Sample Application
2011 Spark! Ignition Grants for Museums

Indianapolis Museum of Art
Indianapolis, IN

Learning How Visitors Look: Applications of Eye Tracking Research

Abstract

The Indianapolis Museum of Art (IMA) will utilize its experience in visitor research, arts education, and technology to conduct a series of controlled experiments that utilizes eye tracking technology. *Learning How Visitors Look: Applications of Eye Tracking Research by the Indianapolis Museum of Art* will consist of three experiments that aim to demonstrate the usefulness and potential barriers to wide adoption of eye tracking technology by the museum community, as well as determine if such methods provide useful tools for improving visitor experience. IMA technology, education, and media departments will collaborate to design, create, execute, and evaluate each experiment.

The first experiment will use eye tracking equipment to monitor the amount of time a visitor's eyes spend looking at a work of art to gauge visitor attention. The second experiment will utilize eye tracking equipment to monitor a user's gaze during a typical Visual Thinking Strategies (VTS) session facilitated by an IMA educator. A video recording (with audio) of the session will be made and synchronized with the data stream from the eye tracking hardware, allowing IMA staff to examine the connection between gaze and response in an attempt to gain a practical understanding of how user's look at art. The final experiment will focus on finding ways to allow the user to access content about a particular work of art using gaze (i.e. looking at a preselected place in the artwork could automatically play an audio file) in order to see if eye tracking proves to be useful in providing interpretive information to visitors.

Finding new ways to meaningfully engage visitors in objects is a perpetual challenge for museum professionals. Eye tracking technology provides a new avenue to understanding how visitors experience works of art. The experiments outlined above will offer insight into ways eye tracking technology and practice might best inform museum practice in terms of exhibition design, programmatic activities, and information delivery.

Individual experiment results will be disseminated on the IMA's website and blog, as well as summarized in a final project whitepaper that describes the findings, benefits, and challenges of adoption. Additionally, the IMA will address specific skill-sets and technology needs required to successfully apply these techniques in other settings. The results of these experiments may potentially reveal entire new fields of study and applications for museum management, fostering a deeper understanding of the cognitive processes of visitors in the gallery, and potentially offer an avenue for improved user-interface design to deliver interpretive resources.

The IMA respectfully requests $24,890 to underwrite equipment, personnel and indirect costs associated with the project. *Learning to Look: Applications of Eye Tracking Research by the Indianapolis Museum of Art* will be executed over a 12 month period beginning July 1, 2011 and ending on June 31, 2012.

I. Assessment of Need

Every year museums welcome millions of visitors to their galleries and exhibitions with the hope that they will discover meaningful experiences that help them understand the world in new ways. Museum professionals spend a significant amount of time and effort studying the ways in which visitors engage with objects in their collections in order to improve the quality of interaction with them. Focus groups held at the Indianapolis Museum of Art (IMA) and elsewhere indicate that visitors see art museums as places for "inspiration" and "contemplation;" however, obtaining a more concrete understanding of what aspects of a visit are found to be inspiring and how museums can actively promote and encourage those experiences remain some of the field's biggest challenges.

While some visitors clearly have meaningful experiences with objects, research shows the average visitor spends only seconds in front of a work of art. In his text, *Learning in the Museum*, George E. Hein, Professor Emeritus in the Graduate School of Arts and Social Sciences and Senior Research Associate at the Program Evaluation and Research Group at Lesley University, states that:

> *Empirical data supports the view that visitors spend little time at individual exhibit components (often a matter of a few seconds and seldom as much as one minute); seldom read labels; usually stop at less than half the components at an exhibit; are more likely to use trial-and-error methods at interactive exhibits than to read instructions; that children are more likely to engage with interactive exhibits than adults, and that attention to exhibits declines sharply after about half an hour.*[1]

Studies of 150 visitors at the Metropolitan Museum of Art[2] found a mean time of less than 30 seconds viewing an object to be typical, with most spending significantly less time. Douglas Worts, former interpretive planner and audience researcher at the Art Gallery of Ontario and museologist, summarizes this behavior as "grazing" and theorizes that the pattern may arise from a mismatch in the goals of curators and visitors.

> *Audience research across the field commonly reveals the characteristic behavior of "grazing" – or wandering slowly past many artworks, spending only seconds looking at any work in particular. It is relatively rare to watch a visitor spend more than a minute with any individual artwork.*[3]

These reports have motivated IMA's own examination of viewing patterns in the gallery in a multi-year effort called *The Viewing Project,* which seeks to encourage active looking, to support visitor creativity and engagement, and to present objects from the permanent collection in new ways. Evaluations from the project's installations studied in-gallery viewing behaviors and found that "time spent looking" typically averages between 12 and 35 seconds. While some significant improvements in engagement have been realized during the course of the project, a quantitative link between looking and engagement remains elusive; measuring that "time spent looking" is a time-intensive, human process.

Research by Abigail Housen and Philip Yenawine asserts that creating repeated opportunities for people to look carefully at and discuss works of art can boost critical thinking and language skills and build personal connections with art. This requires more time spent with "eyes on canvas" and their facilitated discussion protocol, Visual Thinking Strategies, supports that extended looking. Are there ways to lengthen the time spent looking without a facilitator? Can choices made by curators and exhibition designers better support extended looking by average visitors? Can understanding what a visitor actually sees when they look at an art object help us make better decisions about display and information resources? Answering these questions is a primary goal of *The Viewing Project*.

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[1] *Learning in the Museum* by George E. Hein, Routledge, 1998, p. 138.
[2] "Spending Time on Art" by Jeffrey K. Smith and Lisa F. Smith in *Empirical Studies of the Arts*, Vol 19, Number 2, 2001.
[3] "On the Brink of Irrelevance? Art Museums in Contemporary Society" by Douglas Worts in *Researching Visual Arts Education in Museums and Galleries: An International Reader*, edited by Les Tickle, Veronica Sekules, Maria Xanthoudaki, Dordrecht: Kluwer Academic Publishers, 2003.

The IMA will utilize its experience in visitor research and expand upon preliminary findings from *The Viewing Project* to implement the proposed project. By conducting a series of controlled experiments that utilizes eye tracking technology, the IMA will determine if such methods provide useful tools for improving visitor experience.

The Potential for Eye Tracking

Techniques for measuring gaze have been an important part of cognitive psychology and many other fields of study since the early 1960's. Environmental scans by Rayner in 1978[4] and again in 1998[5] summarize the scope and evolution of research linking eye tracking and cognition. Agreement in the research suggests that gaze and attention are tightly coupled (Hoffman 98) [6] implying a direct relationship between the way we look at museum objects and our thinking about them. Research by Wooding[7] in 2002 examines the use of eye tracking systems and art from the collection of the National Gallery in London. While the data seems promising, Wooding's work focused more on a generalized method for visualizing eye tracking data and not on specific applications of these techniques for art history or museology. Automated scientific equipment for eye tracking became more widely available in the 1970's, but involved complex and expensive hardware and often constrained the user's head movement. More advanced eye tracking systems were developed later which were head-mounted and worn like goggles or glasses. These systems allowed users to move their heads freely and supported more a mobile study of eye tracking. While these systems were an important improvement over immobilizing the user's head, they still required detailed calibration and cumbersome equipment to be worn by visitors. Recently several newer systems[8] [9] have become commercially available which feature small and discrete cameras in addition to software-based systems which can detect and track a user's eyes without the need for head-mounted devices[10]. These systems also feature much more friendly calibration schemes and would seem to overcome many of the concerns regarding the use of such equipment in a museum setting.

While still somewhat expensive, these new tools offer – for the first time – the ability for museums to directly study what our visitors are looking at when they spend time with a work of art. There are many potential applications of this technology which have yet to be tried by museums which may yield discoveries that will increase museum understanding and lead to improved visitor experience. Future eye tracking technology will likely include software-only systems which will run on common laptops and desktop computers. Several academic software tools already exist that attempt to track gaze in this way. These systems are still largely experimental at this stage and lack the accuracy and ease-of-use for routine deployment in galleries.

Museums have the opportunity now to explore and model a number of ways in which eye tracking techniques can be used to improve visitor experience allowing them to exploit those advances as hardware costs continue to fall, and as software-based systems become more common. Eye tracking has the potential to transform the ways we understand visual processing in the arts and at the same time offers a direct way of studying several important factors of a museum visit.

II. Project Design

Seeking to explore useful and practical means of applying eye tracking technology to common problems faced by museums, the IMA proposes a series of three experiments be conducted as part of this project which will demonstrate the usefulness and any potential barriers to wide adoption of eye tracking technology by museums.

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[4] Rayner, K. (1978). Eye movements in reading and information processing. Psychological Bulletin.
[5] Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. Psychological Bulletin.
[6] Hoffman, J. E. (1998). Visual attention and eye movements. In H. Pashler (ed.), Attention (pp. 119–154). Hove, UK: Psychology Press
[7] Wooding, D. (2002). Fixation maps: quantifying eye-movement traces. In *Proceedings of the 2002 symposium on Eye tracking research \& applications* (ETRA '02). ACM, New York, NY, USA, 31-36.
[8] http://www.tobii.com/
[9] http://www.eyetechds.com/
[10] http://thirtysixthspan.com/openEyes/

Staff from the Museum's technology, education, and media departments will collaborate to design, create, execute, and evaluate each experiment. Technology staff will provide any assistance with hardware configuration or software design needed. Educators will conduct discussion sessions with visitors. In addition to a whitepaper produced at the end of the project, the IMA will use its blog and social media channels to share about the preparations and results of each experiment as they are conducted over the course of a one year period.

Subjects for experiments will be recruited from the IMA's internship and volunteer programs, as well as from among museum visitors. All subjects will be unpaid volunteers and will be required to sign a human subject release form explaining the nature of the experiments. A pre-participation questionnaire will be administered to gauge subjects' level of experience with art.

EXPERIMENT 1: Is eye tracking useful and practical for measuring visitor attention?
Museums have many different ways to measure gallery attendance. From hand clickers to beam counters and even thermal cameras, museum technology has become quite sophisticated; however, museums have made little progress towards understanding just what those visitors do once they enter the door. Museums are already studying the amount of time visitors spend with works in their collections, but these studies require a set of observational rubrics which are labor intensive and subjective. The ability to automatically measure the attention of visitors in front of a museum object would be a transformational metric for gallery design, collection management, and interpretive development in museums.

This experiment will attempt to use the eye tracking equipment to monitor the amount of time a visitor's eyes spend looking at a work of art, as opposed to reading label texts or people-watching, for example. It will be important to eliminate the calibration step as part of this experiment so that a visitor's normal patterns of viewing the art are not disrupted. To provide a baseline for these results, subjects will be observed and timed using the observation rubrics from *The Viewing Project* and then compared against the automated timing. Please see a full description of *The Viewing Project* in the supporting documents section of this proposal.

EXPERIMENT 2: Is eye tracking useful and practical for understanding how users look at art?
Based on previous research, IMA educators strongly believe that longer looking is the basis for all significant levels of critical thinking and aesthetic engagement. Using techniques from the Visual Thinking Strategies (VTS) system, educators regularly engage groups of visitors of all ages in interactive discussions as a means of drawing out visitor observations and interpretations of a work of art. While such discussions often provide unique insight into an individual's thoughts about a work of art, direct measurements of the connection between viewing and thinking are often difficult and subjective.

In this second experiment, the eye tracking equipment will be used to monitor a user's gaze during a typical VTS session facilitated by an IMA educator. A video recording (with audio) of the session will be made and synchronized with the data stream from the eye tracking hardware, allowing IMA staff to examine the connection between gaze and response. The experiment may reveal a valuable new way to study the impact of comments on looking and the ways in which visitors with varying levels of experience approach new objects in museum collections.

EXPERIMENT 3: Is eye tracking useful and practical for providing interpretive resources to visitors?
Many museums seek to engage visitors by creating a wide range of interactive exhibits that provide additional information and context to an object that cannot be communicated through traditional gallery labels. Many of these techniques are successful and valuable additions to the museum visit. In most cases, museums attempt to guess what information visitors will want to know, and in what context. Many museums are experimenting with distributing this content via a user's personal mobile device, many of which will allow users to access all of a museum's collection on-demand in the galleries. As museums continue to improve the user experience in accessing this content, is eye tracking an attractive alternative interface for engaging audiences?

The final experiment will track the user observing a particular work of art. A set of interpretive audio content will be developed for the work and keyed to locations on the artwork. The experiment will focus on finding ways to allow the user to access this content using gaze (i.e. looking at a preselected place in the artwork could automatically play an audio file). As one potential example, consider the portrait to the right of several Hoosier Group artists on display at the IMA. It's difficult for visitors unfamiliar with the Hoosier Group to know which artist is which. Using the eye tracking system, a simple glance at one of the gentlemen in the painting will cue an audio file with the artists name and short description.

Adams, Wayman – *the Art Jury*

How users perceive this interaction, and whether the gaze tracking *"feels"* natural or intrusive will be a primary factor in determining the success of using these techniques for delivering interpretive content. The IMA is aware of the potential lag that exists in the cognitive processing of audio relative to the visual processing that is reflected by gaze tracking. Subjects of this particular experiment will be surveyed after their session to measure the qualitative factors of the experience and provide feedback regarding the suitability of these techniques for in-gallery use. The IMA anticipates the results garnered from this experiment will leverage future research about the relative speeds of visual versus language-based thought and processing that would has the potential to benefit multiple disciplines.

Challenges and Barriers

A key factor to the wide adoption of this technology in museums will be in understanding and overcoming several potential barriers to adoption. An important output of this project will be the examination of these challenges and a reporting on the potential solutions and trade-offs associated with these techniques. Specifically, the project will look at factors related to the accuracy of the resulting data from the eye tracker under a number of circumstances. Understanding accuracy will put limits on the types of potential uses which are appropriate using current technology. Issues regarding user permission and privacy will be examined yielding concrete information regarding best-practice for integrating these methods into an unattended gallery experience. Factors regarding the types of calibration that are needed for the equipment, and whether or not uncalibrated use is even possible will be also examined. Appropriate lighting needs for the camera equipment will be determined and documented. These issues regarding lighting are particularly important for light-sensitive collections such as works on paper.

III. Innovation and Impact

It's clear that the recent advances in eye tracking technology hold significant promise for applications in museums that are currently untapped. Adoption of these techniques will first need a set of proven use cases before museums will feel comfortable investing in the equipment needed for eye tracking. The project's proposed experiments offer a broad examination of the appropriateness and application areas for the technology that can be implemented across a wide cross-section of museums. The results of these experiments may potentially reveal entire new fields of study and applications for museum management, fostering a deeper understanding of the cognitive processes of visitors in the gallery, and potentially offer an avenue for improved user-interface design to deliver interpretive resources.

While broad in their potential impact, these experiments are still feasible and realistic within the scope and funding of this particular grant. The project's documentation and publication plan will ensure that project staff will benefit from the findings of each experiment, and the general recommendations regarding practical matters and challenges to implementation will be described in detail. Staff members from the IMA will speak and write about the project findings in venues including the Museum Computer Network Conference, the International Conference of Museums and the Web, the National Arts Educators Association, and others. This project is a rare opportunity for museums to innovate current practices by integrating methods and techniques from across disciplines to uniquely

fulfill institutional missions and objectives. Museums seldom have the chance to lead the adoption of technology, and are often responding to external forces. By adopting tools ahead of the curve, this project affords a unique opportunity for the museum community to set a precedent for the professional use and application of eye tracking devices.

IV. Evaluation Plan

Evaluation Plan

The primary objective of this project is to determine the potential application of a new technology for the field of museums. The experiments outlined above will offer insight into which ways eye tracking technology and practice might best inform museum practice in terms of exhibition design, programmatic activities, and information delivery. Results of each experiment will be summarized and interpreted in written reports to be published on the IMA's website and promoted on the Museum's blog. These individual reports will be summarized and combined into a final project whitepaper that describes the findings of each experiment and outlines the benefits of this approach, as well as any outstanding challenges to adoption. Findings of each report will be evaluated in light of a desire for the adoption of these techniques by a broad cross-section of museums with a variety of experience and background with technology. The final whitepaper will make specific reference to the skill-sets and technology needs required to successfully apply these techniques in other settings.

V. Project Resources

Project Management

The IMA is uniquely positioned among museums to be effective in exploring the ways that eye tracking technology can be applied in museums, and to make recommendations regarding the potential applications and challenges inherent in using these techniques with visitors. As a recognized leader in the application of technology for museums, the IMA has a proven track record of openness and sharing as demonstrated in many of the technical collaborations pursued in the past several years. The IMA has played an important and ongoing role in the technical planning and execution of the Steve.Museum social tagging project since the inception of the Steve Research grant in 2006 through today. Presently the IMA is leading the technical efforts of both the Steve-in-Action software development project and also the T3: Text, Tags, Trust research grant. Each of these grants features a broad collaboration of important cultural partners and is dedicated to sharing both tools and research openly with the community.

In early 2009, the IMA founded the video streaming website, ArtBabble[11] as a place where museums can collaborate through the sharing of art-video online. A niche-content portal, ArtBabble plays an important role as a destination for video about art and has proven to be an effective tool for reaching new audiences. Now featuring 28 partners from across arts and culture sector, the IMA runs ArtBabble as an open collaborative and provides free hosting for every partner. In 2010, ArtBabble won the Best Overall Site award at the International Conference of Museums and the Web. The peer review panel had as much to say about the IMA as they did the ArtBabble website, *"the Indianapolis Museum of Art has stuck its collective chin forward and said it will lead in the issue of transparency ... bravo!"*

The IMA has a consistent commitment to producing and sharing the results of its efforts through the development and release of open-source software tools. Efforts such as the IMA Dashboard[12], TAP: The Museum Mobile Tour System[13], and the tools released by the Steve.Museum[14] project demonstrate the IMA's ability to execute and deliver results that benefit the larger community of museums. Members of the project team are highly sought presenters and authors as demonstrated in their track record of publication. This practice and history help ensure that the work

[11] http://www.artbabble.org/
[12] http://dashboard.imamuseum.org/
[13] http://code.google.com/p/tap-tours/
[14] http://www.steve.museum/

of this project will be well disseminated through the field of museums and able to be put into practice by a large segment of the community.

Implementation Schedule and Milestones
The project will be executed over a 12 month period beginning July 1, 2011 and ending on June 31, 2012. The project will be split into four phases to be completed in three month intervals throughout the 12 month period. The first three phases will be devoted to the experiments outlined in the project proposal with Experiment 1 being conducted starting in July, 2011; Experiment 2 beginning October, 2011; and Experiment 3 beginning January 2012. The final phase will be dedicated to the authoring and publication of a final project whitepaper. The authoring of the whitepaper will take place between April of 2012 and the project completion the following June. The whitepaper will benefit from the interim reports generated for each experimental milestone and will summarize the findings and outcomes of each experiment.

Key Personnel
- **Chief Information Officer and Project Director, Robert Stein (5 days)**
  Project management, authoring, budgetary oversight, and supervision of overall project goals and deliverables
- **Director of Education and Co-Project Director, Linda Duke (3 days)**
  Oversight of baseline evaluation for Experiment 1, authoring of reports, VTS Facilitation for Experiment 2
- **Assistant Director IMA Lab and Co-Project Director, Charles Moad (5 days)**
  Detailed project management and technical facilitation of software development; authoring of reports
- **Senior New Media Producer, Daniel Beyer (2 days)**
  Media creation tasks in support of Experiment 2
- **Tiffany Leason, Manager of Higher Education Programs & Research Assessment (3 days)**
  Pre-participation questionnaire, analysis of video recording for Experiment 2, authoring of reports
- **Aileen Novick, Research & Evaluation Coordinator (3 days)**
  Baseline evaluation of visitor attention for Experiment 1, analysis of video recording for Experiment 2, post-experience survey of participants for Experiment 3
- **Software Developer (7 days)**
  4 days to become familiar with the system and software API's; 1 day for software integration for each experiment.

Budget
The total cost of the project is $30,987 with $25,000 requested from IMLS and $6,097 committed by the IMA. Please see detailed budgets and budget justification for a complete description of expenditures.

Finding new ways to meaningfully engage visitors in objects is a perpetual challenge for museum professionals. Eye tracking technology provides a new avenue to understanding how visitors experience works of art. However, the museum field lacks sufficient research on how this technology can be meaningfully applied. The IMA is confident it is fully capable of leading the effort in determining whether such tools are effective for cultural institutions, and if so, what applications are most valuable to the museum community.

BUDGET FORM: Section B, Summary Budget

	$ IMLS	$ Cost Share	$ TOTAL COSTS
1. Salaries and Wages	$4,874.00	$2,860.00	$7,734.00
2. Fringe Benefits	$975.00	$572.00	$1,574.00
3. Consultant Fees	$0.00	$0.00	$0.00
4. Travel	$2,000.00	$0.00	$2,000.00
5. Supplies and Materials	$12,500.00	$0.00	$0.00
6. Services	$0.00	$0.00	$0.00
7. Student Support	$0.00	$0.00	$0.00
8. Other Costs	$0.00	$0.00	$0.00
TOTAL DIRECT COSTS (1-8)	$20,349.00	$3,432.00	$23,781.00
9. Indirect Costs	$4,541.00	$2,665.00	$7,206.00
TOTAL COSTS (Direct and Indirect)	$24,890.00	$6,097.00	$30,987.00

Project Funding for the Entire Grant Period

1. Grant Funds Requested from IMLS	**$24,890.00**
2. Cost Sharing:	
a. Applicant's Contribution	**$6,097.00**
b. Kind Contribution	0
c. Other Federal Agencies*	0
d. TOTAL COST SHARING	**$6,097.00**
3. TOTAL PROJECT FUNDING (1+2d)	$30,987.00
Percentage of total project costs requested from IMLS	**80 %**

*If funding has been requested from another federal agency, indicate the agency's name:
n/a