, mediation designed to support participation should put visitors with vision loss into the middle of the live exhibit action and enable them to share in the experience of their partners and other visitors. This mediation should effectively describe the details of the visual scene and convey associated exhibits facts in real-time, features that are insufficiently addressed by current mediation strategies.

CHAPTER 3

FORMATIVE WORK

This chapter provides an overview of the completed work that guided the development of this dissertation. This work represents several years of research including informal and formal studies. I will begin by discussing the barriers that adults with vision loss experience at live aquarium exhibits based on a post-occupancy evaluation completed at the Georgia Aquarium and focus groups with adults with vision loss. Then, I will review the issues with existing mediation strategies identified through studies at the Georgia Aquarium with docents and audio describers.

3.1 Barriers to Access and Participation at Exhibits

This section will provide an overview of my research activities that have explored exhibit design at the Georgia Aquarium and the experiences of individuals with vision loss who have visited the Aquarium and similar venues. The first part of this section will discuss a post-occupancy evaluation that identified barriers and facilitators to exhibit access at the Georgia Aquarium. Although it does not directly address the concept of participation, it provides insight into how exhibit factors that create access barriers negatively impact the visit. The second part of this section will summarize several focus groups that were conducted to clarify the specific exhibit factors that create problems for adults with vision loss and further refine participation themes.

3.1.1 Post-Occupancy Evaluation at the Georgia Aquarium

This study[1] sought to evaluate exhibit features and characteristics that were either barriers or facilitators for visitors with disabilities at the Georgia Aquarium to provide feedback on exhibit design by: 1) documenting the current exhibit display and interpretation (mediation) design practices used at the Georgia Aquarium; 2) providing visitor feedback on the usability of exhibit displays and interpretation (mediation); and 3) discussing the needs of visitors with disabilities. Visitor factors were predominately addressed at the level of capacity factors, although some personal factors such as preferences were inferred. The main focus of this study was to investigate physical environment and mediation factors.

3.1.2 Methods

Post-occupancy evaluation is a systematic evaluation of a facility in use. One aspect of a post-occupancy evaluation is how the setting meets the needs of users. This type of evaluation is an effective process for generating information that provides experiential feedback that is useful in development of future research and design. This evaluation was conducted through touring interviews and focus groups with individuals who had various disabilities.

[1] Bruce, C., "Post Occupancy Evaluation: Aquarium," in The State of the Science in Universal Design: Emerging Research and Developments, (J. Maisel, Ed.), Bentham Sciences Publishers Ltd. (2010).

3.1.2.1 *Participants*

Twenty-nine adults (15 males and 14 females) were recruited through local organizations involved in disability service provision. The participants each had at least one functional limitation, including impairments in vision, motor, hearing, speech, and cognition. Participants ranged in age from 24 to 80 years old, with a mean age of 48 years. Subjects were divided into 10 groups, with eight groups arranged homogeneously according to primary functional limitation: blindness, low vision, hard of hearing, deafness, motor impairment, cognitive impairment, and speech impairment. Two additional heterogeneous groups were comprised of individuals having vision, motor, speech, and/or hearing impairments. Each group visited two pre-identified sets of exhibits (galleries) for the touring interviews and then participated in a focus group. Twenty subjects' comments were recorded during the touring interview to collect more detailed information. All 29 subjects participated in the focus groups after visiting the galleries.

3.1.2.2 *Data Framework*

Description of the exhibits involved systematically documenting each area in the five galleries of the Georgia Aquarium. The framework for categorizing exhibit features and characteristics is seen in Table 1 below.

Table 1. Exhibit Factors, Features, and Characteristics.

Exhibit Factors	Features and Characteristics
Physical Environment-Habitat The environment the animal lives in.	• **Display** o Viewing height: the height of the wall, waterline, etc. that impacts viewing. o Interaction height: the height of the wall, waterline, etc that impacts interaction. o Distance: how far away the display is, given that the visitor is as close as possible. o Visibility: whether the display is visibly apparent and whether its contents can be seen, given the opacity/transparency of the display materials. • **Animal** o Viewing height: the height of the animal that impacts viewing. o Interaction height: the height of the animal that impacts interaction. o Distance: how far away the animal is, given that the visitor is as close as possible. o Visibility: whether the animal is visibly apparent • **Lighting** o Light level: the brightness or darkness of lighting. o Color: the color of lighting. o Glare: light reflection that makes it hard to see.
Physical Environment-Other The features and characteristics in the space around exhibits	• **Lighting** o Light level: the brightness or darkness of lighting. o Color: the color of lighting. o Glare: light reflection that makes it hard to see. • **Path** o Flooring: type, texture, and reflectivity of the surface. o Elevation changes: steps in or slope of the surface. o Width: the side-to-side passage distance in front of or around exhibit. o Color/contrast: the color or tone combination of the surface. • **Ambient sound:** the type and loudness of sounds (non-crowd) in the surrounding area. • **Fixtures and furnishings** o Dimensions: height, length, width, etc. that affects visitor s' interaction with or use of fixture/furnishing. o Obstructions: physical barriers preventing view, interaction, or use. • **Crowd** o Sound: the noise produced by the crowd. o Navigation: the density and flow of the crowd in front of or around the exhibit that impacts traveling. o Viewing: the density or height of the crowd in front of or around the exhibit that impacts viewing.
Mediation The descriptive or informational detail typically presented in *static* (delivery of "canned" facts) or *dynamic* (interactive and flexible content and style of delivery) formats through techniques such as signage, kiosks, recorded video, docents, and/or recorded audio. Mediation helps the visitors to understand the animals and their habitat.	• **Position** o Viewing height: the height at which the mediation can be viewed. o Interaction height: the height at which the mediation can be touched, activated, or controlled. o Distance: the how far away the mediation is, given that the visitor is as close as possible. o Proximity: the distance the mediation is from the display. o Angle: the slant of the mediation from the horizontal or vertical plane. • **Lighting** o Light level: the brightness or darkness of lighting. o Color: the color of lighting. o Glare: light reflection that makes it hard to see. • **Visibility:** whether the mediation is visibly apparent and whether its information can be seen, given the opacity/transparency of the mediation materials. • **Text Readability** o Speed: the timing of mediation or the amount of time before the mediation changes. o Font size/type: letters/characters height, width, and style. o Color/contrast: the color or tone combination that makes the text distinguishable from the background. o Finish: surface texture or appearance. • **Graphics:** drawings, pictures, and other non-textual content. • **Information sufficiency:** the quantity, depth, and relevancy of information presented. • **Sound** o Speed: rate at which tones or speech is presented. o Gender: the male of female quality of the speech. o Loudness: the intensity of the sound.

To evaluate the exhibit factors that created access barriers for visitors with disabilities at the Georgia Aquarium, this project included two phases: 1) site documentation: the description of physical environment and mediation factors; and 2) visit evaluation: evaluation of physical environment and mediation factors through touring interviews and focus groups.

3.1.2.3 Site Documentation

The investigators visited the aquarium several times at the start of the study to physically review exhibit factors. Photographs and observations of visitors enabled the investigators to become familiar with exhibit features and characteristics.

3.1.2.4 Visit Evaluation

Touring interviews involved groups of two to four people and were completed with 20 of the subjects. Each study group visited two of the five galleries, with each gallery being visited by two different study groups. After visiting the exhibits, subjects participated in focus groups to discuss their experiences. All data were analyzed and classified into the factors shown in Table 1.

3.1.3 Results

Touring Interview Within Exhibit Analysis of Barriers. The data revealed that three exhibits (out of 38), Cold Water Quest touch tank, River Scout Electric Fish, and Tropical Diver Coral Reef, had the highest number of reported exhibit factors that caused access issues, accounting for 30% (n=43) of the total number of comments (n=147). Comments related to barriers included display interaction and viewing height; viewing height and visibility of the animal; mediation position, readability, information

sufficiency, and sound; and crowd, ambient sounds, and access to fixtures and furnishings.

Touring Interview Across Exhibits Analysis of Barriers. The features and characteristics that individuals commented on the most were position of the mediation (n=26), visibility of display and animals (n=22), viewing height of the display (n=20), lighting for mediation (n=11), and readability of mediation (n=10). Position of mediation included viewing height (n=17), proximity (n=7), distance (n=1), and angle (n=1). Comments for lighting of mediation referred to light level (n=9) and glare (n=2). Readability of mediation included comments on font size and style (n=4), "other" (overall readability) (n=3), and contrast (n=3).

Focus Group Results for Barriers. The four exhibit features and characteristics that represented the greatest number of comments about barriers during the focus groups were crowd issues (n=11), general information sufficiency (n=8), position of mediation (n=7), and fixtures and furnishings (n=7). Crowd issues were related to sound (n=4), navigation (n=4), and viewing (n=3) problems. Position of mediation comments were associated with viewing height (n=5) and interaction height (n=2). Barriers with fixtures and furnishings were noted according to physical access (to hand washing) (n=3), obstructions, (n=2), and seating (n=2).

Touring Interview Within Exhibit Analysis of Facilitators. During the touring interviews, participants also provided positive feedback about the usability of design features and characteristics of exhibits. The data suggested that participants had the greatest number of positive comments (n=9) related to the Arawana and Arapaima exhibit in River Scout. This exhibit had three comments related to the readability of the

mediation (a video sign), three related to information sufficiency of the video sign, and three comments that were categorized as "other" referring to liking the video signs.

Touring Interview Across Exhibits Analysis of Facilitators. The features and characteristics that produced the majority of positive comments were readability of mediation (video signs) (n=7) and docents (n=11). Readability included issues related to "other" (overall readability) (n=4) and font size and style (n=3). The docent category consisted of comments about docents providing personal assistance for touching ("other") (n=4), docents' overall helpfulness and attitude ("other") (n=4), sound of docents (n=2), and information sufficiency (n=2).

3.1.4 Discussion

The findings from this study indicate that across disability groups, there are several characteristics that can be barriers or facilitators to accessing exhibits at the Georgia Aquarium: 1) habitat, including viewing height, interaction height, and visibility of the display and animals; 2) mediation, including position, readability, lighting, visibility, and sufficiency; and 3) physical environment, including crowd and lighting.

As expected, visitors with vision loss experienced issues with habitat and mediation viewing, suggesting that alternative means of accessing exhibits and mediation is necessary to improve their experience. It is important to mention that during the focus group with these subjects, we talked about audio tours as mediation. Subjects referred to past experiences with audio tours and criticized them for infrequent updates to the information and their repetitive nature (they give the same loop of information every time you listen). They also pointed out that they could listen to an audio tour at home and have the same experience because the tours don't tell you what the animals are doing

while you are standing in front of the exhibit. This conversation was the catalyst for developing a real-time descriptive mediation system that could deliver live exhibit details.

3.1.5 Focus Groups

Focus groups were conducted to confirm and expand on the issues identified by participants in the post-occupancy evaluation and explore the notion of participation at live exhibits from the perspective of adults with vision loss[2].

Participants. Twenty-five adults (12 females, 13 males) with vision loss (non-congenital) ranging from low vision to complete blindness participated in groups that had an average of five members. Groups were held at the Center for the Visually Impaired in Atlanta and the Georgia Industries for the Blind facilities in Griffin, Bainbridge, and Albany to encourage a variety of viewpoints from urban and rural areas. All participants reported to have visited a zoo or aquarium at least once during the previous five years. One participant was still sighted during his last visit to a zoo or aquarium, but was able to discuss what he perceived to be potential barriers at aquarium exhibits. It is important to note that a zoo visit was included in the inclusion criteria as a result of anecdotal evidence and recruitment probes that indicated adults with vision loss are not frequent visitors at aquariums due to perceived or actual barriers. This highlights the significance of the problem being addressed in this proposal.

Procedures. The focus groups were structured according to specific questions about visit purposes and experiences, as well as suggestions or ideas they had for

[2] Bruce, C. and Walker, B., "Designing effective sound-based aquarium exhibit interpretation for visitors with vision loss," Proceedings of the 12th International ACM SIGACCESS Conference on Computers and Accessibility, October 2010.

improving future visits. Questions were presented to the group and each person was given a chance to respond. Interactive discussions and relevant deviations from the topic were allowed, but carefully managed to ensure that the necessary themes were covered. The discussions were audio recorded and transcribed later by the researcher and research assistants. The planned questions included:

1. Why do you visit zoos or aquariums?
2. Tell me a little about your experience at the exhibits at the last zoo or aquarium you revisited.
3. Do you remember anything specific about the exhibits that was a big problem for you/helped you?
4. Were you able to experience the exhibit the way you wanted to?
5. Were you able to get all of the information you wanted from the exhibit?
6. Was there a sign? Audio tour? A staff member talking about the exhibit?
    a. How was that?
7. Have you had experience with an audio tour? A docent/narrator?
    a. Tell me about that.
8. What is the most/least important information for you to get at an exhibit?
9. What things are important to describe?
    a. What level of detail?
    b. Is real-time information important to you?
10. What are the different roles you can carry out by going to an aquarium exhibit?
11. What kinds of things would make it easier for you to carry out these roles?
12. What kinds of things do you want to be able to do at an exhibit? For example, if you are a parent, what do you want to be able to do with your child? (e.g., talk about the animals, etc.).
13. What makes an exhibit successful for you?
14. What's important for you to be able to share with another person?

Results. A preliminary content analysis has been conducted on the data from these focus groups. Data relevant to participation included the intended outcomes of visiting zoo or aquarium exhibits, the ways in which participants want to share the exhibit experience with others, and roles that participants want to fulfill. Four main themes arose that represent participation goals: learning, entertainment, restorative, and social. Interestingly, these themes parallel the motivational themes identified by Packer [2].

Discussion related to **learning** was about expectations and goals that participants had for themselves and for supporting their partners in regards to acquiring or adapting knowledge or other educationally-relevant activities. **Entertainment** outcomes were associated with watching the animals for fun, seeing performances or nature shows, and "being amused" by the exhibits. **Social** goals were frequently mentioned, with participants describing spending time with friends and family and sharing stories after the visit. Participants also talked about **restorative** motivations that were not related to entertainment, learning, and social aspects. These were about introspection, spirituality, and relaxation and their descriptions suggested an almost meditative quality.

The most common complaint about exhibits was not being able to see the animals. This was primarily due to visitors' vision loss; however participants reported that lighting concerns such as glare and reflection as well as color contrast issues such as dark fish in a dark background compound the problem. Locating and reading sign-based mediation was also affected by lighting and color contrast in addition to smaller font size and font styles that were hard to interpret. The most common facilitator that was discussed was sound-based mediation through mounted push buttons with recorded sounds (e.g., dolphin noises), public docents, personal tour guides, or audio tours. Tactile components were also popular mediators that participants talked about, referring to models, animal artifacts, and live animal encounters.

Discussion. The preliminary results from these focus groups complement and expand on my previous work. Participants discussed their motivations, expectations, and goals for a zoo or aquarium visit, helping to further characterize participation. These

results also confirm the exhibit barriers reported by the participants in the post-occupancy study.

3.2 Sound-Based Exhibit Mediation Systems

In this section, I will present two studies that have been conducted to examine the current real-time exhibit mediation at the Georgia Aquarium and explore visual descriptions of live exhibits. The first study on docent practices included an analysis of mediation presentations and follow up interviews with docents about their strategies for interpreting the visual scene. The second study was completed with trained audio describers to learn about visually describing live exhibits for people with vision loss. The data from both of these studies is still being processed and analyzed, so only brief overviews will be given. I will also provide a brief summary of the real-time descriptive mediation system that is being developed through the Accessible Aquarium Project.

3.2.1 Docent Study

The current practices of Georgia Aquarium docents in delivering information about dynamic exhibits were examined to understand how they view the visual scene, then make decisions about what to describe and how to describe it[3]. Docent presentations occur at the Beluga and Ocean Voyager exhibits throughout the day with docents at Belugas mediating nearly continuously while on duty and docents at Ocean Voyager mediating for an average of 5-7 minutes a few times an hour depending on the crowd

[3] Bruce, C. and Walker, B., "Designing effective sound-based aquarium exhibit interpretation for visitors with vision loss," Proceedings of the 12th International ACM SIGACCESS Conference on Computers and Accessibility, October 2010.

levels that day. The other main difference between the two exhibits is that docents at Belugas engage with the audience during mediation by asking and answering questions whereas docents at Ocean Voyager do not interact with the audience during mediation.

Methods. Eleven docents (6 females, 5 males) were audio and video recorded at the Beluga and Ocean Voyager exhibits (n=22). Video and audio were conducted at various times throughout week days to ensure that a range of crowd levels and animal activity was represented. Follow up one-on-one interviews were scheduled with the docents on a separate day from the recording. These interviews were semi-structured and intended to collect data about preparing for mediation (e.g., resource materials), mediation techniques for certain audiences, animal behaviors that are likely to elicit mediation, strategies they do or might employ with visitors with vision loss, visitor questions, and ways that technology could be used in mediation. Interviews were audio recorded for later transcription and analysis.

Mediation audio recordings were transcribed, video recordings were converted into workable file formats, and data were loaded into ELAN software for annotation. Separate annotation lines were created for docent transcription, docent gaze direction, docent gestures, visitor transcription, and animal movement. For any point in time, the information from each of those lines of annotation can be retrieved. For example, at the 1:30 time mark, one can see what the docent or visitor was saying, the direction the docent was looking in, any gestures the docent was making, and the animal movements that were occurring. Transcriptions were also linguistically analyzed through the AntConc software.

Results. Highlights from the preliminary analysis include examples of docent gestures that indicated location, direction, size, shape, and movement; animal location and behaviors that triggered mediation such as appearance into viewing area, body rubs on habitat surfaces, and fast movements; and real-time description of live events.

The AntConc analysis showed that an average of 8:30 of audio recording yielded 18,338 words spoken by docents at Belugas and 16,549 spoken words at Ocean Voyager. Word frequency percentages for the top 25 words were similar to standardized English word lists, with the top 11 words shared across both exhibits. Exhibit-specific keywords (e.g., whale, shark, beluga, fish, ray, water) were also frequently spoken and deictic terms related to location of the animal (e.g., over to the "right") and the subject (there "he" goes again) were used throughout mediation.

Discussion. Interviews revealed that the content of interpretation was primarily affected by predefined exhibit goals that are established by the education department with input from the staff biologists. The format (interactive, non-interactive) and length of the mediation presentations were affected primarily by crowd levels and the resulting crowd management strategies. Additionally, docents had little experience and knowledge related to mediating for people with vision loss. They were all interested in improving practice for better serving visitors with vision loss and regarded docent training and mediating technologies as potentially useful strategies.

3.2.2 Audio Description Study

The gold standard for describing visual scenes to people with vision loss is audio description. A study[4] was conducted to understand how live aquarium exhibits could be mediated using audio description techniques. Professional audio describers provided description for the Beluga and Ocean Voyager exhibits and discussed the challenges associated with this setting.

Methods. Four female audio describers visited the Beluga and Ocean Voyager exhibits and participated in one-on-one touring interviews that covered overall procedures for describing visual scenes, actual descriptions of some of the exhibit elements, and expected difficulties with describing live exhibits. Additionally, each audio describer participated in a lab session in which she watched videos of the Beluga and Ocean Voyager exhibits, described the visual scene in real-time, and answered questions about describing live exhibits. The Aquarium visits and lab sessions were recorded and transcribed.

Results. An initial review of the data showed that all of the audio describers started with a general overview of the scene, then focused on specific elements. In general, the audio describers varied in their personal style, with some using more artistic (e.g., "there's a light source emanating down and illuminating…") versus practical (e.g., "about 5" long and circular in shape") language. Estimates of shape and size often included a comparison to a familiar object (e.g., shaped like a dinner plate, as big as a fist). Movement was described more frequently than shape, size, and color.

[4] Bruce, C. and Walker, B., "Designing effective sound-based aquarium exhibit interpretation for visitors with vision loss," Proceedings of the 12th International ACM SIGACCESS Conference on Computers and Accessibility, October 2010.

All of the describers were emphatic about the need for live exhibits to be described effectively for people with vision impairments. They acknowledged that describing live exhibits is a challenging task and requires skill and practice. Specifically, they believed that describing visual elements that create mood (e.g., shades of blue, lighting, balletic movements) could be difficult without overlaying opinion or language artistry. They also all emphasized the need to provide information about exhibit elements other than the display such as the shape of the room, location of seating, and sign placement. Additionally, they reported that a resource with vocabulary or phrases relevant to live exhibits, including technical information about the animals as well as particularly useful adjectives and verbs, would be helpful in providing effective real-time mediation.

Figure 7. Camera at the Ocean Voyager Exhibit at the Georgia Aquarium

3.2.3 Real-Time Mediation System Design and Prototyping

Primarily based on the needs of visitors who took part in the formative study, *Post-Occupancy Evaluation at the Georgia Aquarium*, design criteria were developed for a real-time mediation system. This system was intended to track animals in a live exhibit and deliver sound-based information in real-time. It was envisioned that the sound-based information would include musical or other non-speech sonifications and

Figure 8. Screen Rendering of Data Found by Detection Processes.

speech. The sonifications were audio interpretations that were mapped to animal physical characteristics, location, and movements. For example, musical mappings associated with an animal's instrumental sound could change pitch as it ascended or descended, tempo as it swam faster or slower, loudness as it moved closer or farther away, and stereo panning as it moved left or right. For speech-based output, it was assumed that the system would deliver specific narrative messages about the habitat and animals that were constructed from the details and facts that study subjects had reported as important.

The team involved in building the detection and identification components of the real-time system provided constraints based on the available hardware and software they were going to use. Within these assumed limitations, the system was designed to detect and identify a single "celebrity" animal or group of animals at any one time. A "celebrity" animal was one that was a prominent exhibit animal, such as a whale shark, with visually distinguishable characteristics (e.g., size, shape, pattern). It was not capable of detecting several separate animals as a way of providing the listener with the choice of animal to focus on. The camera was fixed on a viewing area, without the ability to

actively pan and tilt. At the point of detection, the system could know the location of the animal which could be used in sonification mappings or speech narrations.

A 60-gallon lab aquarium was installed as the basis for the initial prototype. This simulated exhibit housed a few species of colorful tropical fish and had a white sandy bottom with several rock groups. A high definition digital camera was positioned outside of the aquarium (see Figure 7) and connected to a computer system that consisted of Linux-based machine that performed computer vision tasks and a Macintosh-based machine that assigned sonification details. The initial prototype system was developed to deliver musical sonifications as the mediation. Several different styles of musical mappings were developed and evaluated through this and subsequent prototypes. While the musical mediation of the real-time system is not the focus of this dissertation, it is anticipated that musical interpretations of live animals will also meet participation needs of visitors, perhaps being better suited to convey information such as mood and artistic movement. Further, music and spoken information are often used in a complementary way in existing asynchronous audio tour mediation systems and could be expected as added value in a real-time system.

One of the prototype real-time mediation systems was also capable of delivering spoken information based on detection and identification of animals. This system used a shape-matching protocol to view the animals in the visual scene and compare their shapes to database models as a way of identifying them (see Figure 8). After identification, the system assigned pre-recorded species-specific messages to be played to listeners. For example, when a snapper was detected, the system could play spoken information about the color and size of snapper. This prototype real-time descriptive mediation system

established feasibility from the hardware and software aspects, but the spoken information that the system delivered was not empirically informed nor designed for evaluation purposes. Additionally, this system did not provide information about an animal's location, so it was difficult for listeners to know which animal was being referenced and where it was in the visual scene.

3.3 Preliminary Design Considerations

The findings from the formative studies and capabilities of the various real-time system prototypes were taken into account during the formation of design considerations for real-time descriptive mediation that could be evaluated. These considerations were designed to meet the participation-based exhibit motivations of adults with vision loss by providing key habitat and animal facts, as well as incorporating design features that would afford a sense of "real-timeness" by conveying dynamics of the visual scene and be effectively descriptive of other salient visible elements in the scene.

3.3.1 Participation

Although participation is widely defined and used in various ways as an outcome of an ILE visit, this research operationalized participation according to peoples' core motivations for visiting exhibits. These motivations are:

1. **Learning** – acquiring or adapting knowledge or engaging in other educationally-relevant activities;
2. **Entertainment –** having fun or being entertained such as watching animals, observing performances or nature shows, and "being amused" by exhibits;

3. **Restorative –** related to introspection, spirituality, meditation, and relaxation;
4. **Social –** spending time with friends and family and sharing the experience.

These participation constructs are not specific to people with vision loss, they are generalizable to all visitors regardless of vision ability. However, as discussed throughout this work in relation to live aquarium exhibits, these constructs are almost always supported through the design of mediation that assumes visitors are able to see what is in the display (visual scene). Participation-based exhibit expectations are consequently restricted for those who have difficulty or are unable to see.

3.3.2 Real-Time and Descriptive Design Features

Effective interpretation of the visual scene supports people in understanding what they are looking at and/or imagining what might be happening in the display while they are standing in front of it. This interpretation can include description of static elements, such as the physical characteristics of an animal or the habitat, as well as dynamic elements of movement (i.e., location and swimming behaviors). The following operational definitions provide more details about real-time and descriptive mediation design features:

> *Real-Time: describe dynamic characteristics of the visual scene in a manner that effectively enables a listener to generate an understanding of location and movement.*

Descriptive: describe less dynamic, yet salient characteristics of the visual scene in a manner that effectively enables a listener to generate an understanding of physical appearance.

Participants with vision loss in the formative studies confirmed that real-time and descriptive features are critical, though often not implemented in the design of mediation. They expressed a desire to know which animals were in an exhibit viewing area and how they were moving so that they could feel more included in the experience, and perhaps aid in justifying the expense of visiting a live exhibit that they have difficulty seeing. They also specifically mentioned wanting to know visual details including colors, patterns, shapes, and sizes of animals and habitat components.

The prototype systems discussed in the previous section demonstrated technical feasibility for supporting these design features through the detection and identification of animals in the scene and retrieval of related animal or habitat information from a database. The speech-based prototype could verbally announce that a certain species was in view and give descriptive information, but did not provide location information. The music-based prototypes assigned specific musical tones or instruments to species and were able to integrate location as part of the sonification of movement, but listeners needed an orientation to these musical mappings to understand them. Additionally, the music-based prototypes could not convey physical description details for animals or habitat components in a way that was easily decoded by most listeners; listeners would need training to understand it. Consequently, a new speech-based system that incorporates real-time and descriptive features would need to include labeling of animals, explicit reference to location, movement details, and description of physical features and

characteristics for animals and habitat elements. I will briefly discuss the benefits of providing information about animal location, animal movement, and physical characteristics of animals and habitat features for people with vision loss, and suggest how this information could be implemented in a real-time descriptive mediation system:

Animal Location: Details about location can help people with vision loss know where to look (if they have some functional vision and want to find it) or where something is in the viewing area (if they can't see it, but want to create a mental image). Location can be expressed through various levels of precision such as, "over here", "on the right side", or "up at the top left", depending on the characteristics of the visual scene and the needs of the listener. Additionally, although location as a real-time feature is most compelling when it refers to the actual position of an animal at a given point in time, it can also be talked about in terms of an animal's typical swimming habits. For example, an animal's expected location could be suggested by reporting on how it is generally found swimming near the lower corners of the display. Additionally, the direction of travel could be inferred based on where the animal was originally detected and a brief history of its path. If an animal was found emerging and moving from the top left portion of the viewing area, the anticipated direction of travel would be towards the right. These types of location information can give the impression of "real-timeness".

Animal Movement: Swimming behaviors such as pattern of travel, body movements, and swimming style and speed could convey the dynamic nature of a live exhibit. It is unclear whether any of this information could be accurately detected by a real-time system, but it may be possible to infer from detectable information or generalize based on typical habits (as can be done with location). For example, talking about typical swimming patterns such as the manta ray's somersaults can give a listener something specific to look for in the display or imagine about the animal's movement. Similarly, references to common swimming style or speed can be leveraged to aid in mediating the visual scene in a real-time manner. For example, "hammerhead sharks have a moderate swimming speed compared to other animals in here and often move their head from left to right as they swim."

Animal and Habitat Physical Features and Characteristics: Less dynamic, yet equally salient features including physical characteristics of animals and the habitat do not change from moment to moment, but an effective description can help a person with low vision to locate it in the visual scene or aid a person who is blind in creating a mental image. Further, pairing a description of what an animal looks like with its species name and location is a more direct approach to real-time identification. Therefore, since descriptions of physical appearance are instrumental to visualizing the dynamics of the scene, they must be of sufficient "descriptiveness" to be useful to people with a range of vision loss. The minimal descriptions provided through docent and audio tour mediation are, for the most

part, not beneficial for people with vision loss because they assume that listeners are able to see the visual scene being referenced. As a result, certain visible exhibit features and characteristics are often not discussed at all or merely mentioned in ways that enable a sighted person to visually distinguish one animal from another. Conversely, being overly descriptive is also problematic since it can overwhelm a listener with too much detail and cause him/her to tune out. Effective descriptiveness is a balance of the most essential details (for listeners) described at an appropriate level of specificity. For example, if you are unable to see an animal, having a description that tells you that it is "one of the small fish," is less useful than a description that states that it is "a yellowish, oval-shaped fish about the size of an adult's hand."

As shown in Figure 9, the basic functionality of a system that can provide *real-time* and *descriptive* mediation includes detection, identification, and content retrieval processes. It begins by detecting a moving animal (Y) in a visual scene where other animals might exist (X and Z). At this point, location of that animal can be determined based on where it was found in the visual scene. After an animal has been detected, the next step is for the system to identify what specific species it is (B) out of all possible species in the scene (A, B, C). This process labels the animal with a species name which then associates it with species-specific information (e.g., descriptions of physical characteristics and typical behaviors, and general species facts). The location, label, and species information can then be combined as a message for delivery as mediation.

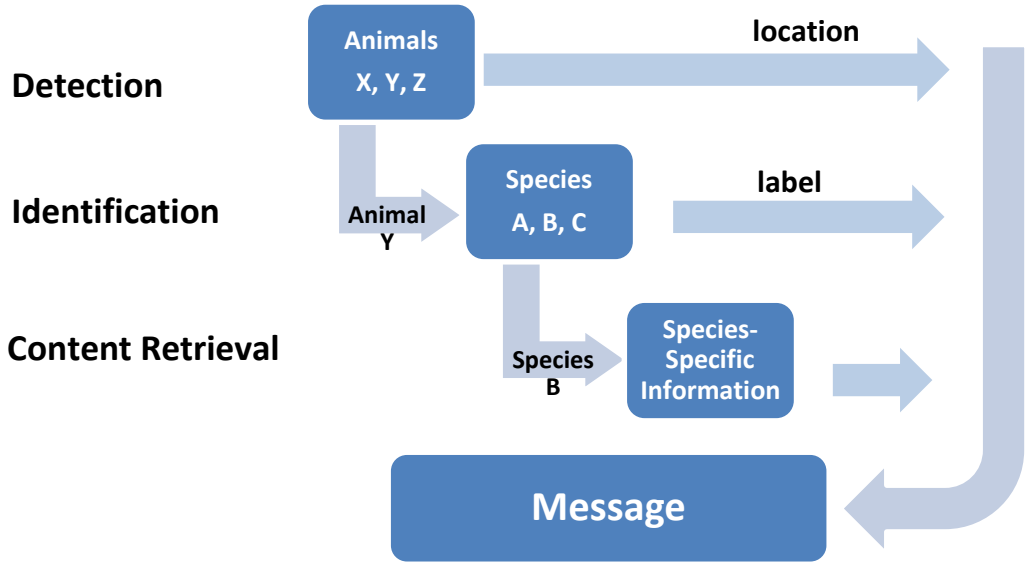


Figure 9. Real-Time Descriptive Mediation System Process. This graphic shows the stages of detection, identification, and content retrieval, and the information available in each stage.

3.4 Summary

This formative and design research took place over the last seven years. This work was not linear in nature with one set of findings leading directly to the next study. Instead, it was a continuous exploration, within the context of live aquarium exhibits, of the barriers experienced by individuals with vision loss, their participation-related needs, and potential mediation interventions. This coordinated research and design effort, informed by literature, ILE practitioners, other colleagues, and countless visits to a variety of ILEs, led to preliminary design considerations for effective real-time descriptive mediation. These design considerations were the foundation for further implementation and examination activities that will be presented in the following chapter.

CHAPTER 4

REAL-TIME DESCRIPTIVE MEDIATION: DESIGN AND RESEARCH PRODUCT

The Real-Time Descriptive Mediation system concept that resulted from the formative research and design activities became the focus of further research. Specific exhibits from the Georgia Aquarium continued to serve as the basis for the mediation development and evaluation. The system concept and exhibits provided a basis for designing mediation that effectively described live exhibits in real-time and addressed visitor participation needs. In this section, I will describe the Georgia Aquarium exhibits used in this work and comprehensive process for developing the Real-Time Descriptive Mediation stimuli. I will link design choices to the designed mediation and strategies for evaluating participation in a lab setting in order to contextualize the subsequent mediation evaluation.

4.1 The Georgia Aquarium Exhibits

The exhibits used to develop the mediation stimuli were the Beluga Whale and Ocean Voyager Theater at the Georgia Aquarium in Atlanta, Georgia. These exhibits were selected because they were extensively examined during the formative research described in *Chapter 2 Formative Work* and they both had docent presentation and audio tour resources that were leveraged to develop representative stimuli for these mediation types.

4.1.1 Beluga Whales

The Beluga Whale exhibit houses several beluga whales and harbor seals. Although the number of animals has fluctuated since the Aquarium's opening, the population during this study was four belugas and four harbor seals. The Beluga Whale habitat is over 800,000 gallons with one main pool and a smaller connected pool separated by a door. The primary habitat features are walls and flooring that are dark brown and rocky. This exhibit is part of a large open exhibition space on cold water animals with several related exhibits including Australian weedy sea dragons and a touch pool with sea stars and anemones. There is a 2-story viewing window that can be accessed at lower and upper levels. On the lower level, visitors can get right up and touch the viewing window that starts at the floor. Much of the area in front of the exhibit is intended for standing and some seating is located at the back of the exhibit space. Based on informal tracking activities, most visitors view the exhibit from the lower level. On the upper level, visitors look into the exhibit from a balcony. To the right side of the viewing window, there is a large video panel that shows recorded interpretive videos and live, behind-the-scenes footage during feeding and husbandry activities. Docents stand on an elevated area off to the right side of the

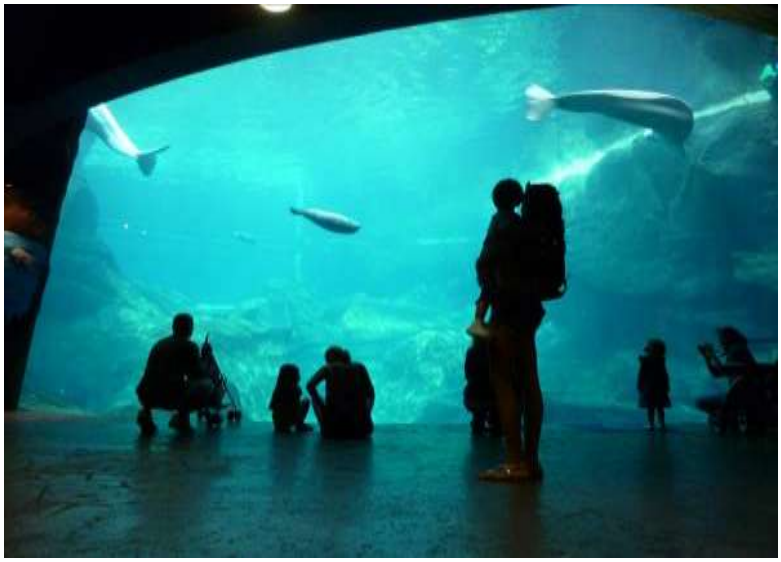


Figure 10. The Beluga Whale Exhibit at the Georgia Aquarium.

habitat's viewing window and talk about the animals and their habitat nearly continuously while on duty throughout the day. There are periods of break for the docent to rest and when a new docent is coming into the exhibit. The style of presentation at this exhibit is short interactive lectures with audience questions often driving the content of the mediation.

Figure 11. Another view of the Beluga Whale Exhibit at the Georgia Aquarium. This view shows the second-story viewing area, video panel, and docent position.

4.1.2 Ocean Voyager Theater

The Ocean Voyager exhibit is home to over 100,000 rays, sharks, grouper, and other fish. The main attraction of this exhibit is the fact that is has four whale sharks that are between 18 and 24 feet long. As a result of these large animals, the habitat has 6.3 million gallons of water and is the largest at the Aquarium. The other habitat features include the colors of the water, dark brown rock formations, and sandy light-colored floor. Visitors are seated or standing in a theater-like viewing area that faces a large window that is 61' wide and 23' tall from the floor up. There are no guardrails or other

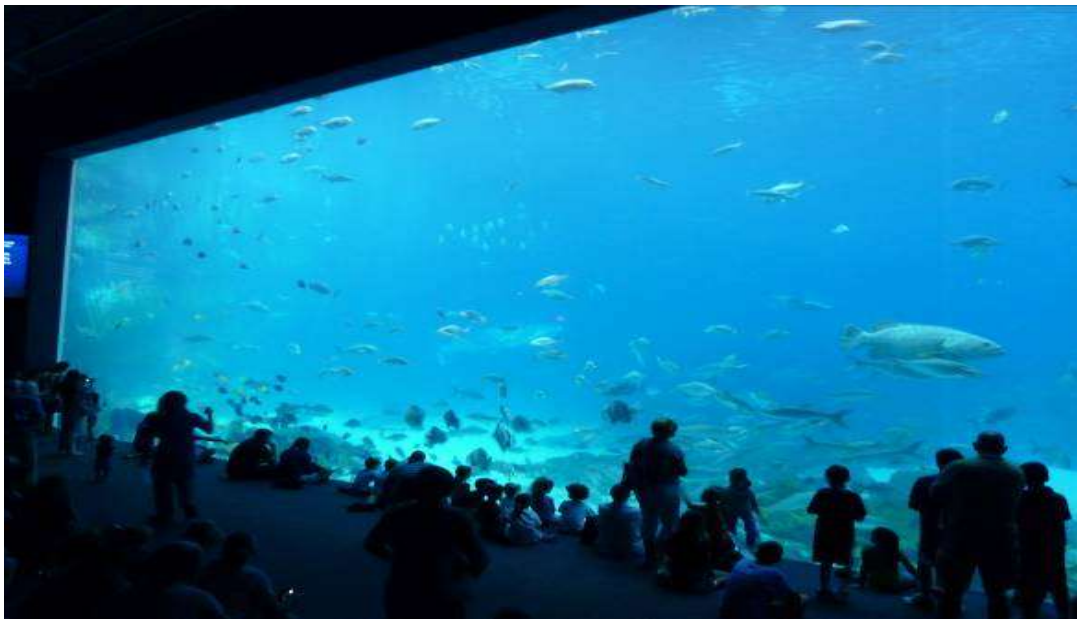


Figure 12. The Ocean Voyager Exhibit at the Georgia Aquarium.

barriers so that visitors can get as close to the exhibit as they want. There are two large video panels mounted approximately 15' high on both sides of the viewing window.

These panels show recorded interpretive videos and live, behind-the-scenes footage during feeding and husbandry activities. The typical docent presentation is in a lecture format where visitors are encouraged to sit or stand and listen to a brief overview of the exhibit. The docent walks back and forth on the floor near the window and gives periodic 5-7 minute presentations a few times an hour. The Aquarium uses this lecture style as a way to help manage visitor flow through the space. Since presentations occur periodically and contain much of the same information, visitors generally stay through one presentation and then move out of the exhibit. If the Aquarium is crowded, the presentations may be shorter and more frequent. On slower days, the docent may talk longer and take longer breaks between presentations. Regardless of the manner of presentation, visitors are allowed to stay for as much time as they prefer and can leave the

Figure 13. Another View of the Ocean Voyager Exhibit at the Georgia Aquarium. This view shows a video panel and a docent presenting to visitors.

exhibit at any time. The presentations are uninterrupted, but visitors can approach the docent afterwards to ask questions. The docent responds to these questions off of the microphone through one-on-one interactions. There are other, less frequent types of presentations given including interactive dive sessions. These presentations can involve an Aquarium staff member talking to the audience about the exhibit during a SCUBA dive and the docent facilitating a question and answer period. Other interpretive resources at the exhibit are legal-sized laminated guides that aid visitors in identifying animal species and a touchable sample of the material used to make the viewing window.

4.2 Design and Development of Real-Time Descriptive Mediation

The Real-Time Descriptive Mediation is the primary research and design product of this dissertation. It was developed according to the preliminary design considerations

and refined through an analysis of existing study resources, by draft script creation, and with contributions from an advisory process. This mediation was designed to include dynamic and static visible exhibit details and associated exhibit facts in a manner that was consistent with the expected real-time system capabilities.

4.2.1 Content Resource Analysis and Development

An analysis of study resources was completed to create a taxonomy and bank of descriptive phrases and associated species or habitat facts that could be used to generate test scripts when working with the advisors. The study resources included data from the formative study involving trained audio describers, the recently developed docent and audio tour scripts used in recording the other study stimuli, and Aquarium-created animal fact sheets.

4.2.1.1 Audio Description

The transcripts from the audio describer study (see Chapter 3) were reviewed for words and phrases (comments) associated with animal and habitat characteristics. These were organized as a taxonomy that considered the details in both exhibits. There were a couple of differences in the exhibit transcripts that are important to note since they reflect visually interesting characteristics of the exhibits. In the Ocean Voyager transcripts, there were descriptions of single versus multiple animals (e.g., schools of fish) since some animals swim alone and others swim in groups. The Beluga Whale transcripts largely talked about individual animals that are rather active, expressive, and interactive, and thus, easier to describe in detail. The analysis of these transcripts provided the following taxonomy:

- habitat size – size of the habitat such as “large” or viewing window such as “about five persons tall”
- habitat lighting – lighting effects on the water such as “very soft texture of light”
- habitat surfaces – walls, rocks, and flooring of the habitat such as “submerged mountain range”, “surrounded by these very large, rough, pointy rocks”, and “the sandy bottom”
- habitat color – color of the water area in the habitat such as “looks like a warm blue”
- habitat feature location – location of color, lighting, or surfaces being discussed such as “around the tank” or “emanating down”
- habitat mood – emotional quality associated with the habitat such as “very peaceful” or “calming”
- multiple animals size – length or general size of the animals in a group such as “larger” or “about 2 feet in length”
- multiple animals shape – shape of the animals in a group such as “thin” or “flat”
- multiple animals color – color or pattern of the animals in a group such as “kind of an iridescent sense to their color”
- multiple animals appendages – fins, flippers, or tail of the animals in a group such as “sharp fins and noses”
- multiple animals quantity – number of animals in a group such as “thousands of fish” or “small school”

- multiple animals swimming style – style of swimming such as “swim in a more rhythmic pattern” or “propel”
- multiple animals swimming path - direction or pattern of swimming of a group such as “they tend to ascend” or swimming in both directions”
- multiple animals swimming location – location or proximity of a group of animals such as “over to the right” or “a little bit off in the distance”
- multiple animals swimming body movement - body movement associated with swimming such as “tails which kind of flicker more as they turn”
- multiple animals interacting – interactions between animals such as “cross each other” or “put their faces together for a moment”
- single animal size – length or general size of the animal such as “large” or “30 feet long”
- single animal shape – shape of the animal such as “cloak-like body with wings” or oval- shaped”
- single animal color – color or pattern of the animal such as “underbelly is white” or “regular striped pattern”
- single animal body texture – the appearance of the beluga whales’ skin or harbor seals’ coating such as “almost like a sculpture” or “furry looking”
- single animal appendages – fins, flippers, or tail of the animal such as “large, rounded wings” or “two fins to the left and right”
- single animal head – head of the animal such as “a very wide mouth”, “saw-shaped nose”, or “seems to smile”

- single animal swimming style – style of swimming such as “erratic” or “undulate their bodies”
- single animal swimming path – direction or pattern of swimming such as “swimming from left to right” or “approaching from the distance”
- single animal swimming location – location or proximity of the animal such as “up at the surface” or “coming in from our left”
- single animal swimming body movement – body movement associated with swimming such as “flapping his cloak-like wings to propel himself” or “waving his tail left to right”
- single animal swimming orientation – orientation of the animal’s body as it swims such as “with their backs up” or “his tail is closest to us as the moment”

Beluga Whales

Overall, there were 209 comments grouped into these characteristics for the Beluga Whale exhibit. There were far fewer comments related to the habitat (n=23; 11%) compared to the animals (n=186; 89%). The largest single category was Animal Swimming Path making up just over a quarter of all comments (n=55). Almost three-quarters (n=138) of the animal data were specific to the beluga whales. Not surprisingly, the majority of animal comments (n=123; 66%) represented descriptions about the animals swimming since they were in almost constant motion. Thirty percent (n= 63) of the overall data were about the physical characteristics of the animals including the size, shape, color, body texture, head, face, and appendages.

There were several concepts, phrases, and terms that stood out due to their more subjective nature suggesting that certain features and characteristics were visually interesting and important to describe. For the habitat categories, the rocky surfaces were the main feature and docents talked about them using adjectives that were slightly less subjective such as “jagged”, “rocky”, or “craggy” and others that were slightly more subjective such as “menacing”, “ancient”, and “old”. One person provided more precise imagery, proposing that the habitat looked like “a submerged mountain range”. The habitat color was referred to as dark blue, with further specification as a “very calm blue color’ and “[the color] has a very relaxing feel to it”. Noteworthy comments about the beluga whale’s body included looking like it was muscular (e.g., “white wave of muscle” and “abdomens look like a human well-developed abdomen”) and like a sculpture (e.g., “moving sculpture” and “an Italian sculpture of a beautiful human form”). In discussing the swimming style of the beluga whales, the audio describers used various adjectives and adverbs ranging from “slow” and “steady moving” to “graceful” and “leisurely”. One of the audio describers used more imagery in remarking that, “They’re white and rippling, so much a part of the water. It’s almost like they don’t displace the water as they move through it.”

Ocean Voyager

Ocean Voyager had 273 comments about the habitat and animals. Similar to the Beluga Whale exhibit, most of these comments were about the animals (n=236; 86%) with much fewer related to the habitat (n= 37; 14%). Comments about multiple animals versus single animals were equally divided at 118 comments each. The largest category was *single animal swimming location* which had 30 comments and the second largest was

multiple animals quantity with 29 comments. A majority of all the animal comments were specific to movement-related attributes such as swimming path, body movement, style, and location (n= 127). Descriptions of the physical characteristics of animals such as color, size, shape, and body parts made up only 34% (n=80) of the animal comments. Within the categories for habitat, the comments about the rocks and flooring were the largest group (n=10), with habitat display size and habitat feature location providing 8 comments each.

4.2.1.2 Other Resources

Examination of the newly developed docent and audio tour scripts was performed by mining the texts according to the audio description taxonomy. Animal and habitat facts and the language used to reference important exhibit or habitat features such as the length of whale sharks (e.g., "…about the size of a school bus") were identified. Content that was similar between the stimuli scripts and the audio description resources was compared to determine whether there was a more effective way of conveying that information and ideally, linking it to visible characteristics. For example, the Audio Tour script discussed beluga whales' blubber by saying, "…to stay warm they have a heavy layer of insulation, or blubber all around their body," and the Docent script said, "…so in order to maintain their body heat, they have up to forty percent of their weight is made up of blubber." These statements deliver the same message about the function of blubber, but the audio tour describes it as a layer which could help in discussing how a beluga whale's body appears bulky and dense, almost like they are muscular. Thus, blubber can be talked about in terms of its purpose, but a description about the way it makes the

beluga whale's body and skin look is helpful for someone who can't see the beluga whale.

The animal fact sheets created by the Aquarium were also reviewed for interesting facts and were particularly useful because they had additional information that was not included in the Docent or Audio Tour scripts. This extra information tended to be more scientific (e.g., "Olfactory lobes of the brain and olfactory nerves are absent in all toothed whales, suggesting that they have no sense of smell") and could potentially be used at later points in mediation for the fewer people who would be interested in those details.

4.2.2 Advisory Input Process

After the content resources were developed, a professional audio describer not involved in the previous formative study provided input for draft versions of real-time descriptive mediation. These drafts were shared with advisors during design meetings to refine the mediation in preparation for the mediation evaluation study.

4.2.2.1 Script Preparation for Ocean Voyager Mediation

The audio describer visited the Georgia Aquarium with the researcher to review the goal of this dissertation work and strategize about describing the exhibits based on known design considerations. The audio describer visited both exhibits and took notes on visual details. He also photographed the exhibits so that he had visual reference materials to refer to in preparing audio description for the study stimuli. The developed content resources were sent to him after his Aquarium visit to supplement his personal notes and reinforce the type of description that he was to help design. The audio describer was instructed to formulate descriptions for the same exhibit video footage that was used for the Docent and Audio Tour stimuli. The resulting script that was provided concentrated

mostly on the location of animals and their swimming direction, with minimal description of the physical characteristics of the animals. Unfortunately, the lack of physical characteristic descriptions made this script largely unusable except for a few examples. The researcher generated a more comprehensive script that included a brief descriptive introduction to the visual scene and short messages for various species or habitat features that could be seen on the video footage and were representative of daily exhibit scenes.

The content for these messages was derived from the methods described previously in the section titled "Content Resource Analysis and Development". Messages were divided into two main groups: 1) driven by visual events and 2) independent of visual events. Messages driven by visual events corresponded to the appearance of "celebrity" animals which were generally the larger and more popular animals such as sharks, rays, and grouper. It was anticipated that the computer vision system could be trained to detect and identify these visual events based on noticeable aspects of animals such as size, contrast, or routine swimming locations/patterns (e.g., whale shark generally found near the top portion of display). For the purposes of developing the mediation stimuli, a human viewer performed the detection and identification task based on the assumed system capabilities. As a celebrity animal was detected on the video, several types of information could be combined as a short real-time message that promoted a sense of real-timeness and a sufficient level of descriptiveness:

1. Location according to a grid layout (LOC)
2. Species name (LAB)
3. Direction of travel (DIR)

4. Physical dimensions or personal characteristics of specific animals in exhibit (i.e., size, weight) (DESC-animal)
5. Physical description and movement style/pattern of species (i.e., size, shape, color, special characteristics) (DESC-species)
6. Species-related facts such as diet, natural habitat details, reproductive behaviors, sustainability, etc. (FACT-species)

Messages that were independent of visual events could be delivered at any point as they were not necessarily related to the animals in view at the point in time. These messages could be used in the exhibit introduction, for periodic orientation to the exhibit, or to fill gaps between celebrity animal detections. The information in these messages was of a sufficient level of descriptiveness and related to the habitat, groups or schools of animals, and general facts about exhibit animals. Messages could include the following types of information:

1. Physical description of the habitat (i.e., viewing window height and width, size in gallons) (DESC-habitat)
2. General facts about the habitat or exhibit (FACT-habitat)
3. Physical description, typical behaviors, and movement style/patterns of groups of animals or all of the animals in the exhibit (DESC-group)
4. Species-related facts such as diet, natural habitat details, reproductive behaviors, sustainability, etc. (FACT-species)

The method for assigning messages during the script writing process was based on the assumed capabilities of the real-time computer vision system. The researcher acted as a surrogate for the computer vision system and made decisions about whether an

animal could be detected in the visual scene and which animal to detect. The video footage was viewed from the pre-identified starting point based on the Docent stimulus. An introduction to the exhibit was provided at the beginning of the script with a message comprised of information that was independent of visual events. After the introduction, animals were detected as they passed through the viewing area. When an animal was detected, a message driven by visual events was coded. This message would begin with the animal location (LOC), species name (LAB) and swimming direction (DIR), then follow with a description (DESC-animal or DESC-species) or fact (FACT-species). Messages were focused on a single topic such as physical characteristics, diet, behavior, and natural habitat. An example message that was driven by visual events:

> LOC: Near the top center
> LAB: a whale shark
> DIR: moves towards the left.
> DESC (animal): These whale sharks are between 18 and 24 feet long, but can grow up to 40 feet or about the size of a school bus.
> DESC (species): They are huge, deliberate swimmers that could almost pass for an underwater version of a slow-moving cloud.

After a message played, there would be a 1-3 second pause before the next message. This pause interval was chosen in order to provide enough time to present a wide range of test messages in the draft stimulus script and coincided with the presumed real-time system capabilities. If it wasn't possible to reasonably detect an animal within this time frame, a message that was independent of visual events was inserted. These messages talked about non-celebrity fish or habitat features and did not contain location or swimming direction information. An example message that was independent of visual events:

DESC (group): The smaller fish slowly meander among the larger fish and seem to all move to the same rhythm. Occasionally, one or several of these fish will dart across or playfully chase one another, making it hard not to notice them as they shimmer in the blue water."

The completed script for Ocean Voyager was recorded using the researcher's voice and then added to the video to create a draft stimulus to use during a meeting with advisors. The researcher's voice was used as a time-saving measure for producing the draft stimulus. The Aquarium docent who recorded the final Docent and Audio Tour scripts would later record the Real-Time Descriptive Mediation final script.

4.2.2.2 Design Meeting with Advisors: Ocean Voyager Mediation

The Ocean Voyager draft stimulus was shown to advisors during a design meeting with the researcher and audio describer to get their feedback for improvements. These advisors (n=3) all reported that they had low vision and either worked at or were clients at a local organization for individuals with vision impairment. During this meeting, the advisors were informed of the mediation design criteria based on the assumed real-time system capabilities and given a review of what they would hear and see on the draft stimulus. After the stimulus was played, the advisors were asked to discuss their immediate reactions. They were also asked to talk about: 1) information needs and priority (e.g., what was important to know, what should be first, second, third, etc.); 2) length of message (e.g., how much information is appropriate in a single message); 3) timing of information (e.g., was the speaking rate and time between messages appropriate); and 4) language style (e.g., how important is artistic language or less

objective descriptions). The advisors' feedback was summarized into the following comments about certain design features:

- Visual scene orientation- An introduction to what listeners can expect to see and/or hear about is useful. The introduction should briefly highlight the main animals.
- Animal location- Location is critical to the "real-time" experience. A grid reference system that uses location phrases corresponding to height (i.e., top, middle, bottom) and left/right position (i.e., right, center, left), such as "top right" or "middle center", was understandable and probably most useful to a wide range of users compared to a clock position reference.
- Animal label- The species name of the animal is also critical. It is not important to know an animal's personal name unless that animal is known for something unusual such as a certain behavior or physical characteristic.
- Animal's swimming direction- Direction is useful for understanding the animal's path. It is also helpful for listeners who have some ability to see and are attempting to visually follow the animal being identified. However, this is not a critical feature and could be omitted from the system if the accuracy of direction estimation was low.
- Message timing- Messages should be presented with longer pause intervals. Providing longer pauses between messages, could give listeners some time to absorb and maybe contemplate what they heard before the

next message plays. These pauses could also give them a brief break from listening.

- Message presentation- The system should present messages driven by visual events only if the identified animal is not too close to other animals. Listeners should not be confused by two animals near the same location. Messages independent of visual events can be played instead.
- Message content- Messages that focus on an animal's physical characteristics such as size, color, or shape should be presented earlier in the audio than other types of messages (e.g., behaviors, diet), so that listeners can create a mental image of the animal and associate its physical characteristics with related information presented later in the mediation.
- Message language- A good balance of artistic and technical language is important and more descriptive words should by used when they could help convey visual characteristics better. For example, saying that an animal is "lumbering by" versus "swimming by" depicts the swimming style in a more specific way.
- Message length- Messages should provide about 1-3 sentences of information and play only while the animal is visible to a visitor without vision impairment.
- Voice- The narrator's voice should have variation and inflection so that listening to the system doesn't get boring.

These comments informed modifications made to the Ocean Voyager script. A brief introduction to the animals in the exhibit was added, messages discussing animal

physical characteristics were presented before other types of messages, some descriptions were reworded to reflect more specific language, and instances where multiple animals could be confused for the described animal were minimized or eliminated.

The most significant change was to the message timing in that a pause interval between 5-12 seconds was provided before the next message. This design feature was confirmed as implementable by members of the real-time system design team. The significance of this feature to listeners who have vision impairment is important to note. This extra time makes it possible for listeners to build mental images of what is being described and can be used to relax or recuperate from listening and thinking. Further, the advisors' commented on how they frequently wanted to use their residual visual skills to view the video exhibit which resulted in visually straining to keep up with the constant mediation. This impacted their listening ability and mental focus, making them feel like they had just missed what was said. The advisors also suggested that being able to turn the mediation down or off would give additional respite and minimize fatigue. Related to this desire to quiet the mediation, one advisor discussed that at certain times there can be a competition between the eyes and ears for directing mental focus. He proposed that this struggle for focus can be seen in how people turn down the radio in their car or don't want to talk to their passengers when they are trying to visually pay attention to traffic or directions.

The revised script was recorded by the Aquarium docent and synchronized with the common video footage for Ocean Voyager used in the Docent Mediation and Audio Tour Mediation stimuli. The new Real-Time Descriptive Mediation stimulus was presented to the advisors through a YouTube link and they provided feedback through

email. The advisors were positive about the stimulus and did not have any changes to suggest as evidenced by the following excerpt:

> "Overall, I thought it was fabulous. I loved some of the other colorful and creative descriptions, such as a group of smaller fish clustering together at times, resembling flocks of birds in the sky. It's clearly evident that a great deal of thought went into the descriptions and metaphors, but I didn't think any of them were strained or awkward in the context of the video."

This stimulus became the final version of the Real-Time Descriptive Mediation for Ocean Voyager. It ran for a total time of 10:35, with time spent on messages at 8:41 and time spent on pauses at 1:54. The pause length averaged 7 seconds and the average duration of messages was 33 seconds, with a range between 12 seconds and 1:05.

4.2.2.3 Design Meeting with Advisors: Beluga Whales Mediation

In contrast to the design of the Ocean Voyager mediation stimulus, the Beluga Whale mediation script writing process began with a meeting with the advisors and audio describer to discuss important features of the habitat and animals, and generate potential messages for the script. The Docent mediation stimulus was played as a way to stimulate the discussion and point out useful/non-useful information. The advisors provided the following feedback:

- Habitat characteristics- Provide details about the features of the exhibit including the water, overall size, rocks, and environmental enrichment devices. They wanted to know that the water had a haziness to it that made the animals and other habitat features look blurry. They also wanted a description of the environmental enrichment devices that mentioned what they looked like and where they were in the habitat.

- Animal behaviors- Mention behaviors that are interesting, but don't get repetitive about them. For example, if it is possible to know when the beluga whale is rubbing its body on the display glass, it only needs to be talked about once or twice.
- Animal swimming behaviors- The way the beluga whale swims is important to describe. Their style of swimming is a very visual experience for viewers and is what most people comment on when they watch beluga whales in an exhibit.
- Animal physical characteristics- Describe the animals according to how they look, don't just give scientific terminology. For example, they wanted to know that beluga whales have blubber and why, but they wanted the visual description of how they look muscular and that when they move their skin jiggles a bit. The description should be about what people perceive about the animal's appearance and then use facts to back up or refute their perception.
- Message content- With fewer animals in the exhibit, it is appropriate to give in-depth information about the animals. Talk about the reproductive and mating habits, their natural habitat, etc.
- Message accuracy- Information accuracy is expected. Do not provide erroneous details or incorrectly identify an animal. Also, since it probably is not possible for the system to identify a specific animal by a personal name (e.g., Beethoven or Maris) with any degree of accuracy, don't worry about naming them as they swim past. Personal names are only important if there is a particular story to tell or visible characteristic to point out (e.g., pregnant, injured). It is sufficient to give a general mention of the animal and a visible characteristic without needing to

identify it as it swims past (e.g., "You may see a beluga whale that has notches in its tail, that is Nico and he was injured earlier in his life").

- Message equity- It is most important to be getting an equitable experience. Give visual descriptions that are closest to what other viewers see and provide the same facts about the animals that other viewers have access to including signs, videos, or audio. Users of the system should not get any more or less information than people not using the system.

4.2.2.4 Script Preparation for Beluga Whales Mediation

After the design meeting, the Audio Describer was asked to provide some descriptive examples instead of a script for the Beluga Whale exhibit. A few of these phrases were incorporated into a script that was designed based on the advisors' input and criteria used for the Ocean Voyager script. Exhibit characteristics also shaped the development of the script including the positioning of the animals in relation to the size of the display window and the focus on only two species of animals. In providing the location of an animal, the locational grid was reduced to referencing height as top and bottom, and left/right position as left, center, right. There was less of a need to divide the height of the tank into thirds due to a smaller display window and the way the animals positioned themselves within their habitat. The direction of travel (DIR) was not as predictable for the Beluga Whale exhibit as it was for Ocean Voyager based on the more agile and variable swimming behaviors of the beluga whales and harbor seals. As a result, swimming direction was not mentioned. Instead, generic phrases such as "swims past" or "is approaching" were inserted to imply a sense of dynamics and add variety to the messages. Information about routine swimming patterns (e.g., "…floating upside

down, rising to the surface, and diving down to the bottom...") was also included to describe beluga whale movement. Additionally, with fewer animals to identify and talk about, there was more time to spend on giving in-depth physical descriptions and animal facts. An example of a message about the animals that was driven by visual events:

> LOC: Close to the middle right
> LAB: a beluga
> DIR: swims past.
> DESC (species): A beluga's body has a banana-like shape, with a rounder middle and tapering at the head and tail areas.
> DESC (species): Their heads have a rounded dome shape and a beak-like mouth. Their triangular tail is flattened and split into two halves called flukes. Two short, broad pectoral fins are located about a third of the way down on either side of their body just below their heads

Also since there were no other species to point out beyond the beluga whales or harbor seals, messages that were independent of visual events focused on further discussing these animals or on describing other habitat features such as the environmental enrichment devices that the animals interact with. An example of a message that was independent of visual events:

> DESC (species): The beluga whale is a slow-swimming, graceful animal with a normal cruising speed around 2-3 miles per hour; however, they can hit bursts of speed in excess of five miles per hour.

Equivalent to the recording process used for Ocean Voyager, the completed script for the Beluga Whale exhibit was spoken by the researcher and then added to the video to create a draft stimulus to share with the advisors. The draft stimulus of the Beluga Whale RTDM was uploaded to YouTube for the advisors to view/listen to and provide feedback.

The advisors were mostly positive about the design of the mediation. For example, one spoke about the usefulness of the location information:

> "It was very helpful. I did not think it was repetitive. For me it was necessary. I knew where to look for the animal. I also knew what animal I was looking for in the viewing window. I used to have more vision than I do now even though I have been visually impaired all my life. Therefore I have bad habits of looking where there is nothing. You helped me look where I needed to which makes it a better experience for me. I did not have to search around for belugas or the harbor seals the way I do when I drop something on the floor when no one is around to direct me which way it went."

Another advisor also talked about the location, but suggested a need to minimize the repetitive nature of the location references given that there were fewer animals to be introduced. He was concerned that using the same phrase would become monotonous and make people tune out. In strategizing with him and the Aquarium docent, it was decided that variation in the way an animal's location was talked about could make it less repetitious. The script was modified to include different ways of mentioning location, including, "close to the bottom left, a beluga glides by," and "over at the bottom center, a harbor seal moves through the water." These changes and a few others were implemented in the script and recorded by the Aquarium docent who voiced the final Docent and Audio Tour mediation scripts. The total run time of the final Beluga Whale RTDM was 9:23, with 7:33 spent on messages and 1:50 spent on pauses. Pause length averaged 6 seconds and the average message duration was 23 seconds, with a range between 7 and 53 seconds.

CHAPTER 5

METHODS

Data collection for this study was based on a mixed methods approach to: 1) aid in examining and comparing the impact of several types of sound-based mediation on participation of adults with vision loss at live aquarium exhibits and 2) evaluate the effectiveness of real-time descriptive mediation on facilitating participation of adults with vision loss. This chapter will detail the participants, data collection methods (i.e., surveys, questionnaires, and interviews), procedures, and data preparation involved in this study.

5.1 Participants

This study was conducted in 24 dyads (pairs) and included adult partners with acquired vision loss and their familiar adult partners without vision impairment who were likely to accompany them to an aquarium (see Table 2). The primary group of interest was the adults with vision loss; their partners were a secondary group. All 48 participants were 18 years or older and agreed to be a part of the research through an informed consent process approved by the Georgia Tech Institutional Review Board. There were a total of 21 males and 27 females in the study, with 16 people who reported to have low vision (males= 6, females= 10), eight reported being blind (males= 5, females= 3), and 24 (i.e., all partners) reported having no vision impairment (males= 10, females= 14). Dyads were asked to identify their relationship to their partner and the largest group described their partner as “significant other” (n=12). Other dyads stated that their

relationship as “friends” (n= 6), “parent-child” (n=4), “siblings” (n= 1), and “paid assistant” (n = 1).

The inclusion criteria related to vision ability were that participants with vision loss must have significant trouble seeing, even when wearing glasses or contact lenses, or be blind [8] and the onset of their vision loss must be acquired and not congenital (before or shortly after birth). Onset of impairment is a common distinction made in research related to vision impairment. Within this distinction there is some evidence that indicates there is a difference in understanding visual concepts [89]. These possible differences were considered as potentially confounding to this particular study, so individuals with congenital onset of vision loss were excluded. Participants with vision loss were only asked to personally report on their vision abilities and were not asked for a medical diagnosis, about the cause of their vision impairment, or to submit to any diagnostic vision testing.

Participants with vision loss self-reported that their vision impairment was either low vision (n=16) or blind (n= 8). However, as a way of more clearly defining vision disability relevant to the visual display used in this study, participants were asked at the start of the protocol to describe what they were able to see of the stimuli. Their descriptions varied, but could be grouped into whether they couldn’t see anything in the stimuli (“nothing”; n= 16) or could see some motion in the stimuli (some motion; n=8). Eight of the participants who initially reported their vision impairment as low vision were not able to see anything in the stimuli, which meant that their vision disability was comparable to participants who reported that they were blind. Participants who reported no vision impairment or disability were defined as “sighted”

Table 2. Study Participant Details. This table shows the 24 dyads according to their type of relationship, gender, vision impairment, and vision disability.

	Relationship	Gender	Vision Impairment	Vision Disability
1	significant other	m	low vision	some motion
		f	sighted	sighted
2	significant other	f	low vision	some motion
		f	sighted	sighted
3	significant other	m	blind	nothing
		f	sighted	sighted
4	significant other	m	low vision	some motion
		f	sighted	sighted
5	significant other	f	low vision	some motion
		m	sighted	sighted
6	significant other	f	low vision	nothing
		m	sighted	sighted
7	significant other	m	low vision	nothing
		f	sighted	sighted
8	significant other	f	low vision	nothing
		m	sighted	sighted
9	significant other	m	blind	nothing
		f	sighted	sighted
10	significant other	f	low vision	nothing
		m	sighted	sighted
11	significant other	f	blind	nothing
		m	sighted	sighted
12	significant other	f	blind	nothing
		m	sighted	sighted
13	friends	m	blind	nothing
		m	sighted	sighted
14	friends	f	low vision	nothing
		f	sighted	sighted
15	friends	f	low vision	some motion
		m	sighted	sighted
16	friends	m	blind	nothing
		f	sighted	sighted
17	friends	m	low vision	nothing
		f	sighted	sighted
18	friends	m	low vision	nothing
		f	sighted	sighted
19	parent-child	m	blind	nothing
		f	sighted	sighted
20	parent-child	f	low vision	some motion
		m	sighted	sighted
21	parent-child	f	low vision	some motion
		f	sighted	sighted
22	parent-child	f	low vision	nothing
		f	sighted	sighted
23	siblings	m	low vision	some motion
		m	sighted	sighted
24	paid assistant	f	blind	nothing
		f	sighted	sighted

5.2 Docent and Audio Tour Stimuli

In attempting to understand the effectiveness of real-time descriptive mediation in facilitating participation at live aquarium exhibits, it was important to examine and compare participants' experiences with traditional docent presentations and asynchronous audio tour mediation. To perform this comparative evaluation, it was necessary to use stimuli that were representative of the existing Georgia Aquarium docent and audio tour practices and content. This section discusses the processes involved in developing docent and audio tour mediation stimuli to be used in evaluation activities.

5.2.1 Docent Mediation

The Docent stimuli were created before the Audio Tour stimuli because it was assumed that a live docent presentation would be more authentic and the video recording of the exhibit during the presentation could serve as the common footage used for the three types of mediation for each exhibit. It was also expected that the Docent mediation would require more post production editing than the Audio Tour. High definition video recordings of docent presentations at the Beluga Whale and Ocean Voyager exhibits were collected at the Aquarium after visitor hours to eliminate visitor interference. A docent from the Aquarium who routinely provided exhibit narrations at the two exhibits was instructed to give a typical narration for each of the exhibits during the recordings. She was asked to present for approximately 6-8 minutes at the Beluga Whale exhibit and 7-9 minutes at the Ocean Voyager exhibit. This timeframe coincided with the average time spent by visitors at these exhibits based on an unpublished timing and tracking study conducted during the formative stages of this work. Her presentations served as a

baseline of the common and current information that was delivered to visitors on a daily basis.

The resulting voice recordings taken during the docent presentations were not of high enough quality nor would they match the quality of the other mediation stimuli that were to be produced in a recording studio. The docent was asked to take the video into the recording studio and perform additional narrations similar to her originals so that high-quality voice recordings could be used for all of the study stimuli. She was specifically told not to rehearse or provide any different information from what is normally given. These studio recordings were compared to the originals to ensure that there wasn't any significant difference in presentation style or information and were chosen to represent the "docent" mediation used as study stimuli.

These recordings were further edited using Adobe Audition software to remove extraneous information that wasn't relevant to the purpose of the current study. For example, instructions for the audience to sit down and leave room for the walkway and advertising for additional services such as behind-the-scenes tours were taken out. These edits did not affect how the narration corresponded to the video details, but did reduce the duration of the Ocean Voyager audio recording by almost 2 minutes. The final audio recordings were synced with the HD video footage for the two exhibits through the Adobe Premiere Pro software. The starting times for the audio in each of these videos were used as the starting times for the other two mediation types (i.e., audio tour and real-time descriptive mediation). This ensured that the audio began at the same times for three Beluga Whale stimuli and three Ocean Voyager stimuli.

5.2.1.1 *Ocean Voyager*

For the Ocean Voyager exhibit, her presentation began with a greeting to visitors and then she told them the exhibit name and introduced herself. She also mentioned where she was located because during live presentations it can be hard for visitors to see where the docent is standing among the crowd. The docent moved into the interpretive content by discussing the habitat dimensions and filtration system, making the link between the enormity of the habitat and the fact that they have four whale sharks. She then went into a brief overview of whale sharks including the length of the sharks in the exhibit, typical size of the species, and dietary habits. The manta rays were talked about by pointing out identifiable color markings and the location of a named animal, mentioning her wing span, providing facts about the exhibit animals and species, and discussing how they use their cephalic lobes to swim. The next two animals in the presentation were the zebra shark and sawfish with references to their unique features. The final animal mentioned was the grouper, with a point about their life span and fishing practices that impact the sustainability of the species. This content led into a message about the Aquarium's Seafood Savvy program cards that inform consumers about sustainable seafood choices for market or restaurant purchases. She ended by thanking the visitors and telling them goodbye. This content was typical of the daily presentations given by other docents. The total time of the final Docent Ocean Voyager mediation was 5:47.

5.2.1.2 *Beluga Whales*

The content provided for the Beluga Whale exhibit began with a welcome and an introduction to the exhibit and the docent. She talked about the beluga whales and named

the one that appeared close to the viewing window and discussed his age, weight, and length. Next, she gave demographic details for the other three beluga whales including where they were born. She then mentioned the color difference between baby and adult beluga whales and how the adult's white coloring helps them blend in with their natural habitat. The docent also discussed that beluga whales are mammals and how their bodies are designed to help them to stay warm in cold waters and periodically breathe air. Information about their dietary habits was also brought up, including facts about their teeth and mouths. The harbor seals were briefly discussed in terms of the similarities between them and beluga whales and how they can jump out of the water onto the rocks above the exhibit. She ended with a thank you and good bye to the visitors. The total time of the final Docent Beluga Whale mediation was 5:12.

5.2.2 Audio Tour Mediation

The Audio Tour stimuli were based on the audio tour that was produced by the Aquarium in 2007 (with minor additions made in 2011). This audio tour was available via a call-in phone service (intended for visitor's mobile phones) or by Internet file download for MP3 players and was discontinued in 2013. It was laid out much like a book with "chapters" representing each of the five major exhibit galleries in the Aquarium and separate sections for specific animals. Visitors could select different sections by using the interface on their phone or MP3player. The existing audio tour was spoken by one of the Aquarium staff members and each section had a brief musical introduction.

The existing audio tour recording was not used since it was important to have the same presenter for all study stimuli. However, a majority of the content on beluga whales and the ocean voyager animals was used with only minor alterations to the Beluga Whale script to remove erroneous information and changes in terminology that the Aquarium was concerned about presenting to the public. The Beluga Whale script was not modified to include information on harbor seals which were added to the exhibit after the audio tour was originally produced by the Aquarium. This choice was made in an effort to represent the reality of using recorded audio tours and that when exhibits change or institutional language evolves, interpretive materials such as audio tours might not get adapted immediately. One of the reasons for this is that editing a traditional audio tour can be challenging because the recording is typically presented in a continuous flow or in a story-telling manner by a single narrator. Changes or additions to the information generally requires a re-recording of a portion or all of the tour depending on the desire for vocal consistency, capabilities of recording and playback technologies, and duration or timing constraints for playback. The new scripts were recorded in the studio by the docent who produced the Docent stimuli just described. These recordings were synchronized to the HD video to begin at the same video start time as the Docent stimuli.

5.2.2.1 Ocean Voyager

The Ocean Voyager audio tour included an introduction and 10 sections for various species including whale sharks, jacks, giant grouper, and zebra sharks. The total time to play all of these chapters was just under 20 minutes. Each of the sections introduced an animal and mentioned at least one distinguishing physical characteristics such as weight or color as well as gave a couple of facts about its diet, its natural habitat,

or an interesting behavior. The information about seven of the 10 animals was compiled into a new script to reduce the overall recording length, and depict the current and frequently visible animals. The total time of the final Audio Tour Ocean Voyager mediation was 8:01.

5.2.2.2 Beluga Whales

The Beluga Whale exhibit information in the original audio tour was produced as one section and lasted just under 2 minutes. It focused on how beluga whales are like humans by the fact that they are mammals that are warm-blooded, breathe air, and nurse their young. There was mention of a few of the beluga whale's important physical features such as the lack of a dorsal fin and their bendable necks. The tour also talked about one of the young beluga whales in the exhibit, how old she was, and where she was born. Other information provided in the tour was about the where the male belugas were from and how the Georgia Aquarium is part of an effort to breed belugas. When this script was given to the Aquarium docent for recording, she mentioned that there had been changes in the content practices of the Aquarium and that some of the information would need to be edited to reflect those changes. As mentioned previously, some content was removed such as the detail about the young female and the comments about breeding efforts and the information on where the beluga whales were from was updated. These edits reduced the duration of the audio recording by about 20 seconds compared to the original. The total time of the final Audio Tour Beluga Whale mediation was 1:30.

5.2.3 Mediation Stimuli Comparison

Although the three mediation stimuli (i.e., Docent, Audio Tour, and RTDM) varied in their content and style in which the content was presented, it was important to

maintain as much consistency as possible in the audio recording to minimize potential listener biases. Characteristics such as sound quality, gender of speaker, and clarity were controlled for by having the Aquarium docent perform the recording for all of the mediation stimuli. Despite these efforts to make the recordings "sound" similar, there were length and rate differences that could impact listeners' experiences. The RTDM recordings were longer and contained more words for both exhibits compared to the Docent and Audio Tour stimuli (see Table 3). However, the speaking rate (i.e., words per minute - wpm) was lower for the RTDM in both exhibits (160 wpm) than for the Docent (Ocean Voyager= 204 wpm; Beluga Whales= 192 wpm) and Audio Tour (Ocean Voyager= 160 wpm; Beluga Whales= 167 wpm) stimuli.

Table 3. Mediation Transcript Attributes. This table depicts the total reading time, word counts, and words per minute for both exhibits across the three mediation types.

		Total Time	**Word Count**	**Words per Minute**
Ocean Voyager	Docent	5:46	1185	204
	Audio Tour	8:01	1206	160
	Real-Time Descriptive Mediation	10:35	1321	160
Beluga Whales	Docent	5:12	992	192
	Audio Tour	1:30	251	167
	Real-Time Descriptive Mediation	9:23	1140	160

5.3 Surveys and Questionnaires

Several instruments were developed for this study because there were no known standardized tools that would provide appropriate data for addressing my research questions without significant modifications to their questions. The instruments prepared for this study were the *Prior Aquarium or Zoo Exhibit Experience Survey, Aquarium Exhibit Expectations Survey, Post-Stimulus Mediation Feedback Survey, Preferred Mediation Questionnaire,* and *Preferred Mediation Impact Survey* (see Appendices A-E). The instruments were designed to be presented and responded to orally for participants who had vision impairment or as a traditional pen and paper format for participants without vision impairment. Large print versions of the response scales were available to those who wanted to use them for reference.

Several techniques were used to determine that the instruments had appropriate face and content validity including reviewing relevant instruments and measures from ILE and rehabilitation fields, and consulting with independent reviewers. However, the focus of this study was not on the development of these instruments, so statistics-based methods for establishing validity and reliability were not employed. Existing resources were collected and analyzed to identify measures that could be adapted for reporting on learning, entertainment, social, and restorative goals.

Resources that had the most applicability included: the *Motivation Categories Tool* from the Visitor Evaluation Toolbox [90]; a portion of a questionnaire on visitor experiences that was created by Packer [2]; the Workplace Participation Scale [91]; a draft version of the World Health Organization's Prevention of Blindness and Deafness (WHO/PBD) *Visual Functioning Questionnaire* [92]; and the Laumann and colleagues'

[93] instrument that examined restorative components. Educational staff members from the Georgia Aquarium also provided input and feedback on potential measures, particularly for exhibit knowledge questions. Additionally, individuals who were not involved in the study helped determine the association of question concepts to participation constructs.

Several individuals with expertise in survey design reviewed draft instruments for readability and understandability before they were finalized. These instruments were also assessed during two pilot tests of the full protocol. Based on these pilot tests, minimal corrections were made to the instruments' layout and instructions and the procedures for describing the content and response choices were clarified.

5.3.1 Previous Exhibit Experiences

Prior Aquarium or Zoo Exhibit Experience Survey (Appendix B) was designed to measure participants' past aquarium or zoo visits in terms of learning, entertainment, social, and restorative outcomes. The survey also included questions about the impact of vision impairment on exhibit experience. Questions on this survey were partially inspired by the instruments referenced above. An example question from this survey was: "Going to zoo or aquarium exhibits is a way for me to be social with my family/friends". The response choices were on a five-choice frequency scale that included: "never", "rarely", "sometimes", "often", and "always".

5.3.2 Exhibit Expectations and Mediation Impacts

The *Aquarium Exhibit Expectation Survey* and the *Preferred Mediation Impact Survey* had similar questions and were designed to measure participants' expectations for exhibits to address learning, entertainment, social, and restoration needs. The *Aquarium*

Exhibit Expectation Survey was completed once by participants prior to exposure to the study stimuli to understand their existing exhibit expectations. The *Preferred Mediation Impact Survey* was the final instrument that participants completed after experiencing all of the study stimuli and focused on whether their preferred mediation would address their exhibit expectations. These instruments were based on Packer [2], with 24 of 30 potential measures adapted from this resource. At least six potential measures were chosen in each of the exhibit outcome categories, including measures such as "use my imagination" and "do something exciting". Ten reviewers were asked to categorize each measure according to the associated participation outcome (i.e., learning, entertainment, social, and restoration) as a method for establishing low-level construct validity. There were 15 measures that achieved 100% agreement in outcome categorization by the reviewers. Three measures from each category were selected for the pilot survey. As previously mentioned, measures about imagination and creativity were included as probes to explore these concepts in relation to participation, but not analyzed as part of this work. A total of 15 items and a 5-choice response scale of agreement ("strongly agree", "agree", "neither", "disagree", and "strongly disagree") were included on both surveys.

The primary difference between the surveys was in the presentation and wording of the survey items. The *Aquarium Exhibit Expectation Survey* asked participants to respond to a main question: "What would you hope to get out of going to aquarium exhibits?" Each item was then listed individually with the same initial carrier phrase: "At an aquarium exhibit, I hope to…" The *Preferred Mediation Impact Survey* asked

participants to respond to each item using the carrier phrase: “The audio that I liked the most would help me to…”

5.3.3 Mediation Preferences

Immediate feedback related to the stimuli was gathered through the *Post-Stimulus Mediation Feedback Survey*. This instrument asked participants to rate the level of support the mediation stimulus gave in addressing learning, entertainment, social, and restoration needs. The survey was completed after exposure to each of the stimuli. Responses were selected from a 5-choice scale of: “a lot”, “much”, “some”, “a little”, or “not at all”. An example question from this survey was: “How much did this audio help you to be able to communicate with your partner.”

The *Preferred Mediation Questionnaire* was developed to identify the mediation stimulus that was most preferred by participants in meeting their overall needs and provide details about how that mediation helped in addressing learning, entertainment, social, and restoration needs. These questions were in an open-ended format to enable participants to provide the depth of information they wanted. This instrument also asked participants to choose the mediation stimulus that would be best at meeting each of the specific needs. For these questions, participants were expected to choose the mediation stimulus for each specific need according to the order in which it was presented. For example, if the participant believed that the stimulus that was presented to him/her first would be best at helping him/her to “learn more about the exhibit,” he/she would select “1”. So, a participant could choose a particular mediation stimulus for meeting their overall needs and discuss how it addressed learning, entertainment, social, and restoration

needs. However, that participant could also report that a different mediation stimulus was actually better at meeting specific learning, entertainment, and restoration needs.

5.4 Post Stimulus Interviews

Brief semi-structured interviews were conducted after each mediation stimulus presentation with both partners. These interviews were used to gather immediate feedback about the design and effects of the mediation and directed in a way that enabled partners to discuss related topics such as shared memories of past museum visits or the perceived capabilities of technology. All study dyads were asked the same introductory question, "What do you think about that audio?" Each participant in the dyad took a turn at responding and as the discussion proceeded, additional questions were asked to probe about certain mediation design features such as voice rate, level of description, and type of information. As participants talked about related topics, they were asked follow up questions to understand their prior experiences, visit expectations, and further inform the design of the real-time descriptive mediation system.

Figure 14. Mediation Study Space. This image shows the arrangement of the study room and presentation of the mediation's visual display.

5.5 Experimental Protocol

During the recruiting process, participants with vision loss were the principle contacts and responsible for identifying an adult partner who was familiar and would be likely to accompany them to an aquarium. Participants with reported vision loss were screened over the phone to ensure that: 1) their vision loss was acquired and not congenital; 2) their partner did not have any uncorrected vision issues; 3) both partners could speak and understand English proficiently; 4) neither partner had a hearing impairment that would affect listening to the mediation or engaging in conversation; and 5) neither partner had been to the Georgia Aquarium in the past two years. The screening also included questions about their vision abilities related to glare effects, acuity,

tracking, and watching images on a television screen. None of the participants had taken part in any of the studies from the formative work.

The study was conducted in a usability lab at Georgia Tech that supported the video and audio display needs for the stimuli. The video portion of the stimuli was projected onto a flat, non-reflective wall to a size of 8' X 4.5' and the lights were dimmed to the level requested by the dyad (see Figure 14). Audio was played through high-end stereo computer speakers and was set at a level that was reportedly comfortable to the

Table 4. Conditions for Mediation Presentation. This chart shows the possible conditions for mediation presentation to which dyads could be assigned.

Presentation Sequence / Exhibit	1	2	3	4	5	6
Beluga Whales	DAR	DRA	RDA	RAD	ARD	ADR
Ocean Voyager	DAR	DRA	RDA	RAD	ARD	ADR

dyad. Participants were seated in typical office chairs that they could adjust for height and move around the room to a position that was optimal for them to see and hear the stimuli.

Participant dyads were assigned to one exhibit (Beluga Whale or Ocean Voyager) and a randomized mediation stimuli presentation. Given the number of exhibits and possible presentation sequences, there were 12 potential conditions for assignment (see Table 4). Two dyads were assigned to each condition to provide an equal distribution across all presentation sequences and exhibits.

At the start of the each session, the study purpose was reviewed and dyads consented according to the approved IRB protocol. Each participant was asked to complete the *Prior Aquarium or Zoo Exhibit Experience Survey, Aquarium Exhibit*

Expectation Survey, and *Pre-Stimulus Knowledge Questionnaire* before exposure to the first stimulus in their assigned condition. Participants with vision loss completed the instruments via oral presentation and response with the researcher recording their responses through pen and paper as well as through audio recording. Participants without vision loss were asked to complete their instruments in a separate room on their own so that they would not be disturbed nor influenced by their partners' responses.

According to the dyad's assigned condition, the first stimulus was played and the post-stimulus interview was conducted. Each partner then completed the *Post-Stimulus Knowledge Questionnaire* and *Post-Stimulus Survey* following the procedures mentioned above. The second and third stimuli were played with post-stimulus interviews and surveys after each. Next, the partners were asked to complete the final two instruments, the *Preferred Mediation Questionnaire* and *Preferred Mediation Impact Survey*. The session ended with a debriefing about the study and an opportunity for the participants to ask questions or provide additional information about their experiences.

5.6 Post-Stimulus Interview Data Preparation

Audio recordings of the post-stimuli interviews were uploaded to a computer after each session occurred and labeled with a numeric code assigned to the subject dyad. These recordings were transcribed by the researcher and one file from each dyad was randomly checked by a secondary transcriber for accuracy. Transcription was not performed according to strict linguistic guidelines as the purpose of this research activity was to capture the perceptions and preferences of the participants and not to investigate the linguistic features of their statements. As the recordings were transcribed, each file

was annotated with important statements or points to be examined later. A total of 72 transcription files were created from the initial post-stimuli interview data, with each file representing one subject dyad and one study condition (e.g., Beluga or OV exhibit as Audio Tour, Docent, or RTDM). Transcript files for the dyads were duplicated so that there would be a data file for each participant in a dyad. Further, additional audio recordings from the study sessions were transcribed since they contained information relevant to the themes of the post-stimuli interviews. There were 150 transcribed files with a total of 43,129 words for the post-stimuli interviews. These files were loaded into qualitative research data analysis software and reviewed for further commenting relative to the coding process.

All transcription data was analyzed based on an open coding content analysis that was partly guided by the researcher's previous work, questions asked during the interviews, and annotation during the transcription phase. Coding proceeded with inductive and deductive influences and memoing [94] was performed to expand on the meaning of certain data and theorize about their importance to my research questions. Over 600 excerpts were thematically analyzed [95] to generate multi-level categories associated with two main groups of data relevant to this study: 1) Previous Experiences and Exhibit Expectations and 2) Feedback on Mediation Features. Data related to *Previous Experiences and Mediation Expectations* included information about positive and negative prior exhibit experiences, mediation techniques that partners have developed on their own, and considerations for improved mediation. *Feedback on Mediation Features data* was the primary goal of the post-stimuli discussions and represented participants' criticisms of and preferences for design features and content.

To review the coding for reliability, an outside reviewer who was experienced in qualitative research was asked to assign randomly selected excerpts to the appropriate main data themes and secondary groupings. This task was completed through a feature of the qualitative research analysis software.

CHAPTER 6

FINDINGS ON MEDIATION AND PARTICIPATION

> "I'm here and standing before these magnificent creatures and I want the sensation that this is happening and with the information. Just the information isolated from the scene is not exactly, it doesn't take into consideration that I've traveled to this exhibit and I'm in this space with others who are having a joint experience, I want a taste of it."

The data presented in this chapter are derived from the surveys, questionnaires, and interviews introduced in the previous chapter. These results are organized according to the themes identified in the interview coding process since the data in the surveys and questionnaires were also relevant to these themes. Recall that the themes were: 1) previous experiences and exhibit expectations; 2) feedback on study mediation; and 3) evidence of study mediation effects. This organization provides a structured perspective for linking data to the concepts of participation, real-timeness, and descriptiveness that were central to my research questions and the inspiration for design features that were incorporated into the real-time descriptive mediation developed for this research.

The heart of this analysis is the qualitative data collected during the interviews and open-ended responses on the questionnaires. However, there were a number of quantitative (or at least, quantifiable) metrics gathered through the surveys and questionnaires. Due to the low number of participants and the primary reliance on subjective reporting in this study, I focus on descriptive statistics in reporting of these data rather than hypothesis testing and inferential statistics. Additionally, I present only those aspects of the data that are meaningful to my research questions. Other important considerations in the analysis of these data are in the comparative experiences and

perceptions of the participants based on their vision abilities (i.e., vision loss and no vision loss) and exhibit on which the mediation focused (i.e., Beluga Whales or Ocean Voyager). While similarities and differences will be noted when important, there will not be a systematic discussion that seeks to separate data based on participants' vision ability or exhibit since there was not a specific research question related to these distinctions.

6.1 Previous Experiences and Exhibit Expectations

6.1.1 Experience and Expectation Surveys

The *Participation-Based Aquarium Exhibit Expectations* and *Prior Aquarium and Zoo Exhibit Experiences* surveys collected subjective quantitative data about exhibit motivations. All participants completed these surveys in the initial segment of their study session.

Results for the *Participation-Based Aquarium Exhibit Expectations Survey* (see Table 5) showed that a majority of participants either *strongly agreed* or *agreed* that they had expectations related to learning, entertainment, social, and restoration motivations. Learning motivations had the most agreement, with all participants at least *agreeing* that they had expectations for learning. Within the group of measures related to learning, "At an aquarium exhibit, I hope to expand my knowledge" had the numerically lowest total mean (1.13), which corresponded to the greatest number of participants reporting that they *strongly agree* they had this exhibit expectation. While there was less agreement about entertainment and social motivations compared to learning, an average of over 91% of participants still *agreed* or *strongly agreed* that they had exhibit expectations associated with these motivations. Expectations related to restorative motivations had the

Table 5. Participation-Based Aquarium Exhibit Expectations. The survey asked participants to respond on a scale of 1 to 5, where 1 is strongly agree, 2 agree, 3 is neither, 4 is disagree, and 5 is strongly disagree. Responses for participants with vision loss are in unshaded rows and those for participants without vision loss are in shaded rows.

	At an aquarium exhibit, I hope to:	1 strongly agree	2 agree	3 neither	4 disagree	5 strongly disagree	Group Means	Total Mean	Median
Learning	Expand my knowledge	21	3				1.13	1.13	1.00
		21	3				1.13		1.00
	Learn something new	19	5				1.21	1.19	1.00
		20	4				1.17		1.00
	Gain a better understanding	19	5				1.21	1.29	1.00
		15	9				1.38		1.00
Entertainment	Be entertained	17	5		2		1.46	1.44	1.00
		15	8	1			1.42		1.00
	Enjoy myself	19	4		1		1.29	1.21	1.00
		21	3				1.13		1.00
	Do something exciting	13	10	1			1.54	1.56	1.00
		12	10	2			1.58		1.50
Social	Interact with others	9	15				1.63*	1.83	2.00
		6	11	7			2.04*		2.00
	Have a shared experience with my partner	12	12				1.50	1.60	1.50
		9	14		1		1.71		2.00
	Talk about interesting things with someone else	11	12	1			1.58	1.69	2.00
		8	13	3			1.79		2.00
Restoration	Relax	11	9	3	1		1.75	1.77	2.00
		10	10	3	1		1.79		2.00
	Get away from the responsibilities of everyday life	9	8	6	1		1.96	2.15	2.00
		3	13	5	3		2.33		2.00
	Find some peace and tranquility	7	13	2	2		1.96	1.92	2.00
		5	18		1		1.88		2.00

Note: An * indicates a result that is significant at the $p < .05$ level.

least overall level of agreement with only 80.6% of the participants who *agreed* or *strongly agreed* that they had related expectations. The numerically highest total mean (2.15) was for the measure, "At an aquarium exhibit, I hope to get away from the

responsibilities of everyday life." However, even though the higher total mean for this measure included participants who indicated neutrality or disagreement, it still represented an overall average agreement that this was an exhibit expectation.

There were no significant differences in the responses of participants with and without vision loss across all measures except for the measure, "At an aquarium exhibit, I hope to interact with others." Participants with vision loss had stronger agreement with the statement as indicated by a mean of 1.63 compared to a mean of 2.04 for those without vision loss, $t(46) = 2.271$, $p = .028$. The basis behind this gap is unclear since the other two measures in the social motivation grouping had lower means and less disparity between participants with and without vision loss.

The first two questions on the *Prior Aquarium and Zoo Exhibit Experience Survey* asked participants to rate the frequency (i.e., *never, rarely, sometimes, often, always*) of the impact of their vision ability (eyesight) on visiting and partner burden at zoo and aquarium exhibits. It was anticipated that the responses on these questions would be statistically different between participants with and without vision loss. On average, participants with vision loss reported that because of their eyesight, they *sometimes* were hesitant to visit exhibits and *sometimes* felt like a burden to their partner at exhibits. Yet, almost half (n=11; 45.8%) cited that they were *often* or *always* hesitant to visit and a third (n=8; 33.3%) mentioned that they *often* or *always* felt like a burden. Conversely, nearly all participants without vision loss *never* felt hesitant to visit (n=22) or like a burden to their partner (n=23). An independent samples *t*-test revealed that the responses from participants with and without vision loss were significantly different for hesitancy and burden. The impact of eyesight on visit hesitancy was significantly greater for

participants with vision loss, $t(27.65) = -6.787$, $p = <.001$. Note that there was a larger variance for the group with vision loss (Levine's test $F(46) = 32.77$, $p < .001$), which reflects the fact that this question is largely irrelevant for participants without vision loss. Similarly, the impact of feelings of burden were significantly greater for those with vision loss, $t(24.63) = -8.523$, $p = <.001$, which was also associated with larger variance within the vision loss group (Levine's test $F(46) = 24.35$, $p = <.001$).

For the remaining questions on the *Prior Aquarium and Zoo Exhibit Experience Survey* (see Table 6), participants were largely positive about being able to address their exhibit motivations during their prior experiences. For learning, social, and entertainment motivations, the average response given indicated that participants have *often* been able to address their needs at zoo and aquarium exhibits. Learning and entertainment had the same mean, which was also the highest (4.44), and social followed closely with only a slightly lower mean (4.42). Restoration had the lowest mean (3.52) for all participants which signified that this motivation was less frequently addressed than the others. Both groups of participants had similar responses with somewhat higher means of frequency for participants without vision loss on almost all questions. One exception was equivalent mean responses (4.42) on the question about social motivations. Based on an independent samples *t*-test, the responses from participants with and without vision loss were significantly different for the measures associated with entertainment, $t(46) = 2.482$, $p = .017$, and restoration, $t(46) = 2.475$, $p = .017$. On both of these measures, participants with vision loss reported lower frequency of these motivations being addressed at exhibits than participants without vision loss. Participants with vision

Table 6. Prior Aquarium or Zoo Exhibit Experiences. This table shows the distribution of participant responses on a scale of frequency for each question. Data in the response columns indicate number of participants. Data in the "Mean" and "Median" columns correspond to the mean and median value on the response scale. Responses for participants with vision loss are in unshaded rows and those for participants without vision loss are in shaded rows.

Question	1 never	2 rarely	3 sometimes	4 often	5 always	Group Mean	Total Mean	Median
2. Because of your eyesight, how often have you been hesitant to visit zoo or aquarium exhibits?	4	4	5	6	5	3.17	2.15	3
	22	1	1			1.13		1
3. Because of your eyesight, how often have you felt that you were a burden to your partner at zoo and aquarium exhibits?	3	4	9	7	1	2.96	2.00	3
	23	1				1.04		1
4. I feel like I learn something when I visit zoo or aquarium exhibits		1	2	8	13	4.38	4.44	5
			5	2	17	4.50		5
5. I feel entertained when I go to zoo or aquarium exhibits		1	5	7	11	4.17*	4.44	4
			1	5	18	4.71*		5
6. Going to zoo or aquarium exhibits is a way for me to be social with my family/friends		2	1	6	15	4.42	4.42	5
	1		3	4	16	4.42		5
7. I feel relaxed or in my own world when I go to zoo or aquarium exhibits	3	3	10	4	4	3.13*	3.52	3
		2	6	8	8	3.92*		4
8. I can experience zoo or aquarium exhibits in the way that I want to	8	7	6	1	2	2.25*	3.13	2
		2	5	8	9	4.0*		4

Note: An * indicates a result that is significant at the p< .001 level.

loss were also less likely to experience exhibits in the way they want as indicated by more than half (n=15; 62.5%) reporting that they are *never* or *rarely* able to get the experience they wanted. Conversely, only 8.3% of participants without vision loss (n=2) reported that they have the same level of difficulty experiencing exhibits. An independent samples *t*-test showed that participants with and without vision loss were significantly different for this measure, $t(46) = 5.470$, $p = <.001$.

The results of the two surveys had a similar pattern in that learning motivations had overall higher levels of agreement for expectations and were more frequently addressed during previous exhibit experiences. Following on that pattern, entertainment motivations had next highest level of agreement and tied with learning for being addressed at an exhibit; social was third in both expectations and being addressed; and restoration had the lowest level of agreement for expectations and was less frequently addressed at exhibit. This hierarchy was not unexpected given the traditions in the design of ILE exhibits and field research that emphasize entertainment and social goals as secondary to learning and rarely include other goals such as restoration.

6.1.2 Post-Stimulus Interview Comments

Although the post-stimulus interviews were primarily intended to elicit feedback about the mediation, participants talked about their previous exhibit and other relevant experiences. The information they shared provided insights about prior encounters with exhibits and mediation. Their comments also revealed the strategies they have developed to address exhibit and mediation challenges as well as the difficulties that persist. Because the focus of the remarks tended to be associated with vision impairment, most of the discussion was driven by the experiences and needs of participants with vision loss. However, there were instances of partners without vision loss explaining shared incidents and their own frustrations with exhibits.

6.1.2.1 Assumptions and Realities about Exhibit Access and Participation

A common thread running through much of the discussion about prior experiences was that participants with vision loss anticipated that certain settings such as aquarium exhibits were not going to be accessible to them. They recognized that these

settings were not likely to meet their needs and in some cases, became places that the person avoided so as to not be frustrated or disappointed. Participants also expressed that they may not feel included in these settings even when mediation was provided.

Deciding not to visit an aquarium may be based on the belief that going with a vision loss will be a lower quality experience compared to previous sighted experiences. One participant who had low vision talked about expecting that certain activities were not going to be the same since her vision declined and because of that, she had not been to the Georgia Aquarium. However, she pointed out that mediation such as the RTDM could improve her Aquarium experience and enable her to share with her partner.

> "I tend not to do some things because I know that it's just not going to be the same experience. So, this is great, I would love to see something like this because I would run to the Aquarium. You know because I haven't gone because I'm like, 'Oh well, this is not going to be a good experience for me.' But, I love doing this with my partner. I love for us to have conversations and stuff. You know, we'll talk about the grouper tonight I'm sure."

Another participant who had low vision voiced his concerns about going places that have visual components and feeling like it is not worth it for him to be there unless he is with a partner who can tell him what is happening. Further, his comments were given after listening to the RTDM and he suggests that this type of mediation would make visiting an aquarium more enjoyable for him despite his vision loss.

> "Overall, this is excellent, because I would enjoy this. Sometimes I don't like to go to different things because I can't see it and there's nothing for me there, so I'm just standing there with [a friend] and she's laughing at something and then she's like, 'Let me tell you what that is.' I'm like, 'What are you laughing at because I can't see it.' So, then I feel like, 'Why am I here?' That's why a lot of things, I don't do any more because with me not being able to see it, my interest disappears if I don't have a person with me that remembers I'm visually

> impaired. Because sometimes I'm with people that are so used to me and they forget. They don't mean no harm, they just forget. So that is why I don't want to go to certain places. But this here, this would challenge me and this would make me want to go to the Aquarium. Now, I'm ready to go the Aquarium."

While some participants reported that they avoid these settings, others described going to these environments, despite their concerns, and ending up feeling excluded from the experience. In one case, a participant explained that she was used to being excluded in these settings due to her vision loss. Her partner and she talked about how it doesn't seem like much effort is put towards making a person with vision loss feel included in these settings.

> 1: "Because I'm used to being a person with visual impairment who is not included in the sense of these kinds of environments."
> 2: "Yeah, you're only included because you show up. But there's nothing special."
> 1: "Yeah, you better bring your husband with you and let him whisper into your ear if you really want to. Or call us three weeks in advance and we'll do something special for you or maybe if you get a group together, you can bring *your people* with you."

A few participants talked about being excluded due to the typical sound-based mediation in these settings not being designed for people with vision loss. For example, a participant with low vision was giving his feedback about the Docent mediation, which he described as "typical" mediation found in environments similar to aquariums, and pointed out that it did not take into account that a person may not be able to see the visual scene.

> "That sounded more typical of these, it sounded live. It kind of had no regard for anyone who was not actually seeing what was going on. So that's why I say it's typical, because most environments that's what you get. So it sounded very typical, very familiar to me. That there was not

> an awareness that somebody like myself was present. That being said, I'm kind of used to that so I listen intently..."

6.1.2.2 *Partner as Mediator*

The design of aquarium exhibits requires mediation for visitors with vision impairment to experience what is being displayed, yet it is not always provided and when it is, participants with vision loss report that it is generally not designed to be useful to them. These exhibit-based mediation limitations make it unlikely that visitors with vision impairment can effectively address their exhibit motivations. As a result, the partners who accompany them often have to perform their own mediation in an attempt to compensate for information inadequacies regardless of whether they are interested in doing so or have the skills. Participants with and without vision loss talked about this partner-based mediation as a dependency that does create stress between partners and impact each person's individual experience.

As would be the case with most partners as mediators, they are not likely to have sufficient knowledge about exhibit animals which would limit the type of information that could be conveyed to the person with vision loss. Another constraint to partner-based mediation is that not all partners are skilled describers of the visual scene and do not give enough detail. A participant with vision loss explained that when she goes to aquariums, her partner can't mediate effectively for her needs:

> "When I go to the aquariums, it's like I'm just there and listening to someone who's not as knowledgeable about the fish. He can describe the colors and size, but not really tell me any detail or anything or any history about the fish. And there's a lot of other things."

Partners may not always be responsible for all mediation components. Exhibit-based mediation commonly focuses on scientific information and interesting animal facts. Partners can complement these components by giving the visual details such as animal location and physical description. One participant without vision loss talked about location information missing from the Audio Tour mediation and said that as a partner, he would have to contribute that information towards more comprehensive mediation. Another participant without vision loss noticed information missing from the Docent mediation and discussed how she would tell her partner those details as part of her mediation:

> "I guess I was thinking as she was doing it that if you've never seen a beluga whale, there could have been more description of the beluga whale itself, you know. Kind of the face and the head and all that. But that's from me trying to. I would be trying to tell it to him so, I mean, I didn't hear all that or the size of the tank and how far they can go or what's in the tank or anything like that. I think if I was describing it to him, I would have told him all of that."

Partner-based mediation results in the person with vision loss being dependent on their partner to provide the visual information that is missing. One participant used terms such as "rely" and "need" when referring to the mediation relationship he has with his partner:

> "I rely a lot on her to point out things that I'm not seeing. Lots of times, I'm seeing things that aren't what I'm really seeing and I need her to be able to point out, you know, what is that? For example, when that seal was in there, I might have mistaken that for a baby beluga."

This dependency may force the partners into a shared experience that does not provide ample opportunity for each partner to have their own personal experience. This could make it difficult for one or both partners to address their exhibit motivations in an

effective manner. One set of partners mentioned that they had used audio tours at museums and found them to be helpful for supporting separate experiences. Conversely, they reported that when the partner without vision loss has to mediate, it makes him miss out on his own experience. At the start of the following excerpt, the partners had been asked if an audio tour encourages separate experiences for them:

> RESEARCHER: "Does it also make you feel like you can have your own experience versus having to rely on each other."
> 2: "Yeah, it does because if we don't have that, then I have to do the audio description."
> 1: "And then he misses out on his own experience."
> 2: "I'm so busy trying to audio describe that I don't necessarily get all of the sensory input that I normally would. To give you an example when we go to a restaurant, I read the menu and read it thoroughly for whatever it is that she wants so that she can make a decision, but what that generally means that I don't really get to see the menu for myself. I've read it and she knows what she wants and the waitress is there and I'm going, 'Wait, wait, I don't really know what's on here myself.' So, I apply that to the audio description, it allows me to get all of my sensory input and be able to enjoy the experience even more."

Mediation dependency can also create tension and stress between partners making it difficult for either to enjoy the experience. For partners without vision loss, they may feel pressure to describe everything and describe it well. One set of partners had a history of mediation stress that led them to talk about specific exhibit experiences. In the following excerpt, the partners explained how mediating causes stress, which then inhibits enjoyment and relaxation in the partner without vision loss. They began by responding to a question about whether the RTDM would help them to relax:

> 2: "Probably a lot for me too because I'm so stressed when I'm having to tell him everything. It takes away…"
> 1: "That's an important point that needs to be known that when you get pairs like that with visually impaired, is that her being under the pressure of describing things accurately takes a lot of enjoyment away from her too.

2: "If I don't have to…"
1: "And she has to do that and I'm saying, 'Well, what do you mean it's doing that?'"
2: "But that's everywhere and everything we do. If you think about it, I mean, I, it's hard to explain."
1: "So, but it goes back to your question about it removes her from the stresses of other things or whatever you said."
2: "I almost had to laugh at a couple of those questions, you know, enjoying myself or relaxing or whatever. Umm, not so much usually, because I'm watching whether he's stepping on somebody or we're falling or we're doing this or that. And sometimes he's less stressed than I am I think because he's just kind of going along and I'm trying to make sure he can get close enough and simply not trample the small little children in front of him."

6.2 Feedback on Mediation Features

A major portion of the data collected during this study was dedicated to participant feedback as a way of understanding the impact of design features (i.e., real-time and descriptive) on exhibit motivations (i.e., learning, entertainment, social, and restoration). Quantitative and qualitative feedback data was the result of post-stimuli interview content and responses from the *Post-Stimulus Surveys, Preferred Mediation Questionnaires,* and *Preferred Mediation Impact Surveys.* This section will begin with the presentation of participants' feedback on specific design features and their association with exhibit motivations. The overall preferred mediation type and mediation preferences according to exhibit motivation will be discussed at the end of this section.

6.2.1 Post Stimulus Interview Comments: Real-Time Features

The three mediation types all had design features that could be potentially linked to real-time movement including information about location and swimming behaviors. Comments related to these design features represented 12.1% (n=75) of all the data codes

resulting from the post-stimulus discussions. Nearly three-quarters of these comments were about location information (n=56) and most were made by participants with vision loss (n=52; 69.3%).

6.2.1.1 *Location Information*

The coded comments associated with location were related to positive, negative, and neutral feelings about the usefulness of location details and awareness that location information was missing. A majority of these comments (n=45; 80.4%) were specific to the RTDM and provided details about the value of location information for understanding the visual scene. Over half (n=31; 55.4%) of all of the comments related to location described the information in the RTDM as being helpful to knowing where to look for the animal being referenced and supporting imagery. For example, one participant who was able to see some of the display mentioned how the location helped him follow along using his residual vision:

> "I like the way she would give you a description as to where to look to see where it's coming in from. When you have limited vision, that at least gives you a starting point to know that it's entering from the bottom left or this or that."

Participants without vision loss also discussed the benefits of knowing which animal was being referenced by the mediation so that they could look for it in the display. Comments such as this point to the universal design potential of the RTDM:

> "It was very good. Especially for someone who is low vision or not sighted at all. But it helps you even if you can see. At least you know what direction to go to find what she's talking about."

Another participant who was blind described how the information helped her create a mental image of an animal's location:

> "I found myself looking, just thinking with my eyes, okay I am looking up and here's this big fish near the top. And it helped me to get the relationship of how the whale sharks swam toward the top and some of the others swam lower down and some of them stayed more towards the sides. So it gave me a better, more comprehensive picture of the full viewing area."

There were only three negative comments about the location information provided in the RTDM and they were all made by the same participant with vision loss. While she had reported being able to see in certain situations, she was not able to see anything in the study stimuli. She discussed that basic location information wasn't useful to her because she couldn't actually look for it in the scene. Instead, she wanted more precise details such as vertical and horizontal depth and current swimming speed to help in mentally visualizing where an animal was and how it was moving. In the following comment, she expressed frustration with being told where to look and gave examples of location and behavioral information that would better meet her needs:

> "I guess for me, saying it's on the left or the right, I mean I can't see anything on that screen really, it's just too dark for me. But I kind of want to know more like it's at this many feet deep or it's right next to glass or it's like way back…It just seemed like, if she's doing it for blind people to say it's on the right or the left, it's just sort of telling me "are you trying to get me to look there and I can't see?" That is sort of like here's some stairs here, telling that to the wheelchair guy. Like, he can't go up stairs. Just saying it's on the right or the left to me, I would want to know there's a big grouper there and it's hovering. It seems like it's waiting to eat something and ambush it. And it's like six inches over the sand and it's really close to the bottom. And the tank is like twenty feet deep, so it's down there almost twenty feet deep to the bottom and the shark swimming like almost on the surface, it's like fifteen feet above it. I didn't really care if it was on the left or the right on the screen just because I can't see it anyway."

Neutral comments about location in the RTDM suggested an indefinite opinion on its usefulness to the participant personally, but an understanding of its purpose. Participants from both groups made assumptions about how it could be used by people with and without vision loss, further promoting the potential of RTDM as beneficial for a range of visitors. Additionally, one participant who was blind talked about the variations within people who have vision impairment and that location information might be more useful to some of them:

> "It was useful in terms of my imagination, but overall it wouldn't have any effect on me, because I can't see it. So telling me to the left or the right, I'm still looking at a gray, cloudy screen. But, there are other people that are visually impaired that would be able to see it. That is why I wouldn't just take my side of it because you going to have so many different levels of vision impairment. So, it can be beneficial overall to someone, so therefore, I would keep it. So for someone like me, I would just pay attention to the next segment or words."

Some participants also discussed how they used the location information without mentioning whether they liked it or found it beneficial to their experience. This comment from a participant with low vision who was able to see some of the display explains how she handled the information as a visual concept rather than as a directive for her to find the visual referent:

> "There were times when I could see that darker, long one occasionally moving, and she would say, 'the lower left or the center right,' and so I began to use it as a concept rather than my actually trying to look. Because I think that's more helpful… If she said that the seal was beginning to move in the upper right side of the screen, I would take her word for it. She had described and if I saw movement around there, I would assume that is what it was. I wasn't trying to distinguish between which one was the seal and which one was the whale."

Docent mediation was only mentioned in 10.9% (n=6) of the location-related comments and discussed mostly in a positive manner with participants pointing out that they liked the docent telling them where the animal was in the display. The only negative comment was made by a participant with vision loss and related to the lack of specificity about an animal's position:

> "I didn't like that she would point out that something was swimming by, she didn't give me any point of reference where to look to that animal swimming by."

Remarks about location information and the Audio Tour mediation comprised less than one-tenth of all comments (n= 4; 7.1%) in this group and were limited to pointing out that location details were missing and generally made the mediation less useful. However, one participant with vision loss commented that although the information was absent, he didn't expect that technology-based mediation would be able to tell a person where an animal is in real-time, so it didn't really bother him:

> "She didn't describe exactly, 'look to the left,' or 'it's going to the right,' or 'it's swimming midway, up towards the top.' She just was describing the animal, she was just describing that period. Whether you look at it or not, this is what she was describing. So, she wasn't giving you any direction, if you didn't know what it looked like, you would only know to identify by what she was saying instead of locating it for you and then describing it. She didn't locate and describe, she just described, and to me that was fine. Because in the aquarium, if fish are moving around, how can you describe it? You don't know how they are going to swim any way... That won't work."

Direction of travel was also a form of location information used to convey real-time movement and specifically included as a design feature in the Ocean Voyager RTDM. However, most participants did not give feedback about this feature. In one of the few references to direction of travel, a participant who had low vision criticized the

fact that the Beluga Whale RTDM did not include it. This exclusion was a design choice made according to assumed accuracy issues in being able to predict the movements of beluga whales and harbor seals based on their highly variable movement patterns and input from the advisors. However, for this participant, the absence of direction information was a noticeable limitation of the Beluga Whale RTDM in depicting animals' movements that enabled her to use her restricted vision abilities.

> "I didn't know where it was going. Like she would say, 'in the upper right, the seal is…'. I began to wonder what direction is the movement going, is it going kind of across or is it going up and down? I didn't know where it was going, so I couldn't track it and that's an important part."

6.2.1.2 *Swimming Behaviors*

Swimming behaviors were another potential source for talking about animals in a real-time manner and included swimming style and speed, body movements, swimming orientation, and pattern of travel. A majority of the comments were positive towards the details on animals' swimming behaviors (n=14; 73.6%), almost all were associated with the RTDM (n=13; 92.9%), and most were provided by participants with vision loss (n=15; 78.9%). A majority of comments were about swimming style and speed with comments relating to creating mental images, deciphering motion that some participants were able to see, and guiding participants in which animal was being referenced. In some cases the descriptions helped participants distinguish one species from another. For example, this exchange between two partners illustrates that the mention of the difference in swimming speed of the two species in the display was a clue for understanding the movement in the visual scene:

1: “You really can’t tell which one is which until she let you know. Now I can somewhat tell the difference now because I know that the seals are zooming through there.”
2: “Yeah, they’re moving faster.”
1: “Faster than the whales.”

Another participant with vision loss mentioned that the RTDM’s description of belugas doing somersaults matched up with her memory of how they looked when she saw them in an exhibit before her vision worsened. She talked about how she remembered the beluga movements in the display reminding her of a lava lamp; they go “up and down in a slow, circular motion” that is “smooth and graceful”.

One pair of participants pointed out the benefit of the RTDM’s explanation of movement to the shared experience. They discussed that the RTDM was more effective than their usual partner-mediated exhibit experience and released the partner without vision loss from the burden of describing the visual scene.

2: “Yeah, … I would tell her things as we’re going along so that she is experiencing things along with me, but here, I could just sit back and not worry about coming up with something to say.”
1: “Or how to describe something so that I could picture it because there’s a lot of times he’ll tell me about something and then I’ll say, “how big is it, what color is it?’ So, it even gave me the movement of the fish—this one just kind of sits there and moves very slow and this one moves with purpose. That helped a lot.”

Only a few comments were made about the Audio Tour and Docent mediation and nearly all referred to their lack of communication about swimming behaviors. The most interesting remark about this inadequacy came during a dialog between partners in which they talk about how the Audio Tour mediation described animal movement assuming that the listener can see. The partner without vision loss affirmed that it was a visible movement and provided a description of it to her partner with vision loss:

1: “There was some assumption that you were seeing this here. She spoke about the way that the whale moves his neck, ‘watch how the whale moves his neck’.”
2: “And you could see it.”
1: “Well, I couldn’t. And I wanted to know, well how’s he moving it? I mean tell me, is he moving it like a giraffe might move it, how is he moving it?”
2: “No, it’s very…It’s like wavelike, it’s a bobbing.”
1: “There was no attempt to describe it. It was shown, but the audio said, ‘Look at how he moves his neck. No other mammal can move his neck like this’. And that was it.”

The one positive comment about the Docent mediation and swimming behaviors came from a participant with low vision who talked with his partner about the way animal movement was characterized as the docent was seeing it happen. This play-by-play style was engaging and made them feel as if the docent were accompanying them in a live experience:

1: “And then she can see them turn and look at it and then she saw the fish turn around and she’s like, ‘And you see on her ventral side,’ and you could see that side of the manta ray. It seemed like it was very real-time, like I was standing at the exhibit and she was looking at it with me. Not like an audio guide would be just like talking in general, ‘what you’re seeing now.’ So in that way, it seemed really more real-time like I was standing right there.”
2: “She was much more engaged. You could feel…”
1: “She was looking at me and the fish and everyone else and talking about what’s happening right then and not just mentioning in general about all of the fish in there. Like that fish went by and she talked about it. I mean on that one, I felt like I was in the aquarium for some reason. It was really more engaging I guess.”

6.2.2 Post Stimulus Interview Comments: Descriptive Features

Comments related to the descriptiveness of the mediation comprised 24% (n= 230) of the overall data and included feedback about the quality and absence of

descriptive information. Nearly 70% of the comments (n= 159) were provided by participants who had vision loss and over half (n=121; 52.6%) were related to the RTDM. Twenty-two of the participants compared the descriptiveness of the mediation types, with slightly more than half directly making the assertion that the RTDM was more descriptive than the others and another 10 participants merely claiming that either the Audio Tour or the Docent was less descriptive than the others. Comments for all mediation types included general statements about the overall descriptiveness and references to specific descriptions of animal and habitat physical characteristics that were useful or missing.

6.2.2.1 Overall Descriptiveness

Participants were largely positive about descriptive components of the mediation stimuli, although there were comments that indicated dissatisfaction with the descriptiveness of the Docent and Audio Tour mediation. Most of the comments about general descriptiveness corresponded to the RTDM and its ability to effectively translate the visual scene. Similar to the location and swimming behavior information, the descriptiveness of the mediation lent structure and detail for participants to generate mental images and supplement what they were able to see. This example from a partner without vision loss depicts her appreciation for the general descriptiveness of the RTDM and its benefit for people with vision impairment, including her mother. Additionally, she indicated that an advantage of the descriptiveness of the RTDM is that her mother wouldn't have to rely on her to describe the visual scene.

> "…it was a nice description. She really went into a complete depth. I can see how if me and my mom were to come to the Aquarium, because my mother's also visually impaired, she would be more enlightened and

> wouldn't have to necessarily ask me, "Well, what does it look like, what is going on?" She would basically get that full vision. So, it was very informative and I guess it would help the visually impaired a lot.

Another participant who had low vision and could not see any of the stimuli during the study talked about the benefit of imagery that was based on the physical characteristics of an animal or habitat feature rather than simply the knowledge that the animal or feature existed in the scene. This is a critical distinction between descriptions that purely identify features in the visual scene (likely assuming that a person can see them) versus descriptions that seek to translate the visual characteristics in the scene through descriptive language.

> "I liked the descriptions of the kind of the texture of the scene. There was an effort to describe not only what was there, but how it might look. So there were words like 'it looked like an underground mountain range', that there was some blueness to the color, that the fish from time to time might appear blurry. Just kind of painting a picture for me so that I could get a sense of a reality, rather than just no effort to help me imagine the texture of it all. So, I liked that."

The descriptive information in the RTDM also helped participants who were able to see the features in the visual scene. Partners without vision loss found the descriptions to be representative of what they saw and valuable to their visual experience. In some cases, participants thought the way a feature was described helped them to see it better. These two examples from separate participants indicate this utility and add evidence to the potential for RTDM to be usable by and useful to people with and without vision loss:

> "It was more descriptive than the first one. By looking at it and hearing it, when she said almost like a mountain range underwater, it was like, 'that's the words I am looking for.' It was like a rocky outlet or an inlet. But when she said it was like a mountain range underwater, it was like okay, I can see that a lot more clearer now."

> "Between her voice and visually looking at it, it almost like formed it up better in your mind. Your mind could just form it up better inside your mind's eye a little bit better. You could actually take it in and okay yes, I think the color is this. But when she was talking, the color of the water she said was a better description. I was like, that was more accurate than the color I had. It gave you a better sense of visualization in my opinion."

The Audio Tour and Docent mediation were predominantly considered to have lower quality or missing descriptions. However, each mediation type did receive positive feedback from participants with vision loss about their descriptions for the Ocean Voyager exhibit. One participant mentioned the usefulness of the size and color references included in the Audio Tour mediation and another participant talked about how the Docent mediation helped him to imagine the scene in his head.

6.2.2.2 *Descriptions of Habitat Physical Characteristics*

There were 46 comments about the habitat characteristics with 56.5% conveying positive feedback and the remaining 43.5% referring to potentially helpful information that was missing. The positive feedback was focused on the RTDM (n=24/26; 92.3%) and the missing information was primarily linked to the Audio Tour (n=13/20; 65%). Participants with vision loss contributed more than half of the comments (65.2%).

The introduction given at the start of the RTDM for both exhibits and the Docent mediation for the Ocean Voyager exhibit was intended to orient the listener to the layout of the visual scene and was predominantly focused on habitat characteristics. Participants with and without vision loss thought that this information gave them a better overall idea of what the display looked like. For example, one participant who could not see the

display talked about the value of hearing about the rocks and water as described by the RTDM:

> "It was very helpful to me. The descriptions she gave me is what I imagined in my mind. The cavernous look, with the bottom looking like the top of mountains and the water had a hazy feel to it and sometimes it was blurry, it can seem blurry. It gave me a picture in my mind of what the exhibit looked like."

The dimensions of the exhibit display were also important pieces of information for people and were present in the Docent mediation and RTDM for Ocean Voyager. A participant who was blind talked about his appreciation for these details and how they helped him to think about where the animals in the tank might be located (RTDM):

> "I enjoyed the description of the tank because it actually gave me a visual of what the tank was. You know she said it was like twenty-three feet high, so I knew exactly how high up and where the whale sharks would be located. And then she told me it was like sixty-one feet across, so I was able to imagine the tank like that. So, I enjoyed that particular part when she described how the tank was set up."

One partner without vision loss talked about the descriptiveness of the RTDM enabling a feeling of being at the exhibit. This comment demonstrates how describing the habitat characteristics and not just talking about the animals adds to the live, in-person experience even for a person who can see the display.

> "I thought that this one was much more informative. It actually, it gave you the feeling of being there. Whereas the other one [Audio Tour], just sort of talked about some fish. It described the aquarium itself, the exhibit, what it looked like and it described how it had the little rocks in the bottom and the sand."

Comments about the Audio Tour mediation were limited to the absence of habitat descriptions and how that affected participants' understanding of the visual scene. Many of the participants merely stated that the information was missing and did not give

specific details. One discussion between partners did have more depth to it as it pointed out certain habitat characteristics that were described in the RTDM, but not in the Audio Tour mediation. The fact that they had heard the RTDM before the Audio Tour mediation helped the partner with vision loss to get an idea of the visual scene. He was then able to use that information when listening to the Audio Tour mediation, but was well aware that it was not a part of the Audio Tour mediation:

> 1: "In the first one [RTDM], she described the view of the tank with the sunlight and how wide the glass is. How deep it is and there's sand on the bottom, there's sand on the rocks, and there's like two or three rocky outcroppings and they look like that. I don't think she did that in this one. So, if I had never heard the first one, and I am blind, I have no idea what we are looking at. So, that was a good thing about the first one [RTDM] and a complete disadvantage in the second one [Audio Tour]. Unless I missed it."
> 2: "You didn't miss it. No."
> 1: "So, she never described the situation that you are in for the blind person."

6.2.2.3 *Descriptions of Animal Physical Characteristics*

Participants provided 49 comments related to the descriptions about animal physical characteristics, with 68.1% corresponding to positive feedback and 31.9% referring to missing information. There was an almost even distribution of the number of comments across the three mediation types with RTDM and Audio Tour mediation associated with 16 comments each and Docent mediation linked to 15. However, there was a difference in how the comments for each mediation type were dispersed between positive feedback and missing information; RTDM had 93.8% for positive feedback, whereas Audio Tour had 50% and Docent had 60%. Nearly 75% of the comments were contributed by participants with vision loss.

Descriptions of animal characteristics provided the same benefits that location, swimming behaviors, and habitat description did for participants with and without vision loss. Participants talked about the ability to create mental images, locate certain animal features in the scene, and help resolve things that were unclear. For example, this participant with vision loss remarked about the RTDM's description of the blubber that beluga whales have and how he was directed to look for it:

> "I appreciated the detail description like when she described the structure under the skin that makes it appear like they have muscles. For me, that called me to focus specifically on that and to not miss it."

Details about color, pattern, shape, and size were reportedly useful for most participants who commented about these characteristics. When this information was missing, participants with and without vision loss noticed and expressed that it should have been included. A few participants mentioned that while they liked the way the information was presented, there were occasions when it was not specific enough to give them a detailed understanding of what an animal looked like. For example, one participant who was blind responded that colors were important to her, but that the vague description of the color pattern in the Docent mediation limited her mental picture:

> RESEARCHER: "And are colors important to you?"
> 1: "Yes, I remember colors and I like the description of the colors. I could picture the spots on the fish and that kind of thing. I wasn't sure about the white markings on the manta ray, it told that it was a black and white, but not a clear description of the white marking."

Another participant who was blind talked about mediation conveying size through a combination of more than one dimension. When he was asked if hearing about the animal's weight was important, his response suggested that it was easier to perceive size when length and weight were both cited:

> "It was a nice addition. It gave you another dimension of picturing the size of it besides just measurement. When they give the length of the fish also, then that gives you that reference point… If you have a marshmallow and well it's this big [gestured], but it weighs nothing. But you could have a piece of lead like that [gestured] and you're like that's heavy. So, the weight doesn't necessarily make me think size, it just tells me how heavy it is.

Associated with actual measurements, participants liked when shape, size, and color were discussed in terms of common referents such as comparing length to the size of an adult human hand or a school bus. These referents gave participants another way of imagining the visible characteristics of the scene and could lend perspective by enabling the correlation of one animal to another or an animal to the habitat. For example, one participant with low vision had a greater appreciation for the size of the exhibit based on the description given in the Docent mediation:

> "And I like the idea of having that comparison with the school bus to give me something to compare to the fish, it's that size and the football field. It makes me understand just how massive we're talking about in terms of the space and the fish."

Not surprisingly, participants reported that they preferred when animal physical characteristics were presented in a way that made them more interesting or memorable. For example, mentioning how the pectoral fins on the beluga whale have an underlying skeletal structure that looks much like a human hand or that the hammerhead has eyes on both ends of its hammer-shaped head to aid in hunting. Some participants enjoyed hearing about the biological or behavioral reason that animals had certain characteristics. The following excerpt is a discussion between partners about their feedback on the RTDM:

> 1: "…But even in the midst of talking about a certain part of the fish, she might mention about the black bottom of the fish or whatever,

she didn't say, 'Oh, this fish have a black bottom,' and then went on to something else. It's like the black bottom is because of whatever. She told you why and the spots are for whatever, now here's what you can get out of one from the other. She gave you something to go on rather than this one has spots and went on to the next one."

2: "Like when she described the mouth of the whale shark, about the digestive hole is only the size of the quarter. And it's like wow, all that mouth and…"

1: "And the reason why. You would think that with the mouth being four feet wide, they can take in a lot of food, but no and here's the reason why."

2: "It also helped in the beginning when she said what they fed off of. And then she came back and told us and explained why they fed off such small fish."

1: "And now I know the difference between whales and sharks. Because the tails. One goes up and down and one goes side to side. The shark, I think, goes side to side."

6.2.3 Post Stimulus Interview Comments: Temporal and Vocal Features

There were a few design features that participants had opinions about that were not anticipated by the research questions, yet were artifacts of designing real-time descriptive mediation for a computer-based system. These include temporal and vocal aspects of delivering spoken information that are dependent on detection, identification, and content retrieval processes. They will be briefly discussed here as an acknowledgement of their contribution to participants' mediation experiences.

In regards to the temporal aspects of the RTDM design, it was assumed that a pause between messages was necessary to enable the system to perform these processes. Further, an outcome of the advisors' input during the design phase of the RTDM was that they thought a longer pause length would be more effective. Thus, the average pause lengths for the RTDM for the Beluga Whales and Ocean Voyager exhibits were 6 and 7 seconds respectively (see Table 2 in Chapter 3 for more details). Associated with pause

length was the fact that information was delivered as message chunks in the RTDM compared to the running narratives in the Docent and Audio Tour mediation. The average duration of the messages that preceded each pause was 23 seconds for Beluga Whales and 33 seconds for Ocean Voyager. The combination of pauses and message "chunking" resulted in the RTDM being longer than the Docent and Audio Tour stimuli for both exhibits.

There were only 19 comments provided related to the length of the three mediation types. All of the comments (n= 8) about the Audio Tour mediation were about the brevity of the Beluga Whale stimulus; six of the comments were negative about the length and the other two were neutral. Some of the remarks about the Docent mediation for both exhibits indicated that it was the right length (n=3) and other comments mentioned that it was short, but did not indicate a positive or negative effect (n=2). For the RTDM, one participant stated that it was an appropriate length; two suggested that it was long, but an expected length for an exhibit; and two others said that it was too long.

Although the pausing was a secondary design feature in the RTDM that was implemented to address technical considerations for delivering real-time information, it makes a clear contribution by providing time for people to listen, process, and comprehend what they are hearing about the visual scene and related exhibit facts. The following comments made by participants with and without vision loss indicate the benefit of the temporal aspects of the RTDM.

> "The timing of giving the information gave you a minute to consume what she just said, even if you had to imagine it. Some things I didn't find right away, but from the description, I was able to get an idea of what was going on and it kind of helped me to really observe the screen a little better. Even if I had my eyes closed, or if I couldn't see, I would have still enjoyed this one better than the other one."

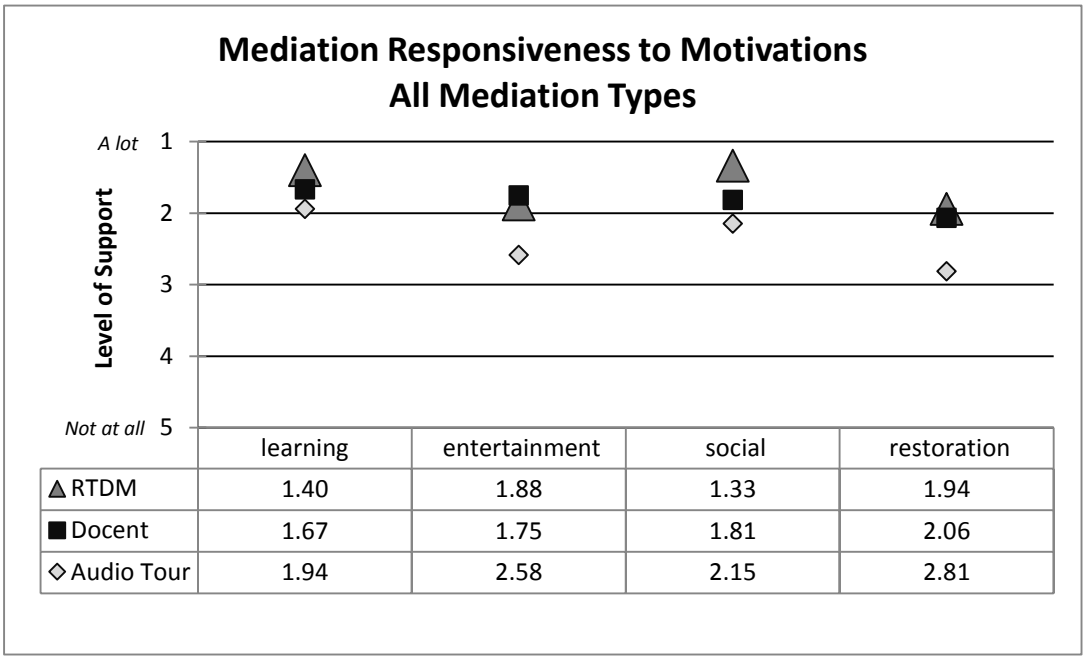
> "Love it! That's what I would be looking for if I went to the Aquarium. I would really be looking for that. She was very detailed, she gave you time to assess the information that she gave you concerning a specific animal. You were able to take it in before she actually went to the next scene. I guess it gave you a sense of…for me as a blind person, it gave me a sense of reality, this is how I would see it if I was there looking out of my own eyes. Because I had my sight before, I would be observing one fish and kind of checking out the details of the fish or whatever and then watching how other fish coming along, from the left or the right or whatever, different things like that. She was very, very good. Very good."

In considering vocal characteristics in the design of the RTDM, each message component was scripted to stand alone from other components in a database format. This was intended to make it possible for components to be retrieved and compiled in a multitude of ways to generate a variety of messages. Additionally, although digitized human speech was used for this study, this design consideration was also implemented to support synthesized speech delivering the messages. As a result of designing the message components to be modular, there was an overt implication that they had to be recorded in a manner that made them seem separate from each other and consequently, they sounded less natural and conversational. Participants noticed this distinct difference in the vocal aspects of the RTDM compared to the Docent and Audio Tour mediation.

6.3 Mediation Preferences

Feedback about the mediation that was relevant to exhibit motivations was derived from participant responses on the ***Mediation Responsiveness Survey***, *Preferred Mediation Questionnaire, Preferred Mediation Impacts Survey*, and post-stimulus

Figure 15. Post-Stimulus Motivation Feedback. This chart shows the average of all participants' responses for level of support provided by each mediation type for each motivation category.



	learning	entertainment	social	restoration
▲ RTDM	1.40	1.88	1.33	1.94
■ Docent	1.67	1.75	1.81	2.06
◇ Audio Tour	1.94	2.58	2.15	2.81

interviews. This analysis section will begin with an overview of participants' preferred mediation choices for the motivations, then continue with a presentation of the feedback for each mediation type according to the motivation categories, and end with participants' perceptions of how well their overall preferred mediation would address their exhibit motivation needs.

6.3.1 Mediation Responsiveness to Motivations

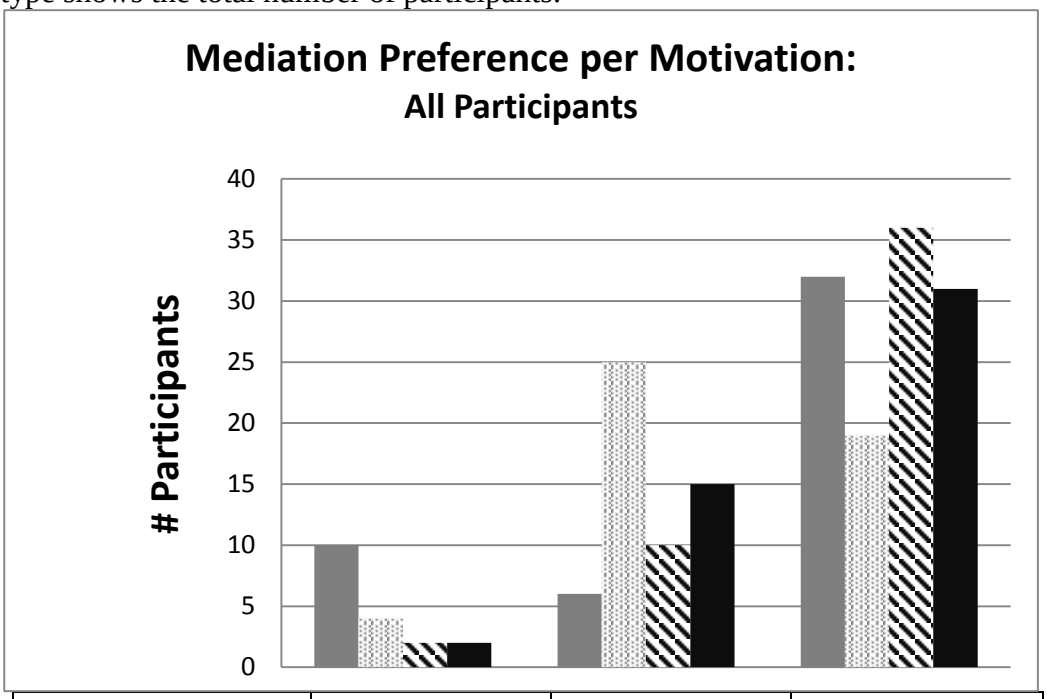
Participants completed the *Mediation Responsiveness Survey* to share their perspectives on how each type of mediation helped them to address their exhibit motivations. The survey results are shown in Figure 15 and indicate that the RTDM had higher levels of support for participants' learning, social, and restoration motivations compared to the Docent and Audio Tour mediation. For entertainment motivations, the

Docent mediation provided more support than either of the other two mediation types with a mean rating of 1.75. The Audio Tour mediation gave the participants the lowest levels of support across all motivations. Overall, participants felt that restoration motivations had the lowest level of support across all three mediation. Across all responsiveness data, there were no significant differences between participants with and without vision loss.

6.3.2 Preferred Mediation per Motivation

After participants experienced all three mediation stimuli, they were asked to identify their preferred mediation type for each exhibit motivation category as part of the *Preferred Mediation Questionnaire*. The data for all participants is represented in Figure 16 and shows that the RTDM was preferred over the Docent and Audio Tour mediation by nearly twice as many participants for three of the four motivations. The mediation and motivation pairing that had the most participants was the RTDM for social motivations which was chosen by 75% of the participants. The Docent mediation was most preferred for entertainment motivations as it was selected by slightly more than 50% of participants. These results parallel those found through the *Mediation Responsiveness Survey* as presented in Figure 15. In those results, the RTDM was also found to be most preferred for all motivations except for entertainment which was linked to the Docent mediation. Although the Audio Tour had the fewest number of participants who indicated a preference for it in addressing entertainment, social, and restoration motivations, it was identified over the Docent mediation as better for learning motivations. There were no statistically significant results between participants with and without vision loss or exhibit. It was interesting that the data were fairly similar for

Figure 16. Mediation Preference per Motivation. This figure shows the distribution of participant responses for mediation preference according to each motivation category. This data resulted from responses on the *Preferred Mediation Questionnaire.* Data in the response columns indicates number of participants. Data in the unshaded cells in the left column for each mediation type represents participants with vision loss and the shaded cells are participants without vision loss. The right column for each mediation type shows the total number of participants.



	Audio Tour		Docent		RTDM	
Learning	6	10	3	6	15	32
	4		3		17	
Entertainment	1	4	12	25	11	19
	3		13		8	
Social	1	2	5	10	18	36
	1		5		18	
Restoration	1	2	5	15	18	31
	1		10		13	

participants with and without vision loss across mediation types for each motivation. Furthermore, the social motivation category had exactly the same results for each mediation type for both groups of participants.

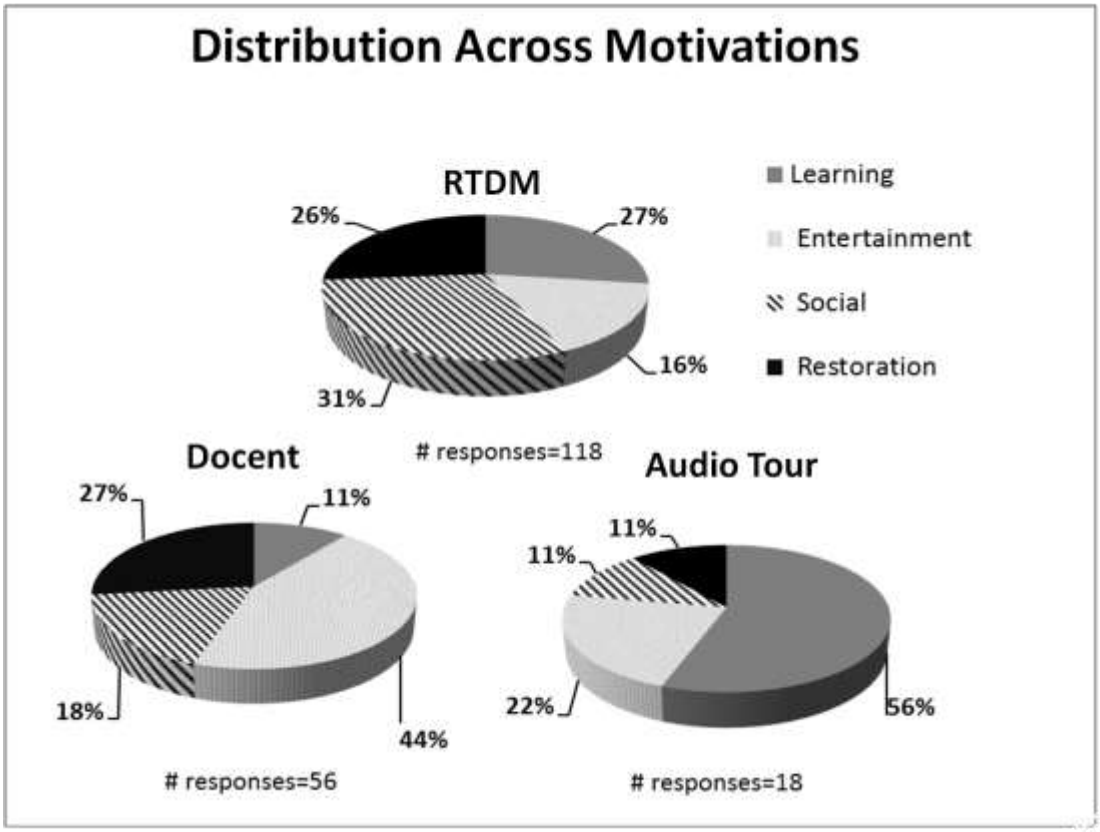


Figure 17. Distribution of Responses Across Motivations. This figure shows separate pie charts for each mediation type with the percentage of responses associated with each motivation. This data is based on the responses from the *Preferred Mediation Questionnaire* that were shown in Figure 16. Each mediation type had a different number of overall responses from which the distribution percentages are based (# responses).

The preference results can also be examined for each mediation type according to the distribution of responses across motivations. Figure 17 shows the three mediation types and their corresponding distributions for the data collected from all participants. The pie charts depict the percentage of responses associated with each motivation for each mediation type. Each mediation type had a different number of overall responses from which the distribution percentages are based. The pie charts for the Docent and Audio Tour mediation types reveal that the preferences for each seemed to align with a

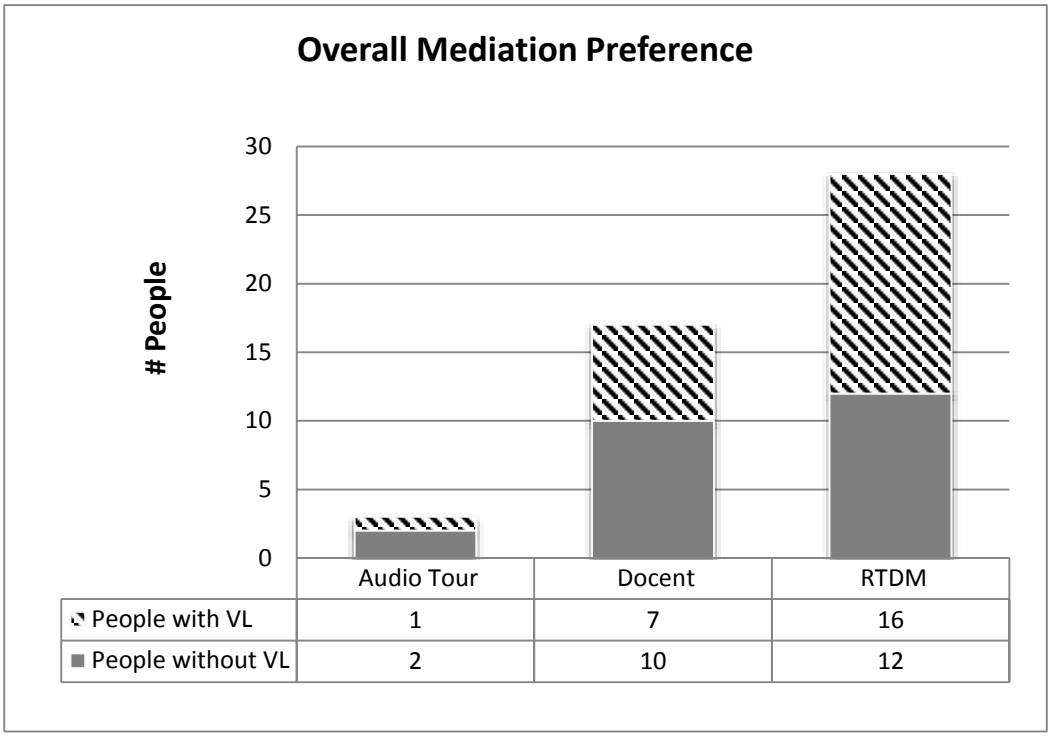


Figure 18. Overall Mediation Preference. This chart shows the number of participants who had an overall preference for each of the mediation types. The data is divided by participants with and without vision loss

particular motivation category. For the Docent mediation, the majority of responses (44%) tended toward entertainment motivations and the remaining amount was divided among restoration (27%), social (18%), and learning (11%). The percentage distribution for Audio Tour favored learning motivations at 56% compared to 22% for entertainment and 11% each for social and restoration. In contrast, the RTDM was more balanced across motivations, with social (31%), learning (27%), and restoration (26%) in close proximity to each other, and entertainment (16%) as the smallest percentage. These results indicate that the Docent and Audio Tour mediation each had a biased focus toward a specific motivation and as a result, were less able to effectively address participants'

other motivations. Moreover, that the RTDM did not target one motivation over the others and in fact, was nearly uniform in addressing participants' motivation needs.

6.3.3 Overall Preferred Mediation

The RTDM was preferred by a majority of study participants with and without vision loss (n= 28; 58.3%) (see Figure 18). Over half (n= 16; 66.7%) of the 24 participants with vision loss chose the RTDM over the other mediation types for both exhibits. The Docent mediation was the next most preferred (35.4%), chosen by more participants without vision loss (n= 10) compared to those with vision loss (n=7). The Audio Tour was preferred by the fewest number of participants (n= 3; 6.3%). There were not any significant differences when comparing participants' preferred mediation according to exhibit type (i.e., Beluga Whales or Ocean Voyager) or vision ability.

There appeared to be an influence for presentation order in that participants were less likely to select the first mediation type presented as their overall preferred mediation. In fact, they were almost 8 times more likely to prefer the second or third mediation presented (OR=7.71: 95% CI [.710,83.77]; Phi Coefficient = 0.329, p=0.020). However, the possibility of this influence was accounted for in the design of the study which randomized participant pairs across presentation order with an even distribution.

6.3.4 Impact of Preferred Mediation on Motivations

Participants provided details about the actual and anticipated impacts of their preferred mediation choice through their responses on the *Preferred Mediation Impacts Survey* and as part of the *Preferred Mediation Questionnaire*. The S*urvey* was designed to parallel the measures included on the *Aquarium Exhibit Expectation Survey* and indicates participants' agreement about whether their preferred mediation choice could

Table 7. Preferred Mediation Anticipated Impacts. This table shows the survey responses on a scale of 1 to 5, where 1 is strongly agree, 2 agree, 3 is neither, 4 is disagree, and 5 is strongly disagree. Responses for participants with vision loss are in unshaded rows and those for participants without vision loss are in shaded rows.

	The audio that I liked the most would help me to:	1 strongly agree	2 agree	3 neither	4 disagree	5 strongly disagree	Group Means	Total Mean	Median
Learning	Expand my knowledge	18	6				1.25	1.27	1.00
		18	5	1			1.29		1.00
	Learn something new	17	7				1.29	1.23	1.00
		20	4				1.17		1.00
	Gain a better understanding	20	4				1.17	1.19	1.00
		19	5				1.21		1.00
Entertainment	Be entertained	12	11	1			1.54	1.58	1.50
		9	15				1.63		1.00
	Enjoy myself	15	9				1.38	1.33	1.00
		17	7				1.29		1.00
	Do something exciting	10	13	1			1.63	1.67	2.00
		10	11	3			1.71		2.00
Social	Interact with others	14	10				1.42	1.48	1.00
		12	11	1			1.54		1.00
	Have a shared experience with my partner	16	8				1.33*	1.48	1.00
		9	15				1.63*		2.00
	Talk about interesting things with someone else	17	6	1			1.33	1.42	1.00
		13	10	1			1.50		1.00
Restoration	Relax	9	14		1		1.71	1.63	2.00
		11	13				1.54		2.00
	Get away from the responsibilities of everyday life	9	10	4		1	1.92	1.96	2.00
		4	16	4			2.00		2.00
	Find some peace and tranquility	6	13	5			1.96	1.94	2.00
		4	19	1			1.92		2.00

Note: An * indicates a result that is significant at the p< .05 level.

help them address their motivations at aquarium exhibits (Anticipated). On the *Questionnaire*, participants were asked to provide details about the ways in which their preferred mediation helped them address their learning, entertainment, social, and restoration motivations (Actual). In their responses, some participants also referred to the

contributions of mediation design features, including real-time, descriptive, temporal, and vocal features, in supporting the motivations. The data is presented here according to the mediation types, with discussion about their support for exhibit motivations and the influence of specific design features.

Results for the *Preferred Mediation Impacts Survey* (see Table 7) showed that a majority of participants either *strongly agreed* or *agreed* that the mediation type they most preferred would help them address their learning, entertainment, social, and restoration motivations. Similar to the results found on the *Participation-Based Exhibit Expectations Survey*, learning motivations had the most agreement, with almost all participants at least *agreeing* that their preferred mediation would aid learning. Within the group of measures related to learning, "The audio that I liked the most would help me to gain a better understanding" had the lowest total mean (1.19), which corresponded to the greatest number of participants reporting that they *strongly agree* that their preferred mediation would help them with this motivation. The agreement ratings were only slightly less positive for entertainment and social motivations compared to learning. An average of over 97% of participants still *agreed* or *strongly agreed* that their preferred mediation could help them with these motivations. Restorative motivations had the least overall level of agreement, yet a majority of participants (89%) still *agreed* or *strongly agreed* that their preferred mediation could help with restoration. The highest total mean (1.96) was for the measure, "The audio that I liked the most would help me to get away from the responsibilities of everyday life", which corresponded the greatest number of participants who responded *neither* or *disagree.*

The only statistically significant difference in responses between participants with and without vision loss was found in the measure, "The audio that I liked the most would help me to have a shared experience with my partner." Participants with vision loss had stronger agreement with that statement with a mean of 1.33 compared to a mean of 1.63 for those without vision loss, $t(46) = 2.070$, $p=.044$.

An analysis was also performed to identify differences in participant responses on this *Preferred Mediation Impacts Survey* and the *Participation-Based Exhibit Expectations Survey*. These two surveys had similar measures, but separate lead-in statements associated with their respective measures. Although the data analysis did not reveal any statistically significant differences between mean responses on both surveys for all participants or separate groups (e.g., vision loss, no vision loss), there were a few interesting trends worth mentioning. First, participants had high agreement levels that were similar for both exhibit expectations and impacts for their preferred mediation. As previously mentioned, participants also had higher agreement levels for learning-related expectations and impacts which was anticipated given established practice and research in ILEs that focuses on learning. Additionally, participants reported that for six of the motivations, their agreement level for the impacts of their preferred mediation exceeded their agreement for exhibit expectations.

6.3.4.1 *Reported Actual Impacts of the RTDM*

Since the RTDM was identified as the most useful mediation type by the majority of participants, there was a greater amount of data to analyze and thus, more excerpts detailing the specific reasons that the RTDM was preferred. Many of the participants who chose the RTDM explicitly linked design features to the support of exhibit

motivations. Comments made by participants with vision loss were centered on the mental visualizations that resulted from the descriptions and how this imagery facilitated learning, entertainment, social interactions, and restoration by establishing an understanding of the visual scene. The pausing between messages was also important because it gave participants with and without vision loss time to process the visual scene details and exhibit facts. Other aspects of the mediation that participants found helpful were the relaxing pace and quality of the voice and scientific facts about the animals.

A primary function of the RTDM is to explain the visual scene through real-time and descriptive features that enable people with vision loss to generate detailed mental imagery. As represented by a majority of participant comments, this imagery was the foundation of their exhibit experience and a first step in the process of addressing exhibit motivations. A comment made by a participant with vision loss sums up the necessity and value of being able to imagine the visual scene:

> "If I understand what's going on, I can engage more, and then be entertained."

His comment suggested that the visualizations resulting from the RTDM encouraged a more active exhibit experience for him. Other participants made similar statements about being able to engage with the exhibit or their partners at a different level because they understood what the exhibit looked like and what was happening over time. For example, one participant with vision loss was referring to restoration motivations and said, "Since I could visualize it better, I was more into it. It just pulled me deeper into the moment."

A richer connection to the visual scene reportedly resulted in an immersive effect for some people, which was particularly important for supporting their entertainment and

restoration motivations. Participants with vision loss described that having a richer picture in their minds made them feel like the exhibit was more interactive because they knew how the animals were moving around and what they looked like. One participant went as far as to say that the RTDM "made me feel like I was almost in the tank with them." Another participant talked about how the interactivity generated by the real-time and descriptive design features helped her to be entertained:

> "I felt like I was experiencing it more. I was hearing the descriptions of motion and it almost seemed more interactive. It was the visualization part that caused that to happen."

Imagery formation was further aided by the pauses between messages because participants felt like they had enough time to unpack and process what they had heard. One participant with vision loss suggested that the pauses embedded in the real-time information gave her an opportunity to build a mental image of the scene that she could think about which facilitated learning:

> "I was so involved. It was like here is the picture, right here. The pauses were helpful and that's funny because when I listen to books, I listen at a faster speed. But this was all new info, so the pause gave me time to put it together and think about it a minute. The descriptions of locations in the exhibit served to paint the picture of the big fish is up to the top, these other ones are over toward the bottom left, these little ones are at the left and right. So it put the picture together."

Participants without vision loss also found that the pausing gave them time to process the information that they were hearing and hence, make it easier for them to learn. One person mentioned that the pauses gave "time between information to get it all in," and another said that he was "able to process what she [the voice on the RTDM] was saying better."

Another key effect of the pauses was that it played a role in people feeling more relaxed and consequently, better prepared to address their restoration needs. Some participants reported that the RTDM had a slower pace and they didn't feel "bombarded" with information due to the pausing. Furthermore, the "relaxing" and "soothing" quality of the voice added to the appeal of the RTDM in relation to restoration. The less stressful presentation of information gave people time to think and focus their attention solely on the exhibit. In fact, several participants talked about being engrossed in the RTDM, providing comments such as "I was totally focused on the enclosure and descriptiveness, that I didn't have to think about anything else," and "You could just close your eyes and it was like you were there. You really didn't have to think that much. I was just relaxing and listening."

Additionally, participants with low vision discussed how the real-time and descriptive features made less work for them because they didn't have to use their vision as much to understand the visual scene. The relief from the stress of trying to see the exhibit gave people a chance to relax. For example, one participant mentioned how the RTDM was better than what she could get with her vision, yet she still felt like she had seen the exhibit:

> "I could rely on her, didn't have to be as sharp with the vision. I could just give it away and let her do it and I would still get something. Actually, I remember seeing very little on this time around [compared to other mediation types]. Her communication was stronger than the visual and so I could let myself off the hook some, which is great. I do feel like I saw because I heard her really well."

A more robust understanding of the visual scene also helped participants with vision loss feel like they had common ground with their partners in the exhibit experience; they were working from similar understandings of the visual scene. One

participant with vision loss discussed the benefit of the descriptions in making it easier to remember and talk about visual details that would later support conversation between her partner and her:

> "If I can describe it like she [the voice on the RTDM] can, then instead of talking like I would, her detailed descriptions and the way she worded it, helped me to put it together and remember it. My partner would pick up a lot of things with their sight and those descriptions help me to communicate with him, 'Do you remember the fish with the spots, the one with the white underbelly and the wide wing span?' Because you probably couldn't remember the names of all the fish, the descriptions help you to be able to talk about them later and that would help in communication."

Support for exhibit partners also included the possibility that the RTDM could fill in the details that the person with vision loss typically needs to ask the partner about (e.g., size, color, identity of animals, etc.). For example, one participant without vision loss conveyed this advantage and pointed out that when he has to mediate for his partner, it negatively impacts his own motivations. Minimizing or eliminating the mediation dependency that partners usually have at exhibits could permit different styles of interaction and encourage more conversation. Several participants with vision loss discussed this potential in their comments:

> "I think it sparked my imagination and that would open up more interesting thinking patterns to lead to more discussions."

> "It made you want to find out if the other person felt the same way, asking them questions to see if they felt the same way or about the descriptions."

> "She provided information that described the environment and where the mammals were positioned or how they were moving in the scene and that would be something that I would seek confirmation with my partner. I would be able to share or seek confirmation and get further details from him."

Participants with vision loss also reported that the RTDM addressed social motivations by giving them a way to share their experience with others who didn't accompany them to the exhibit. These comments suggest that the real-time and descriptive features could help a person with a vision impairment feel confident in discussing the visual scene with someone who wasn't at the exhibit with them. For example, one participant talked about how she could convey the dynamics and other details:

> "The way she did it made it easier for me to translate to someone else all the colors, details, where they were located. I could actually explain to someone that the fish came in from the left and then swam over and stuff like that."

An important overall outcome of the RTDM design features was that people felt more included in the experience and thus, better able to address exhibit motivations. By having a more comprehensive view of the visual scene, people reported that they were more likely to be able to share with their partners and be a part of the larger audience of people at the exhibit with the RTDM compared to the other mediation types. The following comments are examples corresponding to particular motivations:

> Entertainment:
> "I felt like there was an awareness, more fullness in terms of information that gave me a sense that I wasn't missing everything. It was much of the same info that other people were getting."
>
> Social:
> "It made me feel like I could actually talk to other people who had seen it or were standing there at the exhibit with me. I could be a part of their discussions just by the descriptions and the facts she [voice in the RTDM] gave."
>
> Restoration:
> "It takes a moment for me to accept that I'm just going to have to do without the information that's not being presented to me and one reacts

> to that. And with this one [RTDM], I kind of felt like I was a part of the audience, the intended audience. It's a sense of welcoming, sense of inclusion, or maybe the absence of the feeling of exclusion."

6.3.4.2 *Reported Actual Impact of the Docent and Audio Tour Mediation*

This section describes participants' perceptions about how the Docent and Audio Tour addressed exhibit motivations as the preferred mediation type. There was less data to analyze for these mediation types compared to the RTDM because they were chosen by fewer participants as their preferred mediation type. Comments about the Docent mediation centered on its conversational tone, friendlier quality, and less technical language, whereas the Audio Tour mediation was talked about in terms of its information and pace.

The Docent mediation was recorded to represent a routine, in-person exhibit presentation that was structured, but not scripted. The resulting improvisational format of the mediation made the Docent's voice sound more natural and enthusiastic to participants. These vocal qualities were particularly important for encouraging entertainment. Participants with and without vision loss offered comments about how the Docent mediation helped them with their entertainment motivations such as, "she had a smile in her voice," "she seemed friendlier," and "she was looser, more comical, and less rigid." The voice was also important for learning as portrayed in this comment from a participant without vision loss:

> "I liked her voice, the cadence. Others were sort of clinical, they were "telling" versus "sharing."

Some participants described how the less formal delivery of the information also made it easier to focus which positively impacted their learning and restoration

motivations. One person with vision loss discussed how she "paid more attention to it naturally instead of having to be told to pay attention". Another participant without vision loss mentioned that because he didn't have to focus so hard on the information, he could just enjoy it without any tension.

6.4 Summary

Participants' exhibit expectations and prior exhibit experiences revealed that learning, entertainment, social, and restoration motivations are important and addressed during visits to aquariums and zoos. However, a majority of participants with vision loss feel they do not get the experience they want. Participants' feedback about real-time and descriptive design features in mediation demonstrated that having an understanding of the visual scene is critical for the participation needs of users with vision loss. The evaluation of the RTDM and comparison to Docent and Audio Tour mediation indicated that participants with and without vision loss largely prefer the RTDM over the other mediation types for motivation-related activities. Although the RTDM provided support that was nearly equal across all motivations, the Docent mediation was reportedly a slightly better match for entertainment given its less scripted nature and "friendlier" feel. Beyond reporting on the design features of a real-time system that supports exhibit motivations, findings suggest that an effective mediation technology has positive impacts on several specific aspects of participation. In the next chapter, I will describe the support that the RTDM's design features provide for exhibit motivations in relation to facilitating specific aspects of participation.

CHAPTER 7

DISCUSSION

The overall goals of this work were to: 1) develop information design criteria for mediation that conveys real-time and descriptive details of an exhibit's visual scene to address participation-based exhibit motivations of adults with and without vision loss; 2) implement the information design criteria as speech-based, real-time descriptive mediation (RTDM) that supports participation-based exhibit motivations of adults with and without vision loss; and 3) evaluate the RTDM and compare it to traditional exhibit mediation (i.e., docent presentation and asynchronous audio tour) to determine its impact on participation-based motivations in adults with and without vision loss. Findings from the design, implementation, and evaluation of real-time descriptive mediation contribute to answering my research questions:

RQ1. What are the effects of conveying static descriptive details about the visible physical characteristics of animals and habitat features of live aquarium exhibits that are intended to support exhibit motivations (i.e., learning, entertainment, social, and restoration) in adults with and without vision loss?

RQ2. What are the effects of conveying dynamic real-time characteristics (e.g., animal location and swimming behaviors) of live aquarium exhibits that are intended to support exhibit motivations (i.e., learning, entertainment, social, and restoration) in adults with and without vision loss?

RQ3. How does real-time descriptive mediation compare to typical sound-based mediation (i.e., asynchronous audio tour and docent presentation) for supporting exhibit

motivations (i.e., learning, entertainment, social, and restoration) in adults with and without vision loss?

In this discussion, I will respond to the research questions through a narrative that highlights the importance of the RTDM design features on enabling equitable exhibit access for adults with vision loss. Having equitable exhibit access made it possible for participants to address their exhibit motivations and led to specific personal and social aspects of participation. These aspects include: *personal understanding of the exhibit; sharing the exhibit experience; independence*; and *belongingness.* The mediation study also made it possible to more directly link and understand design features and their impacts on exhibit motivations to participation, which were the main objectives of this work. Furthermore, carrying out this research helped explain the proximal implications surrounding exhibit mediation for adults with vision impairment and their partners, while also suggesting possibilities for more distal areas of research and practice within and outside of the ILE domain. These future directions will be presented at the end of this chapter.

7.1 Beyond Accessibility: Mediation that Facilitates Participation

Exhibit mediation through a real-time system was originally conceived as an accommodation solution to an accessibility problem for visitors with vision impairment. It was funded under a project called the Accessible Aquarium, which initially emphasized vision-related functional limitation and later expanded to include other barriers to viewing an aquarium exhibit such as not being able to see over other visitors because a person is short or seated on a bench or in a wheelchair. A benefit of this dissertation was

in examining the utility of real-time descriptive mediation beyond merely an accessibility solution to a technology that could facilitate participation. However, while it is possible to create the opportunity for participation by employing accessibility tactics such as accessible design and assistive technologies, relying solely on accessibility as the vehicle for participation is unlikely to truly promote participation.

Frequently, accessibility in ILEs is accomplished through specialized services or equipment for visitors with disabilities. Yet, as Sanford [94] cautions, specialized design inherently results in separate solutions for certain people depending on the type and level of their ability. Accordingly, requiring a visitor to check out special equipment or get information about an exhibit in a specialized manner simply based on the fact that he/she is unable to see, hear, or touch the exhibit implies exclusionary practice that expects different treatment of visitors with disabilities. Exclusion through specialized design or treatment is in direct opposition to the notion of participation set forth by the ICF. Instead, participation can be facilitated by offering a well-designed mediation technology to all visitors regardless of their vision ability that interprets, supplements, *and* complements the visual scene depending on the visitor's needs.

Designing to facilitate participation was the basis of this work. Evidence from the study suggests that the design features incorporated into the RTDM were useful to people with and without vision loss and contributed to equitable access. As Figure 19 shows, equitable access is the link between mediation design features and exhibit motivations. Participation and its facets can be achieved as a result of addressing exhibit motivations, but they also contribute to defining and shaping exhibit motivations.

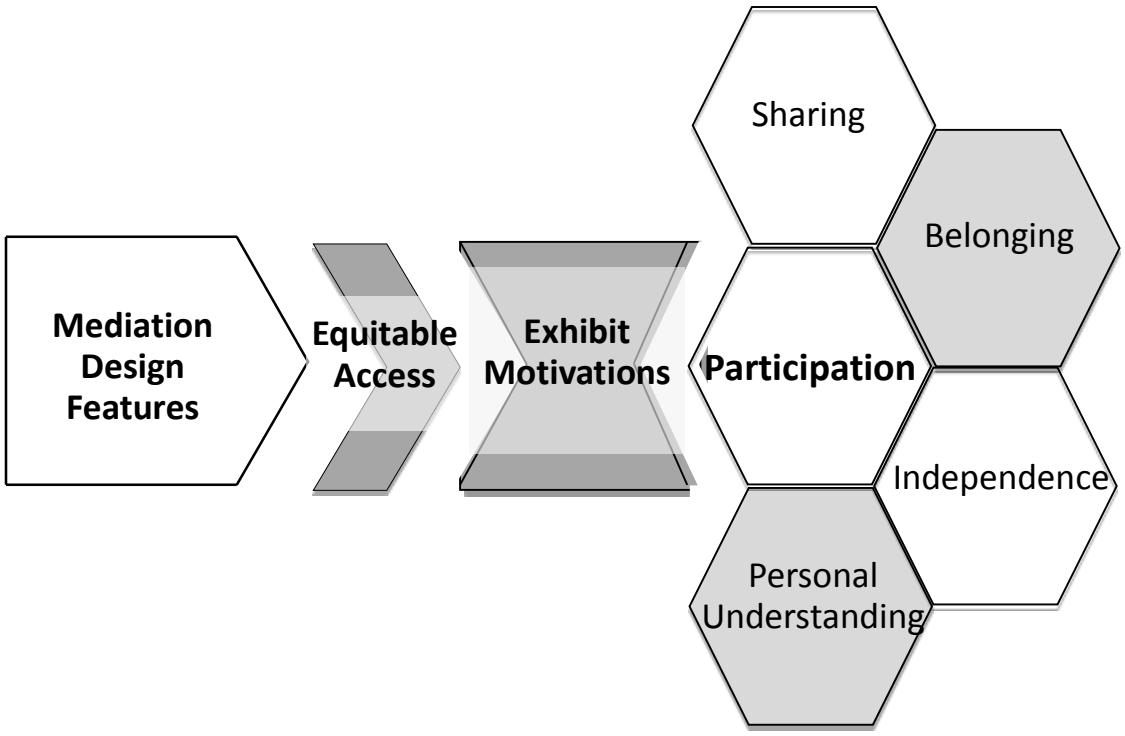


Figure 19. A Model of Participation-Based Mediation Design. This graphic depicts how mediation design features that provide equitable access to support exhibit motivations aid in facilitating participation.

7.2 Equitable Access

The notion of equal access in ILEs is important for ensuring that all people, regardless of their ability, are given the same opportunity to have an experience. However, depending on the design of an exhibit and its mediation (if available), all visitors may not have access to the same types or depths of experiences. More unfortunately, some visitors may not be able to address their exhibit motivations at all because the exhibit and/or its mediation are not in a format that is understandable nor accessible to them. This is really more a problem of equity and not so much about equality. Ideally, all visitors deserve to experience an exhibit in a way that is most effective for them, which does not mean that all visitors must experience an exhibit in the

same way. Visitors, regardless of their abilities, should be given equitable access to exhibit experiences through formats that are usable and useful to them so that they can address their exhibit motivations, deciding which motivations are important to them and how they are going to use exhibit information in relation to these motivations.

Typical sound-based mediation methods for live aquarium exhibits largely do not provide equitable access for visitors with vision loss which negatively impacts their ability to meet exhibit motivations. This is primarily due to absent or inadequate translation of the visual scene since it is assumed that visitors are able to see the exhibit and therefore, do not need to be told what an animal or the habitat looks like, or where something is specifically located. This work showed that an audio tour is less effective at helping people address their exhibit motivations due to its minimal descriptions and inability to represent the dynamics of the visual scene. Docent mediation, while more effective than an audio tour for addressing most motivations, also does not result in equitable exhibit access because of its limited descriptions of the dynamic and static components of the visual scene. The deficiencies of these typical forms of mediation make it difficult to impossible for adults with vision loss to have a personal experience or share in a common experience that is based on the visual nature of a live animal exhibit.

Conversely, the RTDM was designed to convey static and dynamic details in a manner that promoted equitable access to the visual scene. This resulted in a more robust understanding of the scene which is central to the experience of a live aquarium exhibit and thus, a necessity for addressing exhibit motivations. People with vision loss reported that they felt like the RTDM gave them access to the same visual scene that their partner could see. Equitable access through the RTDM also made it possible for partners to

collectively encounter the visual scene which promoted opportunities for sharing, including recalling joint past experiences and discussions about exhibit animals, as well as relieved the partner without vision loss from mediation responsibilities. Sharing is also an important part of addressing exhibit motivations, particularly socially-oriented ones. Furthermore, the more level playing field for addressing motivations fostered a feeling of independence and belonging in the context of a live aquarium exhibit. Thus, regardless of being able to see the exhibit or not, most participants felt that they knew what the exhibit looked like and were better able to meet their motivational needs. In fact, the RTDM was more balanced in support of the four motivations compared to the traditional types of mediation according to participants with and without vision loss.

Equitable access is an enabler of participation. It is also an element of Universal Design as represented in the Equitable Use principle from the original and commonly used principle set [96] and incorporated in subsequent interpretations from other researchers [97-100]. In Sanford's interpretation [97], he makes the argument that the original principles were based on design usability, with outcomes of use related to activity and not to participation. He contends that designing so that people can engage in the same activity only creates the opportunity for participation, but does not guarantee it since a design may result in separate or segregative means of engagement. His solution is to reconceptualize the equitable use principle and add two new principles, social integration and contextual integration, to more explicitly attend to participation outcomes.

While the current work's discussion of equitable access shares some of the essence of Sanford's interpretation, it is not the intent to compare the two since this work makes reference to equitable access as a direct result of study findings and not as a

presupposed design goal. However, this work is in agreement with the idea that participation can be achieved through design that promotes social and contextual integration. Equitable exhibit access through the RTDM means that people have exposure to the same visual scene from which to base their experience. This access makes it possible for people to generate a personal understanding of the exhibit, share the exhibit experience, feel independent, and have a sense of belonging, which are all vital supports involved in addressing exhibit motivations and in line with goals of social and contextual integration.

7.3 Personal Understanding

The RTDM succeeded at providing equitable access to the exhibit for visitors with vision loss where the other traditional mediation types largely failed. The combination of its real-time and descriptive audio features acted as a surrogate for the visual scene and made it possible for participants with and without vision loss to have similar knowledge about the layout of the habitat, types of animals, physical characteristics, and movement. The mediation helped participants conjure mental images, fill in or confirm visual details, and direct gaze and attention.

A sufficient awareness of an exhibit's visual scene makes it possible for a person to develop their own understanding of the exhibit and thus, make their own meaning. Meaning-making in ILEs, as discussed by Silverman [101], is a "constant process of remembering and connecting" (p.162) and is heavily influenced by a person's ability to contextualize what he/she perceives. In effect, meaning-making is contingent upon being able to discern exhibit information and generate a personal understanding that is useful to

the individual. This personal understanding is what fulfills and shapes exhibit motivations. People in the current study were more likely to feel like they had been able to address their motivations if they had a more detailed understanding of the live animal exhibit that was attributable to the RTDM. An exception to this was that the Docent mediation was most preferred for entertainment purposes primarily because of its friendly and conversational tone (which could be incorporated into a technology-based mediation system).

Personal understanding, while important to all motivations, is particularly relevant for restoration motivations. This type of motivation is more prone to subjectivity and intrinsically, more personal in nature. As Kaplan and Talbot's [102] work in restorative experiences points out, people use settings and activities to engage in personally restful and reflective behaviors. However, they suggest that, along with other attributes, the setting or activity needs to support fascination and be compatible with the person. Their concept of fascination requires that a person spend less directed attention to maintain interest much like the RTDM was capable of encouraging in participants with and without vision loss. Compatibility, according to the authors, is the relationship between environmental demands and an individual, and is optimal when the demands do not obstruct the individual's goals [102]. This concept is similar to others found in rehabilitation literature [70, 72, 76] that advocate for design that minimizes or eliminates the impact of a functional limitation such as vision loss. Real-time and descriptive design features attempt to do just that and thus, the RTDM proved to enable a more compatible exhibit experience for people with vision loss which likely made it easier to meet restoration needs.

For most visitors, personal understanding at an exhibit is only partly guided by mediation. Visitors with vision loss rely almost entirely on mediation at live animal exhibits which creates the potential for their personal understanding to be based on a filtered perspective. The status quo for them is a filtered experience because typical audio tours and docent presentations assume that visitors can see, so redundant visual information is left out of the mediation. Also, as several participants in this study talked about, partner mediation is also filtered because often, partners provide information that is interesting to them personally or that they feel comfortable conveying. One person alluded to the significance of developing an unfiltered personal understanding when she mentioned that she wanted to use other people's eyes and have them tell her exactly what they see without opinions or personal perspective. She did not want other people making decisions for her based on what they described. Although the RTDM was not a truly unfiltered form of mediation, it presented visual details that made it easier for a person to form an understanding based on less bias or information constraint.

7.4 Independence

For most people with vision impairments, independence is often difficult to achieve in unfamiliar environments or when barriers are present. In a typical aquarium, the lighting conditions, visitor traffic, wayfinding and navigation cues, and inadequate or nonexistent mediation are challenges for a person with vision impairment and frequently dealt with through the use of a partner. The relationship between the visitor with vision impairment and his/her partner is generally unbalanced since the visitor with vision loss is dependent on their partner to provide assistance and access to exhibit information. This

can create feelings of burden from the perspective of the visitor with vision loss which leads to stress and tension between partners. Additionally, this dependence stresses the partner without vision loss because he/she has the responsibility of acting as the mediator, in addition to other duties, and may not be able to fulfill his/her own motivation needs or participate in the way that he/she wants.

Concerns of burden and stress as a consequence of being dependent on another person were not an unexpected finding from this study. This phenomenon has been investigated in a range of health-related literature [103-105]. What was unexpected, but not surprising was hearing that the stress induced by dependency made it challenging for both partners to address their motivations as well as made it difficult to develop personal understandings, share with their partner, and feel like they belonged. Not being an independent partner had a significant impact on participation. An additional, yet pleasant finding was that people who expressed ideas of stress, burden, and responsibility could find relief through effective third-party mediation. Several participants talked about how the real-time and descriptive features of the RTDM provided details that the partner without vision loss typically has to give and that having this type of mediation would permit the partners to be independent.

The notion of "tagging along" or having to go for the benefit of others was another important topic related to independence that participants discussed. As a consequence of a history of inaccessible or poorly designed exhibits and mediation at aquariums and other ILEs, people with vision loss may assume that they cannot have an independent experience. So, they either don't go or only go along because their family and friends are going. However, given the option of the RTDM, participants with vision

loss mentioned that they would be more willing to go to an aquarium because they could have a better experience. One participant who was blind even talked about the possibility of going to the exhibits by himself if the mediation could give him real-time descriptive information.

7.5 Sharing

Aquariums are designed as public venues that maintain various forms of information sharing, including institution to visitor, visitor to visitor, and visitor to non-visitor. Sharing in ILEs has been studied as a phenomenon associated with mediation technologies [18, 28, 30] and tied to participation [43, 52]. This dissertation work showed that sharing was inherent in the social motivations that visitors have and can also be coupled to learning and entertainment motivations. However, sharing between a visitor with vision loss and their partner is frequently strained and constrained due to partner mediation responsibilities and an unbalanced mutual understanding of the exhibit.

For institutions, sharing is about conveying information to visitors through exhibits and mediation; they share artifacts, animals, text, photos, videos, music and other things as a way of communicating with visitors. They also attempt to facilitate sharing among visitors both during and after a visit through the design of the exhibit and/or its mediation. If an exhibit or mediation is poorly designed or excludes certain visitors, it is less effective at sharing information and consequently, visitors may not be able to address their motivations adequately or at all. The RTDM was developed to minimize or eliminate the barriers presented by an exhibit that, through its visually centric design, is mostly inaccessible to visitors with vision impairment. Moreover, it was an improvement

over existing sound-based mediation that was shown to be insufficient for sharing the live nature of the exhibit with visitors who have vision loss. Thus, the RTDM is a mechanism through which aquariums and other ILEs can enable and improve institution to visitor sharing.

Many visitors go to an aquarium with the intention of sharing with their family or friends as a co-located experience or perhaps through post-visit discussions. As Silverman [101] noted, visitor groups leverage their common history and knowledge of each other during a visit and assist in shaping their partner's frame of reference for building an understanding of the exhibit. Study participants repeatedly talked about sharing as part of their social motivations and reported that sharing was even more important when a person has vision loss. Visitors with vision loss rely heavily on their partners when building frames of reference for exhibits since their partners often have to assume the role of mediator. Consequently, the sharing between visitors with and without vision loss is predominantly unbalanced towards mediation by the partner without vision loss. When an imbalance between partners occurs due to the dependence of one partner on the other, evidence from health-related literature suggests that their interactions can be inhibited, with partners concealing their needs from each other [103-105]. Within the context of an aquarium exhibit, the imbalance not only negatively shapes partners' ability to share information with each other, but it creates stress between partners which has an adverse effect on the overall shared experience. This was quite clear in the feedback from one particular set of partners who talked about their previous experiences in ILEs as less than enjoyable due to problems with sharing. Study partners

expressed a desire to engage in other types of sharing that are better balanced and allow for partners to contribute more independently.

Technology-based mediation such as the RTDM can improve visitor-visitor interactions by providing the right types and levels of information to generate a mutual understanding of an exhibit, whereby a form of conversational grounding can emerge. This conversational grounding can lead to more efficient communication between partners [106] which creates the potential for improved sharing. Designing to facilitate sharing is particularly important for helping visitors address their social motivations. The RTDM was found to offer more support for partner communication and sharing during and after the exhibit experience compared to typical mediation.

Another form of sharing that visitors may anticipate or unexpectedly encounter is sharing the exhibit experience with the broader audience of visitors. Some visitors may choose to go alone, but want to share in the collective experience with other visitors who are there at the same time or simply share in the experience had by past and future visitors. These latter motives may not involve direct interactions between visitors, but can be linked to desires of inclusion or belonging which are examined in the following section.

7.6 Belonging

When people experience a sense of belonging, they feel included in a group, the experience, or a setting. Belonging is a form of social support that is important to most people and has been shown to be linked with a range of life factors including mental and physical health [107-110], learning [111, 112], and community integration [113, 114]. In

disability-related research and practice, belonging is generally referred to as inclusion or integration. As previously cited in the discussion on equitable access, inclusion and integration have been recommended as measurable constructs of participation. Thus, belonging, as a proxy for these concepts, is coupled with participation and inherently important to exhibit motivations. It is also closely tied to the other participation-related themes already mentioned; the desire to belong can drive a person to want to generate a personal understanding, share with others, or be independent. Belonging can also be a result of being able to do these things.

Having equitable access to an exhibit experience through effective mediation makes it less likely that a person will perceive that he/she is being excluded or segregated. The design features of the RTDM were useful to individuals with a range of vision loss not only because they were able to visualize the scene according to the mediation, but also because they felt like they had access to the same information as other people who could see the exhibit. This gave them a sense of inclusion or integration into the social situation. Furthermore, partners with and without vision loss were exposed to the same mediation as a way to encourage communication between partners. Thus, a shared experience was imposed and the mediation was not intended to serve as accommodation just for the partner with vision loss.

In comparing the RTDM to typical audio tour and docent mediation, it is valuable to acknowledge the benefit of combining the real-time and descriptive features as a support for promoting belonging. While an asynchronous audio tour can provide well-described static details, it cannot present real-time information. Docent presentations could incorporate more detailed static and dynamic information, but it is not current

practice likely due to the reasons already described and perhaps because it would be a challenging task for a human to do well. The effective combination of real-time and descriptive features is what provides a contextually-relevant experience. These details are the reason that people without vision impairment go to look at aquarium exhibits. Offering a translation of these details through mediation creates an opportunity for a person with vision impairment to be included in the experience.

The real-time design features were the primary strategy for stimulating belonging in the context of a live animal exhibit. The RTDM and typical docent presentations are able to deliver real-time information that helps people feel like they are part of their group or an audience. Participants with vision loss identified that the RTDM and Docent mediation were better at providing this benefit compared to the Audio Tour mediation. Technically, docent presentations have the best potential for offering real-time information because a human can detect and identify with greater speed and accuracy than a mediation system based on computer vision. However, as discussed earlier in this document, docents generally present real-time information through statements that use deictic references and therefore, depend on unimpaired or sufficient vision ability and good sightlines to the visual scene. On the other hand, the RTDM has limitations based on technology constraints that impact the type and depth of real-time information that can be delivered. Nonetheless, statements in the RTDM about where animals are typically located in the exhibit, how they routinely behave, and how they compare to other animals in the same exhibit, while not a synchronous form of real-time information, can afford a sense of being in-the-moment and sharing the visual scene that supports a feeling of belonging.

7.7 Future Directions

The RTDM system was successful at supporting learning, entertainment, social, and restorative exhibit motivations as well as a facilitating participation. Yet, it would be premature to consider the RTDM a solution to access and participation difficulties for visitors with vision impairment without further work. This work in fact, generated many new research directions and development ideas that will be reviewed in this section.

7.7.1 Virtual Exhibits

Although the study methodology was developed under the pretense that the videos were proxies for the in-person Georgia Aquarium exhibits, it should be realized that the videos could be exhibits in and of themselves. This is consistent with the growing interest in creating virtual exhibits and even ILEs as a strategy for engaging broader and more diverse audiences. At one point, we had even envisioned that the Accessible Aquarium real-time system could be a virtual link to a live exhibit with the display being located in a non-ILE space (such as the airport) or in a partner institutions ILE (such as another aquarium or a zoo). Therefore, the participants were asked to presuppose that the video stimuli were the actual exhibits. They were to interact with the virtual exhibits and each other as well as respond to study questions based on their actual experiences versus trying to imagine what this technology would be like at a physical exhibit. Additionally, this approach also helps to allay concerns that the videos don't represent the full environment of a traditional aquarium. It is true that the videos do not and cannot represent the actual Georgia Aquarium, but considering the videos as virtual exhibits makes them stand alone and offers the benefits of being able to assume that environmental variables could range depending on where a virtual exhibit is eventually

presented and that for this study, environmental conditions can be controlled with less apprehension about them being uncharacteristic of the "real thing".

7.7.2 The Real World

The natural next step for this work is to conduct research with the RTDM in an actual aquarium exhibit. While the lab study I performed enabled me to control many variables, it is important to acknowledge that some of those variables could have major influence on the use and success of the RTDM. The most critical of these variables was the exhibit as a recorded experience which made it possible for the three mediation types to be associated with the same footage and consequently, for participants to be exposed to a standardized set of stimuli. Additionally, the mediation was based on simulation of the computer system because the design features needed to be tested prior to software implementation. Real-world implementation and evaluation of the computer-based RTDM would make it difficult to maintain consistent stimuli across a large group of participants, but it would enable testing under typical listening and viewing conditions including ambient lighting and sound levels and other exhibit visitors. Real-world implementation could also make it possible to study repeat visits by the same person or groups.

7.7.3 Congenital Vision Impairment

The success of the RTDM for people with and without vision loss is attributable to its real-time and descriptive features that were intended to translate the visual scene. These translations were based on the needs of people with acquired vision loss. The choice to constrain vision impairment to this group and not yet consider people who had been blind since birth was made to enable this research to delve more deeply into a set of

design considerations for the larger population of people with vision impairment first. Because the mediation design was centered around people who previously had unimpaired vision, certain design choices were made that relied on assumptions about people's visual understanding of spatial location, color, movement, size, and shape. It is unclear how well this type and level of detail would meet the needs of people who did not develop or do not depend on an understanding of visual concepts that would be relevant to an aquarium exhibit. Exploring design considerations of a real-time mediation system for people who have been blind since birth is an obvious extension to this work and could have benefit beyond an aquarium context. For example, an evidence-based understanding of needs and preferences for describing science information could inform STEM education resources such as the design and delivery of course-based lectures and translations of electronic textbooks.

7.7.4 Vocal and Temporal Design Features

While this work did not emphasize the design of mediation from the vocal and temporal aspects, these were found to be influential to people's mediation understanding and preferences. These design aspects are ripe for investigation within and outside of this work particularly since there is a significant gap in the research on audio tours and vocal and temporal aspects of design. The lack of guidance from empirical work in audio tour design brings to question how the field continues to produce sound-based mediation that has little to no science founded in acoustics, speech, perception, or cognition.

Characteristics of narration such as gender of voice, inflection/style, rate, and information spacing/timing have not been studied and are heavy influences on people's listening attention, ability to understand, and listening preferences. Additionally, audio

tours are generally not designed according to the acoustics of the space in which they will be used. This may not be as important for mediation used in fine art museums where crowd noise is fairly low, but aquariums can be louder spaces and would therefore need sound-based mediation that can overcome the ambient noise. Studies are needed to investigate the impact of space acoustics and ambient conditions on listeners' experiences with sound-based mediation. The method of aural delivery of mediation (e.g., air conduction, bone conduction, and sound field) may also have an impact and needs exploration.

7.7.5 Combining Sounds and Interactive Mediation

This work investigated the design of sound-based mediation that was conveyed through speech. The larger project includes delivery through music and other non-speech sounds [115], yet the music and speech components have not been combined into a single form of mediation. Future work could experiment with speech and music serving specific roles in the mediation such as speech as real-time and descriptive information mechanism and music as the scene setter for animal activity level or "mood" of the habitat. Speech could also introduce musical information that is associated with real-time movement. This work would need to explore the most effective matches between aspects of the visual scene and speech or musical features.

Additionally, more work should be directed at interfaces that allow visitors to interact with the exhibit mediation. The Aquarium Fugue [116, 117] was a collaborative project associated with the Accessible Aquarium work that leveraged real-time information about the animals to engage visitors in a collaborative music-based sonification by moving tangible fish models in front of a motion capture system. The

Fugue and other projects could systematically explore how interactivity impacts exhibit motivations and participation in visitors with and without vision loss, and including children.

CHAPTER 8

CONCLUSION

The work of this dissertation explores the impact of technology-mediated visitor-exhibit interaction on participation. While there are well-established bodies of research related to exhibit design and exhibit technologies, few studies have examined the needs and experiences of visitors with vision impairment. More importantly, this is the first study that investigates the design of technology-based mediation to facilitate participation. The research presented in this dissertation has supported the thesis that:

A mediation system that incorporates real-time and descriptive design features for conveying visual scene information at live aquarium exhibits will facilitate participation of adults with and without vision loss by supporting their learning, entertainment, social, and restoration motivations.

In this chapter, I will discuss the ways in which my design and evaluation activities have led to successful contributions.

- First, by developing participation-relevant mediation design criteria that support exhibit motivations and facilitate participation in adults with vision loss and their adult partners, I generated evidence and methods that can be used to advance design and evaluation of mediation in ILEs.
- Second, by evaluating the RTDM and comparing it to traditional sound-based mediation, I demonstrated the feasibility of RTDM as a support for exhibit motivations and facilitator of participation for adults with and without vision loss.

- Third, by designing mediation to support learning, entertainment, restorative, and social motivations, I operationalized and validated participation as a design goal in the context of live aquarium exhibits.

8.1 Generating Evidence-Based Information Design Criteria

Despite a recent history of attempting to overcome exhibit accessibility issues by promoting awareness and encouraging design of inclusive interactive exhibits, there continues to be poor implementation of accessible or universal design in ILEs. Furthermore, exhibit-related participation outcomes are often absent or ill-defined in the exhibit and mediation design process and often do not represent interests beyond educational/learning objectives. As the work of this dissertation shows, participation outcomes are fundamental to the visitor experience and should be understood from a range of visitor needs and perspective, including individuals with vision impairment.

In this work, I not only identified specific, measurable participation-based outcomes (exhibit motivations) as part of the design process, but also used these expected outcomes to inform the RTDM design. Further, the findings of the mediation study propose particular aspects of participation associated with exhibit motivations (personal understanding, independence, sharing, and belonging) that could also be considered outcomes for exhibit and mediation design. These outcomes, with the exception of learning, are underrepresented in documented processes of exhibit and mediation design and evaluation, which is an unfortunate gap in ILE research and practice.

Additionally, this work clearly emphasized the significance of understanding the impacts of impairment on visitors' motivations, aspects of participation, and interaction with the exhibit and mediation. The design of mediating technologies (and indeed other exhibit technologies and interactive components) must, at the very least, include input from visitors with impairments and their partners as a strategy for supporting a range of visitor needs. However, the more sophisticated and comprehensive approach that this work carried out was to manage a systematic and iterative process of involving prospective end users with vision impairment throughout the lifecycle of this dissertation work.

8.2 RTDM as Support for Motivations and Facilitator of Participation

The real-time and descriptive design features of the RTDM were proven to support exhibit motivations and shown to be particularly more effective for learning, social, and restoration when compared to traditional sound-based mediation. The findings of this study also revealed that the RTDM system enabled other contributions to participation that had not been pre-identified during the formulation of the research questions and hypothesis nor in the design of the study measures (e.g., surveys and interview probes). This work shows that through a lens of participation, it is possible to better understand how exhibits and mediation are appropriated by individuals and groups, and perhaps develop designs, policies, and practices that are more inclusive of the diversity of ILE visitors.

The RTDM's design was informed by a robust body of formative work including analysis of existing exhibit design and mediation, investigations of user needs,

examination of specialized description methods, and prototyping of real-time mediation systems. This study focused on the design and evaluation of the mediation itself and not on the technology that would generate and deliver the mediation. However, design considerations accounted for the known and assumed capabilities and limitations of a technology-based system. A real-time mediation technology that is based on the considerations evaluated and affirmed through this work can feasibly support exhibit motivations and facilitate participation in visitors with vision loss and their partners.

8.3 Operationalizing and Validating Participation as a Design Goal

The formative and design work that led to the RTDM used in the mediation study was based on a predefined concept of participation informed by various V-E interaction models, including the World Health Organization's ICF [6], as well as exhibit design and evaluation constructs from the ILE field. This concept of participation was focused on exhibit motivations as design targets and measurable constructs. An explicit definition of participation was never assumed and not an expected outcome of this research. The benefit of remaining neutral about the definition, while implying a link between participation and exhibit motivations, was that I could allow other themes that have associated with participation, such as sharing and inclusion, to emerge from the data without dedicated efforts to elicit responses related to these other themes. Thus, not only did the work confirm that the RTDM was able to facilitate participation by supporting exhibit motivations, it also revealed specific aspects of participation that were associated with addressing motivations. Another important component of this work was in recognizing that although ILEs are primarily designed to focus on learning, visitors also

have motivations related to social interaction, restoration, and entertainment. This is of value because visitors, regardless of their abilities, seek out experiences that meet their needs and will ignore ones that they perceive or know will not satisfy them.

8.4 Closing

Throughout this document, I proposed and demonstrated that mediation based on real-time and descriptive information at live aquarium exhibits can facilitate participation in adults with vision loss by effectively supporting exhibit motivations and that this mediation would be preferred over sound-based mediation by adults with vision loss. Further, it was shown that partners who accompany these adults with vision loss to aquariums and other ILEs preferred and benefitted from the RTDM.

Enabling and enhancing access and participation at ILEs is an important link in expanding opportunities in STEM-based leisure activities, education, and careers. This research focused on the development of an innovative method for mediation that could enable visitors with vision impairment to have aquarium exhibit experiences that have previously been difficult or impossible. This research advanced knowledge of mediation design from accessibility and participation perspectives. These advances are vital to promoting universal design within the ILE context. This work should encourage ILEs to provide new opportunities for all visitors, including individuals with vision impairment, to address their motivations and participate in meaningful ways throughout their visit.

APPENDIX A

PRIOR AQUARIUM OR ZOO EXHIBIT EXPERIENCES

These questions refer to visiting exhibits at an aquarium. It can be any aquarium you have ever visited. If you have never been to an aquarium, you could describe your experience at a zoo instead. Do **not** include your thoughts about non-exhibit experiences such as parking, gift shops, food areas, ticketing, and restrooms.

NEVER BEEN TO A ZOO OR AQUARIUM _____

1. How many times a year do you visit zoo or aquarium exhibits?

   0 1 2 3 - 4 5 - 6 7 or more

2. Because of your eyesight, how often have you been hesitant to visit zoo or aquarium exhibits?

   never rarely sometimes often always

3. Because of your eyesight, how often have you felt that you are a burden to your partner at zoo or aquarium exhibits?

   never rarely sometimes often always

4. I feel like I learn something about animals when I visit zoo or aquarium exhibits.

   never rarely sometimes often always

5. Going to zoo or aquarium exhibits is a way for me to be social with my family/friends.

   never rarely sometimes often always

6. I feel entertained when I go to zoo or aquarium exhibits.

   never rarely sometimes often always

7. I feel relaxed or in my own world when I visit zoo or aquarium exhibits.

   never rarely sometimes often always

8. Zoo or aquarium exhibits make me feel more creative or imaginative.

   never rarely sometimes often always

9. I can experience zoo or aquarium exhibits in the way that I want to.

   never rarely sometimes often always

APPENDIX B

AQUARIUM EXHIBIT EXPECTATION SURVEY

Think about why you go to exhibits at an aquarium. What are your goals? Please respond to the following statements thinking about what you hope to experience at an aquarium exhibit. Use the scale and tell me which choice best matches your thoughts. Let me know if I need to repeat any of the questions.

What would you hope to get out of going to aquarium exhibits?

1. At an aquarium exhibit, I hope to use my imagination

   strongly agree agree neither disagree strongly disagree

2. At an aquarium exhibit, I hope to interact with others

   strongly agree agree neither disagree strongly disagree

3. At an aquarium exhibit, I hope to expand my knowledge

   strongly agree agree neither disagree strongly disagree

4. At an aquarium exhibit, I hope to be entertained

   strongly agree agree neither disagree strongly disagree

5. At an aquarium exhibit, I hope to enjoy myself

   strongly agree agree neither disagree strongly disagree

6. At an aquarium exhibit, I hope to relax

   strongly agree agree neither disagree strongly disagree

7. At an aquarium exhibit, I hope to get away from the responsibilities of everyday life

   strongly agree agree neither disagree strongly disagree

8. At an aquarium exhibit, I hope to do something exciting

   strongly agree agree neither disagree strongly disagree

9. At an aquarium exhibit, I hope to find some peace and tranquility

   strongly agree agree neither disagree strongly disagree

10. At an aquarium exhibit, I hope to have a shared experience with my partner

    strongly agree agree neither disagree strongly disagree

11. At an aquarium exhibit, I hope to talk about interesting things with someone else

    strongly agree agree neither disagree strongly disagree

12. At an aquarium exhibit, I hope to be creatively inspired

    strongly agree agree neither disagree strongly disagree

13. At an aquarium exhibit, I hope to learn something new

    strongly agree agree neither disagree strongly disagree

14. At an aquarium exhibit, I hope to think of new ideas

    strongly agree agree neither disagree strongly disagree

15. At an aquarium exhibit, I hope to gain a better understanding

    strongly agree agree neither disagree strongly disagree

APPENDIX C

MEDIATION RESPONSIVENESS SURVEY

1. How much did this audio help you to be able to communicate with your partner (during or after)?
   a lot much some a little not at all

2. How much did this audio help you to learn more about the exhibit?
   a lot much some a little not at all

3. How much did this audio help you to be entertained?
   a lot much some a little not at all

4. How much did this audio help you to think more creatively or imaginatively?
   a lot much some a little not at all

5. How much did this audio help you to relax or take your mind off things?
   a lot much some a little not at all

APPENDIX D

PREFERRED MEDIATION QUESTIONNAIRE

1. Which audio did you prefer? Why?

2. Which audio do you think could best help you to:

   a. relax or take my mind off things
      1 2 3

   b. learn more about the exhibits
      1 2 3

   c. be entertained
      1 2 3

   d. think more creatively or imaginatively
      1 2 3

   e. communicate with my partner or others
      1 2 3

3. Thinking of the audio that you most preferred, how would that audio help you to:

   a. communicate with your partner

   b. learn more about the exhibit

   c. be entertained

   d. think more creatively or imaginatively

   e. relax or take your mind off things

APPENDIX E

PREFERRED MEDIATION IMPACT SURVEY

Thinking of the audio that you preferred the most, provide a response for the following statements.

The audio that I liked the most would help me to….

1. use my imagination

   strongly agree agree neither disagree strongly disagree

2. interact with others

   strongly agree agree neither disagree strongly disagree

3. expand my knowledge

   strongly agree agree neither disagree strongly disagree

4. be entertained

   strongly agree agree neither disagree strongly disagree

5. enjoy myself

   strongly agree agree neither disagree strongly disagree

6. relax

   strongly agree agree neither disagree strongly disagree

7. get away from the responsibilities of everyday life

   strongly agree agree neither disagree strongly disagree

8. do something exciting

   strongly agree agree neither disagree strongly disagree

9. find some peace and tranquility

   strongly agree agree neither disagree strongly disagree

10. share an experience with my partner

    strongly agree agree neither disagree strongly disagree

11. talk about interesting things with someone else

    strongly agree agree neither disagree strongly disagree

12. be creatively inspired

    strongly agree agree neither disagree strongly disagree

13. learn something new

    strongly agree agree neither disagree strongly disagree

14. think of a new idea

    strongly agree agree neither disagree strongly disagree

15. gain a better understanding

    strongly agree agree neither disagree strongly disagree

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