The brain inside the heritage machine: Exploring inclusive natural history neuromuseology

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ABSTRACT

This paper explores the use of neuroscience approaches to investigate the potential of inclusive interactive technologies in natural history museums to enhance visitor engagement and empathy. It discusses the role of augmented reality in creating multisensory experiences, allowing visitors to co-author their unique heritage journeys. The paper reviews recent advancements in human-computer interaction and the potential contributions of neuroscience to museum visiting and heritage, and suggests empirical methods to measure the impact of these immersive experiences that strive for fuller visitor inclusivity and engagement. One such biological measurement, electroencephalography, is explored, as is its implementation as part of investigative Mobile Brain-body Imaging paradigms for natural history museum settings.

CCS CONCEPTS

• **Human-centered computing → Human-computer interaction (HCI)**; • **Mixed/ augmented reality**;

KEYWORDS

Heritage; Museum; Natural History; Augmented Reality; Neurodiversity; Inclusion; Immersion; Neuroscience; Neuromuseology; Brain; Electroencephalography

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1 INTRODUCTION

With the onset of interactive technologies that mediate perceptual relations across levels of multisensory immersion (from augmented to virtual reality; i.e., from AR to VR), the unique heritage journey that the museum visitor pieces together, of which they are a co-author, became an idiosyncratic collection of sensory processing and steps in higher cognition. The combination of real and virtual elements within one single space afforded by AR — the "overlaying [of] real-world objects or their digital representations with extra text, audio, video, or other virtual elements or information" — represents a unique opportunity to drive engagement with spaces of informal pedagogy, their collections and stories, while fostering action [21]. Here, immersion is framed essentially as "fundamentally the user's sensation of involvement in the AR world," a multisensory set of "unique combinations wherein users can immerse as well as interact with simulations" [17].

In this paper, we briefly explore the potential of neuroscientifically-informed approaches to natural history engagement — a particular concern within the wider LoGaCulture research project, given its focus on natural and cultural heritage — and consider the experimental steps that may be taken to measure the engagement impact of the connection between visitors and museum collections/interventions. After surveying recent work on the possibilities of neuromuseology, we briefly cover the use of real-time brain activity measurement on the museum floor to evaluate how visitors' brains negotiate the different elements and narratives they find in these spaces. We finish by proposing empirical avenues for investigation of immersion and the role of affect in visitor-museum interactions.

2 TOWARDS AN INCLUSIVE NATURAL HISTORY NEUROMUSEOLOGY

2.1 What is a brain-friendly museum?

In the past three decades, partly in response to Dierking and Falk's 1992 Redefining the Museum Experience, the museum sector has realized the need for ever more gripping and immersive experiences [9, 18]. This mandate to cater to publics that "are no longer satisfied with common and homogeneous experiences, [but who rather look for] personalized and emotional experiences" has entailed some degree of reinvention [5, 6, 18]. One such direction has come out of the growing interest amongst human-computer interaction (HCI) researchers in how insights from neuroscience can be used to investigate how humans interact with space and information, thus fostering inclusivity and engagement while creating more immersive and accessible cultural spaces of empathy [1, 11, 12, 15]. This accessibility can and should recognize that "Once the needs of the

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brain are met, visitors will have a better chance of appreciating our heritage" [3]. Turning a museum space and its natural collections into a so called "brain-friendly museum" — an institution "based on the respect of human beings' cognitive processes and emotions as well as on the protection, preservation, dissemination, and appreciation of our tangible and intangible heritage for the purposes of education, study, and enjoyment" — opens a wonderfully productive space that values neurovariability and neurodivergences [3]. Concerns with engagement for neurodivergent visitors and the curation of cultural heritage experiences that respect neurodiversity should be at the forefront of neuromuseology, fostering "a sense of belonging, challenge stereotypes, and provide meaningful experiences for individuals with diverse sensory and cognitive abilities" [13].

Shedding new light on the interpretive interface of visitor and museum collection/interventions, including those pertaining no natural history, the neuromuseology of these new times is encouraging scholar to "look again at all aspects of the collecting and display of visually interesting objects, taking a broader view than is often associated with the discipline" [14]. The recently called for 'fourth wave HCI,' which places 'politics and values and ethics' at the forefront of HCI practice and research, proposes to bring an "even greater, more active engagement with real-world issues that goes beyond mere recognition or discussion into action and change" [2]. In their recognition of this space of possibility between users and technology, these novel spaces in HCI ultimately invite us to "leave user-centred design behind and develop agonistic, participatory speculation methods to design meaningful relations, rather than optimising user experiences" [10].

2.2 Looking inside the museum-friendly brain

Non-invasive techniques have been used to measure brain activity for a century, with electroencephalography (EEG) as one of the most pivotal brain imaging tools available to basic and clinical neuroscience, as it allows for the measurement of the electrical fields produced by the brain's neural circuits and their subsequent correlation with a myriad of cognitive processes [7]. These applications have included the evaluation of user experiences when interacting with technology [20]. Even though the EEG has a low spatial resolution when compared with other brain imaging techniques (3.0 to 4.0 cm of brain tissue for EEG; 0.3 to 0.6 mm for computed tomography (CT) scan, for instance), it allows access to a still detailed picture of the vibrating life of our central nervous system in real-time without resorting to cumbersome or excessively expensive machinery [16].

By capturing real-time neural activity, museums may tailor mixed-reality experiences and hypertext narratives to enhance cognitive and emotional engagement, creating personalized, immersive environments. This approach may prove particularly valuable in ethically designing experiences that accommodate neurodiversity, as a fuller understanding of diverse neural responses to museum interventions should allow for the creation of inclusive, adaptive interfaces that respond to individual needs.

One of the cognitive scientists' sleights of hand that allows for a direct measurement of affect is the activity in the prefrontal cortex (PFC) of the human brain (responsible for many of our executive functions, such as memory processing, regulation of attention or regulation of inhibition) [4]. Designated as PFC asymmetry, the higher levels of frontal cortical activity on one hemisphere when compared with the other have been correlated with positive or negative valence (e.g., higher activation of the right PFC has been associated with reduced motivation and higher levels of anxiety and stress, whereas higher activation of the left PFC has been correlated with increased motivation, higher affect and behavioral resilience) [19]. PFC asymmetry plays an equally important part in complex cognition, from problem-solving and decision-making to speech and language processing, opening a convenient window to the study of the awake behaving brain [19]. When implemented with dry electrodes, which do not require a gel-based conductive medium between the scalp and the recording electrodes, the EEG — e.g., as a simple, yet powerful, 4-channel dry EEG portable headband in what is called Mobile Brain-body Imaging (MoBI) — may be a formidable ally of the heritage researcher, including in museum settings [8]. With such a brain imaging paradigm, real-time measurement of neurobiological engagement with innovative interventions created under a neuromuseology paradigm becomes possible.

3 CONCLUSION AND FUTURE WORK

On considering the possibilities of neuromuseology to change the way varied publics interact with natural history museum collections, including spaces of ever increasing empathy with concerns for neurodiversity, much optimism is granted. By integrating portable EEG technology, we may start to measure the cognitive and emotional impact of these interactions, providing empirical evidence of increased empathy and engagement. Such a successful implementation of neuroscientifically-informed approaches with diversity concerns should ultimately ensure that all visitors, regardless of cognitive differences, can meaningfully interact with and interpret museum content. This wave, opened by neuromuseology as applied to museum visiting and heritage, paves the way for deeper, more meaningful connections and novel possibilities for inclusion in spaces of informal science learning.

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