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"The Old Version Flickers More": Digital Preservation from the User's Perspective

Margaret L. Hedstrom, Christopher A. Lee, Judith S. Olson, Clifford A. Lampe

Abstract

Most criteria for evaluating digital preservation strategies are based on needs and requirements from the archivist's perspective. In the CAMiLEON Project, we wanted to learn what significant properties users consider worth preserving. In this article, we present the results of two experiments that used human subjects to learn about user preferences for different formats of preserved digital objects. We tested subjects' reactions to digital materials that were preserved using three common methods: 1) conversion to a "software-independent" format; 2) migration; and 3) presenting the original bitstream using emulation. The results of this exploratory study suggest directions for further research and help archivists understand how user needs and preferences may inform selection of preservation methods. Further research on the effectiveness of emulation and migration needs to account for the quality of the emulator, the impact of specific approaches to migration on document attributes and behaviors, and numerous aspects of the original computing environment that may affect the user experience. Research on the importance of authenticity should consider how users judge authenticity and the tradeoffs they are willing to make between using the original source and the ease of access and use.

For more than forty years, archivists have debated the best strategies and methods for preserving digital information. They hold strong opinions about the feasibility and effectiveness of different digital preservation strategies, whether preserving data in software-independent formats, migration, or emulation. Most evaluations of these strategies have been based on the relative merits of theoretical models, pilot projects, or practical experience in
Most criteria for evaluating digital preservation strategies rely on requirements from the archival perspective that emphasize ease of accessioning, simplicity of long-term maintenance, and authenticity. Users’ needs and preferences are rarely considered when evaluating digital preservation strategies or when choosing which methods to apply. In the CAMiLEON Project, we conducted research that differs in two important respects from previous research on digital preservation strategies. First, our primary interest was to learn about digital preservation from the user’s perspective. We wanted to understand which features users consider worth preserving, rather than what archivists believe is important or what theoretical models would predict. Second, we used experimental methods and gathered empirical data from human subjects to evaluate how well different preservation methods retained the original “look and feel” of digital objects.

Researchers at the University of Michigan and at the University of Leeds conducted the CAMiLEON Project jointly. Its broad goals were to test the technical feasibility of using emulation for preserving digital information and to evaluate the effectiveness of digital preservation strategies from the user’s perspective. The research team at the University of Leeds was primarily responsible for evaluating the technical and practical aspects of emulation. The University of Michigan researchers, whose results are presented in this article, evaluated users’ perceptions and responses to digital objects in their original format and to those same objects preserved using emulation and migration.

Emulation uses computer programs, called emulators, to imitate the functionality of obsolete computer platforms. Emulators make it possible to run obsolete software on current computer platforms and to present users with an exact copy of the original material. Jeff Rothenberg introduced the concept of


2 CAMiLEON was an International Digital Library Initiative Project funded by the National Science Foundation, award number 99-09935 and the Joint Information Systems Committee from 1999 to 2003. CAMiLEON (pronounced like chameleon) stands for Creative Archiving at Michigan and Leeds: Emulating the Old on the New. Additional papers and reports from the CAMiLEON project are archived at www.si.umich.edu/CAMiLEON/.

3 There is an extended debate in the literature about what constitutes “original” digital information. For the purposes of our research, “original” means the bitstream as it was created or an exact copy of that bitstream.
emulation as a potential method for long-term preservation of digital materials in 1995.4 Advocates of emulation contend that emulation would make it possible to retrieve, display, and use digital documents with their original software. This strategy could have the advantage of preserving the “look and feel” and authenticity of digital objects because the original bitstream is never altered and the objects can be used in a software environment identical or similar to the original one.5 Some digital preservation experts, however, have reservations about emulation, asserting that this approach is complicated, expensive, unreliable, and unnecessary to satisfy users’ needs.6 Migration, a more widely implemented preservation method, involves the periodic transfer of data from an obsolete computing platform, medium, or format to current platforms, media, or formats. Migration almost always changes the original bitstream, and it can have a significant impact on the appearance and performance of preserved digital objects. Creating hardware- and software-independent versions means either creating digital information in a format that all widely available hardware and software can handle or converting older digital information to such a format.

All preservation strategies can alter the presentation, appearance, behavior, and even content of digital objects, whether converting digital information from one format to another, migrating it to current generations of hardware and software, or using emulation. Any of these strategies may affect hundreds of features, attributes, or properties, such as document layout, font styles, color matching, or the speed of input and output devices, in ways that range from extremely obvious to almost imperceptible. We wanted to learn which features users notice and which make a difference in their perceptions of the digital objects, their interactions with them, and the ease or difficulty of using the objects in different formats. We refer to features, attributes, or properties that impinge upon future use and understanding as significant properties.7 Significant properties warrant ongoing preservation due to their demonstrated or

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5 Jeff Rothenberg and Tora K. Bikson, Carrying Authentic, Understandable and Usable Digital Records through Time (RAND Europe, 1999); David Holdsworth and Paul Wheatley, “Emulation, Preservation, and Abstraction,” RLG DigiNews 5 (15 August 2001); Rothenberg, Avoiding Technological Quicksand.
predicted contributions to the appearance, interpretation, or usability of digital objects. We first identified thousands of properties that may be affected when copying, converting, or reformatting digital information, and we developed an abstract model to represent these properties.\(^8\) Then we tested our \textit{a priori} assumptions about significant properties by comparing our very large set of significant properties with the properties that human subjects detected in two different experiments.

In this article, we present the results of two experiments, the first evaluating responses to different versions of a computer game, and the second examining responses to different versions of documents. In both experiments, we gathered data from human subjects and observed them performing tasks in order to gain insights into users' responses to digital materials that were preserved using different methods. Following a review of the literature and prior work, we briefly describe the methodology and design for the two experiments. We then present the findings and results of the two experiments. Finally, we draw some general conclusions from both studies and suggest areas for further research.

\textbf{Literature Review}

We drew on literature from five different areas that address some aspect of "look and feel," significant properties, authenticity, and usability of physical and digital objects: 1) past experience with defining significant properties; 2) theoretical approaches; 3) institutional policies; 4) user considerations and requirements; and 5) human-computer interaction and usability studies. Across this diverse literature is a consensus that preserving useful and usable digital objects entails more than simply preserving the content. Context, structure, and appearance may also be important for future reuse. The literature offers some guidance based on prior experience with physical materials, institutional policies, and theoretical models, but little is known about the specific properties of digital objects that users will consider significant. The Human-Computer Interaction (HCI) literature includes rich empirical research on user needs and usability, but most of the research focuses on current users of current materials, not on future users of obsolete systems and noncurrent materials.

Past experience with preserving physical materials offers several criteria to guide decisions about preserving properties of physical artifacts in their original form. Factors such as age, evidential value, aesthetic value, scarcity, associational value, market value, and exhibition value help archivists, librarians, and curators decide when to preserve materials in their original form rather than,\(^8\) Margaret Hedstrom and Christopher A. Lee, "Significant properties of digital objects: definitions, applications, implications," in \textit{Proceedings of the DLM-Forum 2002}, Barcelona, 6–8 May 2002 (Luxembourg: Office for Official Publications of the European Communities, 2002), 218–27.
or in addition to, reformating them. The archival literature has contributed the concepts of “intrinsic value” and “symbolic value” as factors that may call for preservation of originals. Several studies have investigated the role of specific characteristics of documents, such as color of text, layout, and annotations. Guidelines for microfilm and digital reformating are also useful when considering which significant properties warrant preservation. Past experience provides useful guidance when identifying the significant properties of physical objects, but there is little research and only limited experience with applying these concepts to born-digital objects.

Archivists have contributed formal models and functional requirements that identify the characteristics of digital objects that may warrant preservation. The models and requirements, typically, have been deduced from the principles of diplomatics and archival science, or generalized from requirements proposed by individuals responsible for the administration, management, and oversight of information or recordkeeping systems. Authenticity has been analyzed

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extensively from theoretical, legal, and procedural perspectives, but there has been little effort to understand how users of digital objects judge their authenticity. Typically, theory-based models have been developed or evaluated by administrators, archivists, records managers, and information technology professionals, with little input from researchers or other potential users of preserved digital objects.

Institutions faced with the need to preserve digital materials have also developed policies and guidelines that attempt to balance the ideal of preserving all of the attributes and functionality of original materials with concerns for ongoing preservation costs, technical feasibility, and institutional capabilities. According to current U.S. federal policy, for example, agencies “may not transfer to the National Archives electronic records that are in a format dependent on specific hardware and/or software.” As a consequence, NARA accepts permanent electronic records in a limited, albeit increasing, number of formats. Researchers at Cornell University applied risk management methods to identify properties that might be altered or lost during migration of several different types of files. They found that the original bitstream could be altered by bugs in conversion software, mishandling or failure of storage media, incompatibilities


16 36 CFR 1228.370(d). The current wording provides for submission only of files that are not dependent on specific hardware and/or software, encoded in “ASCII or EBCDIC with all control characters and other non-data characters removed.”
between the original and the migrated formats, and changes in compression, file sizes, media density, and file names. Such changes may introduce errors; affect the resolution, dynamic range, and color spaces of images; change or eliminate linkages to other files, such as metadata files, database directories, scripts, and URLs; or eliminate unique features of the original format that are not supported by the migrated format. Clearly, practical considerations of feasibility and cost come into play when evaluating digital preservation strategies, but with little research and limited experience with preserving born-digital materials, it is difficult to assess how the trade-offs among costs, technical feasibility, and potential loss of information affect future use of digital information.

Archivists and curators recognize the need to consider the contexts of purpose and use when choosing preservation strategies, including who the users will be and what they will need. The Open Archival Information Systems (OAIS) Reference Model introduced the concept of a designated community defined as "an identified group of potential users of the archives' contents who should be able to understand a particular set of information." In a survey of research, practice, and common understandings among stakeholders in digital preservation, Abby Smith and Daniel Greenstein observed that a trustworthy digital repository "must be explicit about what digital information it preserves, why, and for whom. It also must be clear about the attributes of the archived information it intends to preserve." David Levy has argued that "determinations of which properties matter are made in the context of purpose and use." This context includes not only the particular class of users, but also the stage of the research process in which they are engaged. According to David Bearman and Jennifer Trant, "[t]o determine which methods are suited for what purposes, it is critical that we better understand the functional requirements for authenticity on the..."
part of creators and potential users of digital resources, and appreciate where in the research process these requirements come into play. These comments suggest that the context of use is an important consideration in choosing digital preservation strategies.

We used several important concepts from the literature on Human-Computer Interaction (HCI) related to significant properties, perception, and usability. The concept of “affordances” from the HCI literature was especially useful. Broadly defined, affordances refer to the “the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used.” Properties of digital objects can provide affordances for viewing, navigating, reusing, and analyzing the contents of the objects. When encountering a preserved digital object, users may find the original affordances of the object important for making sense of its contents as well as for understanding the functional context in which it was created, used, and acted upon. Concepts and methods from usability design and evaluation helped us design the experiments and make use of the “Thinking-Out-Loud” (TOL) method.

CAMILEON Project Experiments

We decided to conduct two laboratory experiments with human subjects during the CAMILEON Project so that we could learn about user preferences for different formats of preserved digital objects. We designed the experiments so that we could observe human subjects as they interacted with digital materials and gather comments from them about the appearance and behavior of digital materials that were preserved using different preservation methods. The first experiment tested subjects’ reactions to different versions of an obsolete computer game called “Chuckie Egg.” The second experiment evaluated subjects’ responses to different versions of speech files and office documents from a former president of the University of Michigan. In both experiments, subjects performed the types of tasks that might be expected of people using preserved digital objects for entertainment (Chuckie Egg) or research (speech outlines).

We used the Thinking-Out-Loud (TOL) protocol where subjects talked about their experiences and reactions as they performed the tasks. The research

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22 Bearman and Trant, “Authenticity and Digital Resources.”


assistants explained each task to the subject and then asked him or her to “think out loud,” which meant mentioning any first impressions, further thoughts, or expectations concerning any aspects of the documents. The research assistants recorded each session, took detailed notes, and transcribed and coded the subjects’ commentary to identify patterns and trends in the subjects’ responses. We also used written instruments to collect data on the differences that the subjects observed when asked to compare original digital materials with other versions that retained only a portion of the significant properties of the original. The two experiments used different types of materials and asked somewhat different questions. Therefore, we discuss each experiment separately and then conclude with some general observations from the two experiments.

Experiment One: The Computer Game “Chuckie Egg”

The first experiment involved Chuckie Egg, which was a popular computer game in the United Kingdom in the mid-1980s, similar to other early maze games such as PacMan. (See Figure 1.) Chuckie Egg was designed to run on the BBC Microcomputer, a computing platform that became orphaned in the 1990s. We decided to run an experiment using a computer game for several reasons. Although computer games may seem like a frivolous example of a new documentary form that hardly merits attention, from the perspective of popular culture, games are difficult to ignore. Computer games are the most common type of software sold for home computers. Young people, particularly, share this cultural icon, but market studies show that more than one-third of computer game consumers are over age eighteen. Computer games have also been the subject of serious research on the formation of gender identity in children and on tendencies toward violence and alienation among frequent users. Moreover, they provide important evidence for understanding the evolution of software, both technologically and aesthetically. Applications such as flight simulators, virtual war games, and interactive educational software such

26 By “orphaned” we mean that the original developer of the hardware, Acorn Computer, and the developer of most of the software, the BBC, ceased support and further development of the platform. The BBC Domesday Disk, which was recovered by the research team at the University of Leeds, also ran on the BBC Micro.
as 3-D visualizations of the human body draw heavily on software design principles developed originally for computer games. Computer games are also good examples of digital objects that are highly dependent on particular hardware and software with many potentially significant properties, including display size, screen resolution, aspect ratio, color graphics, and input/output speed variation.

We chose the Chuckie Egg game for both pragmatic and conceptual reasons. Three different versions of the game were available: the original game that ran on the BBC Micro, a disk image of the original game that could be played on a Windows platform using an emulator of the BBC Micro, and a version that was migrated to run directly on a Windows platform. We were able to use versions of the game that already existed rather than having to build an emulator or write a migrated version. Like many computer games, Chuckie Egg had a built-in scoring mechanism and a means for players to move to more advanced levels as their performance improved. The scoring mechanism offered one way to measure subjects’ performance and to determine how quickly they became proficient enough to move to levels one and two when playing different versions of the game.

We started the experiment with two assumptions based on assertions in the literature about user behavior and emulation. First, archivists and others contend that under some circumstances users prefer to work with original documents rather than copies or surrogates. We began, therefore, with the hypothesis that users would prefer to play the original game on the BBC Micro

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rather than an emulated or migrated version. Second, advocates of emulation claim that emulation preserves the original "look and feel" of digital objects. We expected that subjects who played the emulated version of the game would find it more like the original than those who played the migrated version.

Experiment One: The Experimental Design

We acquired and set up a working BBC Micro in a usability laboratory on the University of Michigan campus. We recruited thirty subjects by posting flyers that advertised the opportunity to participate in the experiment and offered the subjects compensation for their participation at several gathering sites on the University of Michigan campus. Most of the subjects were graduate or undergraduate students in the age range of eighteen to forty-four years with a mean age of 24.4 years. About two-thirds of the subjects were American citizens; one-quarter were from Asia, and the remainder were from Europe or the Middle East. Most significantly, no subjects had used a BBC Micro or played the Chuckie Egg game prior to the experiment. Therefore, the subject pool is similar to future users who will not have had experience using original computer platforms or applications that have become obsolete.

The research assistants trained each subject to play the original Chuckie Egg game on the obsolete BBC Micro platform. After completing a one-hour training session, the subjects switched to a modern PC platform. One group played the version of the game that emulated the BBC Micro and the other group played the migrated version. We recorded all interactions and collected measures of subjects' performance while playing the game. We used the TOL protocol for one round of the game and asked subjects to think about differences that they noticed between the training condition (the original game) and their test condition. Each subject also filled out a questionnaire asking about differences between playing the original game on the BBC Micro and playing the game on the PC platform with either the migrated or the emulated version.

Experiment One: Findings

We measured three aspects of user experience: 1) satisfaction (was the game interesting and fun to play?); 2) perceived ease of use (how easy was it to play the game?); and 3) performance (how quickly could users accumulate enough points to advance to level one and level two of the game?). People who play computer games find them entertaining because players are challenged to improve their performance with practice. In our experiment, satisfaction fell almost in the middle of the scale (from very fun and interesting to not fun or interesting at all), regardless of whether subjects played the
migrated or emulated version. Subjects considered all versions of the game easy
to play. On the performance measure, there was no statistically significant dif-
ference in the total amount of time it took subjects to reach level one or level
two between the migrated or the emulated versions of the game. For this game,
there is no statistically significant evidence that the emulated version preserved
the original “look and feel” and behavior of the original game better than the
migrated version did.

The subjects’ comments during the TOL session further elucidated their
reactions and experiences. Some subjects found playing the game on the
original BBC Micro boring and frustrating because of the obsolete keyboard
and display, slow pace, and unfamiliar patterns of interaction. Subjects in the
emulation group mentioned that compared to the original BBC Micro version
of the game, “the keys are nicer, a softer touch,” “it looks like the screen is
scrunched,” “the character can jump farther,” and “it might be a little softer, or
it could be the hardware.” Similarly, subjects who played the migrated version
remarked that “the keyboard makes it easier to control Chuckie,” “the old
version flickers more,” “the blue birds are smarter,” and “sounds are a little
sloppier.” Subjects reported many differences between playing the game on the
original BBC Micro and playing either the emulated and migrated versions, as
indicated in Figure 2.

Many of the differences that subjects observed about the different versions
of the game concerned the hardware environment, especially differences

<table>
<thead>
<tr>
<th>Emulated Version (N=15)</th>
<th>Migrated Version (N=15)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Screen/Display:</strong></td>
<td></td>
</tr>
<tr>
<td>• &quot;The screen is more squished together.&quot;</td>
<td>• &quot;Better looking because the pixels aren't so big.&quot;</td>
</tr>
<tr>
<td>• &quot;Screen seems vertically compressed.&quot;</td>
<td>• &quot;The old version flickers more.&quot;</td>
</tr>
<tr>
<td>• &quot;Looks like the screen is scrunched.&quot;</td>
<td></td>
</tr>
<tr>
<td>• &quot;I liked the other screen better, it reminded me of the last time I played a game like this.&quot;</td>
<td></td>
</tr>
<tr>
<td><strong>Keyboard:</strong></td>
<td></td>
</tr>
<tr>
<td>• &quot;The keys are nicer, a softer touch.&quot;</td>
<td>• &quot;Keyboard makes it easier to control Chuckie.&quot;</td>
</tr>
<tr>
<td>• &quot;Feels easier, but that could be related to the keyboard.&quot;</td>
<td>• &quot;Something different about how it responds, I think it's the keyboard.&quot;</td>
</tr>
<tr>
<td><strong>Interaction Patterns and Speed:</strong></td>
<td></td>
</tr>
<tr>
<td>• &quot;Character flashes, makes it easier to recognize.&quot;</td>
<td>• &quot;Blue birds are smarter.&quot;</td>
</tr>
<tr>
<td>• &quot;The character can jump farther.&quot;</td>
<td>• &quot;Seems faster.&quot;</td>
</tr>
<tr>
<td>• &quot;All elements move faster, can get through the levels quicker.&quot;</td>
<td>• &quot;The (increased) speed makes it a little harder to time your jumps.&quot;</td>
</tr>
<tr>
<td>• &quot;Can jump further, and catch stuff above you, which you couldn't do before.&quot;</td>
<td></td>
</tr>
<tr>
<td><strong>Sound:</strong></td>
<td></td>
</tr>
<tr>
<td>• &quot;Sounds are a little sloppier.&quot;</td>
<td>• &quot;Sounds are more annoying.&quot;</td>
</tr>
<tr>
<td><strong>Other:</strong></td>
<td></td>
</tr>
<tr>
<td>• &quot;There's a new bar,&quot; (artifact from the emulation software.)</td>
<td>• &quot;Different from the Commodore 64 feeling you get with the first one.&quot;</td>
</tr>
<tr>
<td>• &quot;Nicer than the first one.&quot;</td>
<td>• &quot;You can see Chuckie's legs, which makes it easier to time stuff.&quot;</td>
</tr>
<tr>
<td>• &quot;Might be a little softer, or it could be the hardware.&quot;</td>
<td></td>
</tr>
</tbody>
</table>

**FIGURE 2.** Differences between Chuckie Egg and Migrated/Emulated Versions.
between the BBC Micro keyboard and the modern PC keyboard, sound, screen display, and interaction speed.

**Experiment One: Conclusions**

We drew three main conclusions from the first experiment. First, the subjects noticed very minor differences between the original and the emulated and migrated versions of Chuckie Egg. Many of the elements of "look and feel" that subjects considered worth mentioning were not anticipated in our abstract model of significant properties. Second, when subjects compared the original with either the emulated or the migrated version of the game, we found no evidence that emulation is better for preserving original "look and feel" than migration. This finding may be an artifact of the specific software that we tested, because the migrated version was developed with great care to make the game perform as much like the original as possible, but it merits further investigation with different programs and platforms. Finally, we discovered that subjects preferred playing the migrated and emulated versions rather than the original game on the BBC Micro. Although a few subjects lamented the loss of the original game "feeling," most valued the greater ease of manipulation and faster speed of the migrated and emulated versions. The obsolete keyboard and screen were important factors in experiencing the original "look and feel" of the Chuckie Egg game, but almost all of the subjects were willing to forego those aspects of the original experience because they also made the game slow and cumbersome. Further research on the effectiveness of emulation and migration needs to account for the quality of the emulator, the impact of specific approaches to migration on document attributes and behaviors, and numerous aspects of the original computing environment that may affect the user experience.

**Experiment Two: Speech Outlines and Office Documents**

One goal of the second experiment was to gain a deeper understanding of the properties of textual documents that subjects consider significant when using, interpreting, and judging the authenticity of digital documents. In the second experiment, subjects interacted with three different versions of speech files and office documents. We also wanted to learn more about the differences that subjects might notice between different formats of the same document and which format they would prefer to use for research. We used the results and findings of the Chuckie Egg experiment to inform the design of our second experiment. For this experiment, all of the versions were presented on the same PC platform, thus controlling for any differences in the hardware configuration. We were also attentive to gathering data on minor differences in the various versions of documents presented to subjects.
Experiment Two: The Experimental Design

This experiment involved three tests, which are discussed separately below. In each test, we gathered data on subjects' reactions to outlines of speeches and notes for public addresses created between 1990 and 1993 by James J. Duderstadt, president of the University of Michigan from 1988 to 1996. Subjects viewed some combination of five speech outlines in the following formats: the original MORE format (MORE) (Fig. 3), a version migrated to Microsoft Word Version 6.0 (Word) (Fig. 4), and an ASCII text version (Text) (Fig. 5). MORE was one of a few early outlining programs available in the early 1990s. An outliner organizes content as a set of topics, subtopics, sub-subtopics, and so on. MORE had the capability of displaying the topics in an outline view, in a bulleted list, or in a tree chart. In the outline view, MORE allowed users to expand or collapse the list of topics, thus hiding or revealing subtopics and sub-subtopics. Today, most word processing and presentation software packages

![Figure 3. Michigan Mandate Speech in MORE.](image-url)
"THE OLD VERSION FLICKERS MORE": DIGITAL PRESERVATION FROM THE USER’S PERSPECTIVE

A year ago, I placed a challenge before the University in the form of a public personal statement that has become known as the Michigan Mandate. It was my belief that the University, to achieve excellence in teaching and research and to serve society, must be leaning on its past, on tradition, on its history, and must sustain a campus community recognized for its values and values-driven.

Hence I suggested that the University had a mandate not merely to reflect the growing diversity of America in our students, faculty, and staff but to go beyond that by building a model of a pluralistic, multicultural community for our nation.

A community which values and respects and indeed, draws its intellectual strength from the rich diversity of people of different races, cultures, religions, nationalities, and wealth.

In such an effort to build the multicultural University of the 21st century, we are attempting to address the most urgent and difficult issue confronting our nation today.

In setting out this challenge before the University, I understood as well my urgent desire that the University take the lead in equal opportunity in the years to come to achieve these objectives.

Hence I suggested a quite different approach. To develop a carefully designed strategic plan which would be an integral part of the University necessary to respond to a changing society and a changing world... an organic plan that would evolve through continuing interaction with the University, as we gained experience and as the University grew on it.

The objectives of this plan were focused on four areas:

1. Planning, recruiting, and development of students, staff, and administration and outreach
2. The environment for diversity
3. The planning and development
4. Staff recruiting and development
5. The environment for diversity

We have since broadened this effort to include a...
provide this functionality, but this capability was quite advanced and uncommon in software packages during the 1980s and early 1990s. As shown in Figures 3, 4, and 5, the Word versions resemble the original MORE documents much more closely than do the Text versions.

Although the distributor of MORE stopped supporting the application in 1997, it still has some enthusiastic users. We were able to purchase an emulator, called Basilisk II, which allowed us to present the original MORE documents to the subjects running under emulation on a modern PC platform with the Windows operating system. The MORE files were the actual files that President Duderstadt created on an Apple Macintosh computer, but we did not tell the subjects which format was the original until the end of the experiment. We also intentionally withheld from the subjects contextual information that was available in the finding aid, such as biographical information, information about the office of the president, and information about the processing of the collection, in order to learn how they would reason about the originality of the documents based only on what they could ascertain by interacting with them on the screen.

We selected outlines and notes for five speeches from a total of 2,144 digital documents in the Duderstadt Papers. All of the documents referred in some way to "The Michigan Mandate," a program launched by President Duderstadt to increase diversity at the university.31 We used the speech outlines from the Duderstadt Papers for several reasons. First, these documents are typical of the types of digital documents that archival institutions preserve for future research. Second, the original MORE files and a version that was migrated to Microsoft Word were available to us.32 We created flat ASCII text versions of the documents from the MORE files for use in the experiment to test subjects’ reactions to "software-independent" or flat text files. Third, the Bentley Library staff decided to save the electronic versions for the purpose of reflecting "some of the ways Duderstadt’s office functioned, particularly in the evolving years of electronic recordkeeping." Finally, we were able to interview President Duderstadt about his use of computing equipment generally and the MORE software specifically.33

We conducted the user tests in two usability labs on the University of Michigan campus. We recruited thirty subjects by posting flyers in locations on campus frequented by faculty and students who do historical research, including the Bentley Historical Library and the Gerald R. Ford Presidential Library. Our goal was to identify subjects who might do research and write papers using pri-

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32 The Word files were created by Bentley Historical Library staff in 1997 and 1998, while they were processing Duderstadt Papers. They decided to convert the MORE files to Microsoft Word 6.0, while also retaining the original Macintosh computing platform, MORE software, and MORE files.

mary source materials in archives. This subject pool consisted mostly of under-
graduate and graduate students in a variety of fields including public policy, law,
education, psychology, business, history, economics, and computer science.
There was one independent researcher and one librarian/archivist in the sub-
ject pool. The age of subjects ranged from twenty years to fifty-four years, with an
average age of 24.6 years. The subjects had an average of more than five years of
computer experience and used computers an average of 25.6 hours per week. All
of the subjects had used Microsoft Word, two-thirds had used text editors, but no
subject had used MORE. All but two subjects had done research using primary
source materials or looked for primary sources on-line.

Each subject completed three tests in sequence and then responded to
questions about usability of the different formats. Each experimental session
lasted from forty-five minutes to an hour and ten minutes, averaging about
fifty-five minutes per subject. We used written instruments and the TOL proto-
col to gather data on the subjects' responses to the speeches in different formats
and to record the differences that they noticed. Each session was taped and the
data were transcribed and coded for analysis. In all three tests, subjects viewed
the documents on a computer screen, and they were able to scroll through
the documents, move from one document to the other, and use the other
functionality that the text editor, Word, and MORE provided. When evaluating
the MORE documents, the subjects were able to expand and collapse the
outline view and to view the documents in outline, bulleted list, and chart form.
The subjects were not permitted to edit or change the documents.

Experiment Two: Tests and Findings

Test I: Comparison of three speeches in one format

The purpose of the first test was to determine how subjects would decide
whether they were viewing the original or a document that had been altered
in some way when shown speech outlines in only one of the three formats.
Ten subjects viewed three speech outlines only in MORE; ten saw the same three
outlines only in Word; and ten saw them only in Text. Subjects were told that
these were "documents that archivists believe were written by President
Duderstadt. They are not sure if these files are the ones he actually created using
his computer, or if they might have been copied or changed in some way
between the time they were written and now." Subjects were then instructed to
look over each document, think out loud, and provide written responses to two
questions regarding the documents they had just viewed:

1. How likely do you think it is that the document you're looking at is the
one that President Duderstadt created?
2. What led you to this conclusion?
When the subjects examined three speeches all in the same format, they reasoned carefully and considered many factors, given the limited amount of information available to them. However, when asked to speculate about how likely it was that they were viewing the original, on average, the subjects were uncertain about the likelihood that they were viewing the original documents. (See Figure 6.)

There was very little variation from format to format in how the subjects ranked the likelihood that they were looking at the originals. In fact, the mean rankings for MORE and Word were identical (3.63), and Text was very similar (3.77). Moreover, the means for all three formats fell very close to the midpoint (4) of the 7-point scale, indicating that the subjects, on average, could not tell how likely it was that they were looking at the originals. Of 27 observations when subjects thought that it was very likely or quite likely that they were viewing the original documents, only 7 were actually viewing the original MORE files. In this test, when subjects saw only one format, the format by itself did not provide subjects with enough information for them to ascertain accurately or with certainty which documents were the originals.

We learned from the written responses and the TOL session which factors the subjects considered when trying to determine whether they were viewing the originals. All of the subjects mentioned some aspect of the contents of the speeches. For example, subjects speculated about whether or not a university president would write such a speech, how an outline with abbreviations and subheadings would be used as the basis for a speech, and whether its main themes were consistent with what a university president might say. Many subjects made observations about the writing style, but they often reached different conclusions. Some subjects indicated that they thought the documents could have been written by President Duderstadt because they were concise and straight to the point, well

<table>
<thead>
<tr>
<th>Format</th>
<th>Mean Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>MORE</td>
<td>3.63</td>
</tr>
<tr>
<td>Word</td>
<td>3.63</td>
</tr>
<tr>
<td>Text</td>
<td>3.77</td>
</tr>
</tbody>
</table>

Figure 6. Comparison of three speeches in one format.
organized, "thorough—not choppy," "written in an intelligent voice," or seemed "professional." Others, however, questioned whether President Duderstadt wrote the documents because they found the outlines too informal, not well organized, extremely casual, too emotional, or too haphazard for a presidential speech.

In speculating about the originality of the documents based on their content or style, most subjects made assumptions about what an author would write in his role as a university president. A few subjects who possessed additional knowledge about President Duderstadt also used this in their speculations. Subjects who were aware of Duderstadt’s academic background as a nuclear engineer took this into account. One subject, looking at one of the speeches in Word format, surmised that it was "more orderly, more focused, has a purpose. Duderstadt was an engineer; he'd likely have those traits and want his work to reflect that." Another subject concluded that it was unlikely that President Duderstadt wrote one of the speeches himself because of the "more rousing and emotional nature" of the speech. "I'm stereotyping and assuming a nuclear scientist would not write a speech like this."

Most subjects also commented on formatting features and the general appearance of the documents. Those who saw the speeches in Text noticed unusual characters that did not convert accurately or odd spacing, or they noted that the flat text file would not be very useful for reading a speech. Subjects also speculated about the computing environment at the time the documents were created, noting, for example, that odd characters suggested that the documents were converted from a different format, that a university president would have used more sophisticated software than a simple text processing package; or, conversely and erroneously, that computers were so primitive at the time that the sophisticated functionality of MORE or Word would not have been available.

Test 2: Comparison of one speech in three different formats

In Test 2, we wanted to learn how subjects would identify the original if they were able to compare three different formats of the same speech. This time, we showed subjects the same speech in MORE, Word, and Text. Subjects were told, "Archivists going through some more of President Duderstadt’s computer files found several documents in three different formats. They’re not sure which of them he created himself." We asked them to rank the three formats based on "how closely you believe it resembles the actual file that Duderstadt created." We then asked the subjects to indicate how confident they were in each of the rankings that they assigned on a 7-point scale (from 1—very confident” to “7—not confident at all”). When subjects were able to compare the same speech in three formats..."
different formats, more subjects identified the original correctly. Fourteen of
the 30 subjects correctly identified MORE as the original, and 9 ranked all three
formats correctly in terms of the degree to which each resembles the original.
(See Figure 7.)

When we asked the subjects to indicate their confidence that they
had ranked each format correctly, their confidence that they had ranked each
format correctly increased. The mean confidence ranking was 4.86 on a 7-point
scale, and almost two-thirds of the subjects (64.4%) were somewhat confident
to very confident with their rankings. They also took more factors into account,
mentioning the appearance, suitability of the format for the purpose of writing
or delivering a speech, and assumptions about the capabilities of computers at
the time the documents were created. Frequently, subjects noted differences
in the appearance of the three formats, especially in how the speeches were
structured and laid out on the screen. Many subjects remarked on different
affordances of the three formats. For example, 10 of the 14 subjects, who ranked
MORE as most closely resembling the original, thought that it seemed like
the best program for outlining speeches and organizing notes because the
collapsing and expanding feature made it easy to read and navigate. Conversely,
many subjects noted that the Text files would be difficult to use when delivering
a speech because of inconsistent indentation and lines of text that exceeded the
width of the computer screen.

Finally, subjects speculated about the computing environment at the time
the documents were created and whether or not software applications with

<p>| For each format, how closely do you believe it resembles the actual file that Duderstadt created? |
| 30 subjects - 3 formats = 90 observations |</p>
<table>
<thead>
<tr>
<th>Ranking</th>
<th>1 (most resembles)</th>
<th>2 (somewhat resembles)</th>
<th>3 (least resembles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MORE</td>
<td>14</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Word</td>
<td>10</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>Text</td>
<td>4</td>
<td>12</td>
<td>14</td>
</tr>
</tbody>
</table>

[Note: cells in bold are correct answers. A correct ranking of how closely
each format resembles the original would be MORE (1 - most resembles),
Word (2 - somewhat resembles), and Text (3 - least resembles)]

Figure 7. Comparison of three different formats.
the features of MORE and Word were available in the early 1990s. Subjects who
believed that Word most resembled the original mentioned that it was a com-
mon software package. All 4 subjects who thought that Text was most like the
original version reached this conclusion based on erroneous assumptions about
the computing environment at the time the documents were created. They did
not think that programs with the features of MORE or Word were available at
the time that documents were created.

Test 3: Comparison of the original MORE documents with Word or
Text formats

In the third test, we wanted to learn about the differences that subjects
noticed between the original MORE files and either Word or Text. Subjects
viewed a speech that they had not seen before and compared the original MORE
version with the same speech in either Word or Text. Twelve subjects compared
MORE and Text; and 18 subjects compared MORE and Word.35 We first asked
subjects to list all of the differences that they noticed between the two formats
(MORE and Text or MORE and Word). Then we asked them to tell us what dif-
fferences were most important in determining which version was the original.

The subjects who compared MORE and Text noticed a larger number of
differences than those who compared MORE and Word, which is not surprising
because the MORE and Text files have more differences and the differences are
more obvious. (See Figure 8.)

They commented most often on conversion errors in the Text version, dif-
fferences in the layout and alignment of sentences and paragraphs, the different
fonts in MORE and Text, and the enhanced legibility of the MORE version.
When asked to indicate which differences were most important for determining
which version was the original, the subjects listed many different possibilities
and sometimes reached contradictory conclusions. The subjects most often
mentioned conversion errors in the Text documents, and greater legibility and
"professional look" of the MORE files. But the "primitive look" of Text files also
confirmed some subjects that the Text files most resembled the originals. Two
subjects who incorrectly identified the Text version as the original indicated that
the "lack of new looking features" and the "primitive versus modern look" of the
Text document were important in their assessments. Another subject, after
noting the odd characters and font of the Text document, said, "If I were look-
ing at a doc from [the] 1980s [sic], I would think the typos and more raggedy
courier new [sic] font was more 'real.'"

35 We did not do a comparison of Word and Text because our research focused on the difference between
the original and the two variants. We asked more subjects to compare MORE and Word because the
differences between the two are less obvious.
The differences between the MORE and Word versions were less obvious than the differences between MORE and Text, and subjects who compared these two formats listed fewer differences. In fact, several subjects thought that the MORE and Word versions were almost identical, listed no differences, or had to be prompted to look closely. Subjects noticed formatting features and the larger font in Word, and speculated about the obscurity of MORE and the Basilisk emulator. (See Figure 9.)

When asked which differences were most important for deciding which version was the original, subjects focused on different features than those who compared MORE and Text, and they used more complex reasoning. Legibility was one issue that the subjects mentioned frequently, especially the ease of reading a speech
"THE OLD VERSION FLICKERS MORE": DIGITAL PRESERVATION FROM THE USER’S PERSPECTIVE

FIGURE 9. Examples of differences noticed between MORE and Word.

<table>
<thead>
<tr>
<th>MORE</th>
<th>Word</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formatting Features</td>
<td>Formatting Features</td>
</tr>
<tr>
<td>• Formatting seems more important in MORE.</td>
<td>• Maybe formatting is more by default in Word, whereas it's done more &quot;by hand&quot; in MORE</td>
</tr>
<tr>
<td>• Paragraphs do not line up ... possibly expanded from an outline.</td>
<td>• The words appear really spaced out (as in not condensed). Kind of confusing later on with short key points because the space between words almost is the same as space between letters.</td>
</tr>
<tr>
<td>• The tabs in MORE are actually real numbers (1/4&quot;, 1/2&quot;, 3/4&quot;).</td>
<td>• The tabs in Word are at odd locations.</td>
</tr>
<tr>
<td>Font Style/Size</td>
<td>Font Style/Size</td>
</tr>
<tr>
<td>• Palatino [font] looks better on Mac</td>
<td>• Size (font) is larger in Word.</td>
</tr>
<tr>
<td>• That’s not much difference. There is a Tic mark at the beginning of the headers in the Mac document.</td>
<td>• The Word document has larger font (at least it appears larger) and is also broken up into separate pages, as thought [sic] this would be printed out and read as a speech.</td>
</tr>
<tr>
<td>Software</td>
<td>Software</td>
</tr>
<tr>
<td>• Software required for MORE seems odd for conference intro.</td>
<td>• Word is ubiquitous.</td>
</tr>
<tr>
<td>• Maybe MORE is more specific to people who must often give speeches in their professional lives.</td>
<td>• Word is for the general public.</td>
</tr>
<tr>
<td>Other</td>
<td>Other</td>
</tr>
<tr>
<td>• There’s not much difference. There is a Tic mark at the beginning of the headers in the Mac document.</td>
<td>• The documents look exactly the same, word for word. It’s prettier with a nicer font in Word.</td>
</tr>
<tr>
<td>• Word has blank page at end ... does not seem to be deliberate: possibly an effect of cutting &amp; pasting from another application.</td>
<td></td>
</tr>
</tbody>
</table>

Outline, but they disagreed about whether MORE or Word was more legible. Several subjects also suspected that Word was not the original because the speech ended with a blank page, which did not seem intentional to them.

Test 4: User preferences and authenticity

In the final part of this experiment, we wanted to learn how important it was to the subjects to work with the documents in their original format and which factors would influence their preference for one format versus another. Without revealing which format was the original, we asked subjects to indicate which format they would prefer to use if they were writing a paper on Duderstadt’s presidency. (See Figure 10.)

Only 1 of the 12 subjects who compared MORE and Text preferred the Text version, while 1 subject had no preference. The one subject who preferred Text stated, “I believe it’s original and would give me more insight into what he intended to say rather than how a transcriber interpreted it.” Most of
the subjects preferred the MORE version because they thought that MORE was easier to read and navigate and more accurate, but 3 subjects also mentioned that they thought that MORE was the original. The 18 subjects who compared MORE and Word were evenly divided in their preferences, and 2 subjects had no preference. Subjects who preferred the Word format to MORE mentioned better legibility and their own familiarity with Word, but subjects who preferred MORE also mentioned legibility and ease of navigation. Only 1 subject stated a preference for MORE rather than Word explicitly because she thought it was the original, while 1 subject said he would prefer the Word versions only "if they were a) original or b) formatting did not matter to my research."

We then explained that MORE was the application in which Duderstadt wrote the documents and that Basilisk is an emulator we were using to imitate his original computing platform. We also told the subjects that the Bentley Library staff had converted the documents to Word and that we had produced the Text files. We then asked subjects, knowing all of this, "would you change your choice of formats that you would rather work with?" (See Figure 11.)

Only 4 subjects indicated a change of preference after being told about the provenance of the three different formats. Surprisingly, 2 of them shifted to Word from an initial preference for MORE. The only subject who initially preferred Text shifted his preference to MORE once he learned that MORE was the original, stating "even if [the Word version] is 99.5% the same, it could be changed enough—Word automatically corrects some typos, etc." The fourth subject who changed preferences shifted to MORE from Word after recognizing that the original was composed in MORE.
We concluded from this part of the experiment that only a small minority of subjects considered authenticity and working with the original source as a paramount concern. Usability was the most important factor for the vast majority of subjects. This was especially true of the subjects who compared MORE and Text where the Text version was very difficult to read and navigate on a screen. The 5 subjects who explicitly mentioned authenticity argued along the lines that archivists often use in pointing out the importance of preserving original records with all of their significant properties intact. As one subject indicated:

Basilisk [MORE] is more like his own hand-written notes, whereas MS Word is more like a finished, very complete document in which you only see the end result, not the thought process he went through in writing it. This thought process would be very important for a researcher using primary sources to write a detailed account of his UM presidency.

Although only 5 subjects explicitly mentioned issues of authenticity and integrity in their choice of format, we do not conclude that the subjects did not care about the authenticity or integrity of the documents they would use for research. Rather, they often considered contextual factors, such as the odds that the documents would have been altered, their status as notes or drafts, and what they knew about their source. Typical of this reasoning are comments from subjects along these lines: the "interim status argues for authenticity (why fake a half-finished work?)" or "don't know why you'd think it is a fake."

Experiment Two: Conclusions

We drew three main conclusions from this experiment. First, subjects used a complex reasoning process that took many different factors into account to judge the authenticity of digital documents. When subjects were shown three speeches in the same format, they inferred primarily from the contents and writing style whether it seemed reasonable for a university president to deliver such a speech. When presented with a speech outline in three different formats, the subjects considered additional factors such as the appearance and layout of the different formats, or the suitability of the format and the affordances of the application for the intended purpose of writing and presenting a speech. Subjects used the appearance of the documents as one factor, but they also drew on their own knowledge and experiences to deduce which format might be the original. When the subjects were given more information to draw from, they became more accurate at identifying the original and more confident in their choices.

The subjects also made assumptions about the author and about the context in which the documents were created. In fact, some subjects were frustrated by the absence of contextual information. As one subject indicated, "I've no knowledge
of J.D.'s style or a possible purpose for this document." Another pointed out that his conclusion about authenticity was based on "an assumption of Duderstadt's style of writing that I have no way of knowing." Most subjects also made assumptions about the computing environment in the late 1980s, and many of these assumptions were incorrect. For example, some subjects doubted that the documents could have been created in MORE or Word because they assumed, erroneously, that no software packages were available at the time with their formatting and outlining features, and several initially thought that Text was the original because of its primitive look. In spite of careful consideration of many factors, however, a majority of subjects (16 out of 30) were wrong a majority of the time (in 49 of 90 observations) when asked to identify the original documents. Their errors in judgment were due almost entirely to the lack of contextual information that would have allowed them to check their assumptions about the author, the production of speech outlines, or the original software environment, and so to bring accurate information into their reasoning processes.

Interestingly, only one subject used any of the metadata associated with documents to help determine which was the original, even though each document had some associated metadata, such as file name, author, type, size, date created, and date modified. For example, the "created" and "modified" dates for the MORE versions were from 3 May 1990 to 25 March 1993, when President Duderstadt actually wrote the documents; the dates for the Word documents were in a range from 9 July 1998 to 19 August 1998, when the Bentley Library staff converted the files to Word. The "last modified" for the Text files were in a range from 31 July 2002 to 13 September 2002, when we created them for this experiment. Additional metadata about the Word documents included the date created, date modified, and the person whom the file was "last saved by." A quick look at any of the metadata available in the "Properties View" would have revealed that the documents had been altered since President Duderstadt first created them. Archivists consider elements such as file name, creator, creation date, and date modified critical for establishing the authenticity of electronic documents. In this experiment, subjects could have used some of the available metadata to help them determine whether the documents they were shown had been altered in some way, but only one subject did so. (See Figure 12.)

Our third conclusion from this experiment is that usability is the primary factor that will influence future users' preferences for the document format they would choose to use in a research project and that authenticity is at best a secondary consideration. Most of the subjects weighed multiple factors in selecting their format of choice, but they placed more weight on issues of legibility and ease of navigation. The subjects were not indifferent to the question of authenticity, but most subjects were willing to assume that the documents were authentic because there was little or no incentive to tamper with them, because they conformed to their prior notion of what an authentic document ought to look
"The Old Version Flickers More": Digital Preservation from the User's Perspective

Conclusions and Lessons for Archivists

When combined, the findings from our two experiments address two main areas: the significance of "look and feel" for preserved digital objects and the importance of contextual information in helping users understand and interpret digital information.

"Look and Feel"

"Look and feel" was important to the subjects in both experiments, but not necessarily for the reasons we originally assumed. In both experiments, subjects thought out loud about how the material "looked" to them, and they often mentioned specific features that looked odd or different when comparing different
versions of the computer game or speech files. In the Chuckie Egg experiment, subjects did not prefer playing an old computer game on its original hardware and software platform because it provided a more authentic experience. In fact, most subjects found the old keyboard and mouse difficult to maneuver and the speed of the original game too slow to offer much of a challenge. In the experiment with speech outlines, subjects analyzed the appearance of the documents to judge whether the documents presented to them looked authentic, looked like a speech, like a draft, like something one could easily read, looked "professional," or conversely, looked "unprofessional."

Our research also uncovered a tension between preserving the "look and feel" of original digital objects and their usability. In both of our experiments, most of the subjects weighed ease of use, their familiarity with current software applications, and the speed of interaction more heavily than the experience of using the original on an obsolete platform. There are also constraints on how much of the original experience of interacting with obsolete digital materials can be preserved. Short of preserving the complete hardware and software environment in operating order, certain aspects of "look and feel" will be lost. Even when emulation is used to run obsolete software on current computing platforms, the "look and feel" of the original input and output devices, such as keyboards and displays, are sacrificed.

Our findings demonstrate also that high-level comparisons of emulation versus migration are not very useful for evaluating different digital preservation strategies. As both Charles Dollar and Paul Wheatley have argued, migration is not a single, unified concept. Rather, different types of migrations entailed varying degrees of change to the original digital object. For example, both the Word and Text files in the second experiment were migrated from the original MORE files, but Word retained many more significant properties than Text. We also learned that not all emulators are equally effective at reproducing the behavior of the original computing platform. Some emulators do not replicate the "look and feel" of the original computing environments as well as some migrations do. Archivists would benefit from a more nuanced view of the advantages and disadvantages of emulation to help determine when it is important to preserve the original "look and feel" of digital objects.

Context Matters

Our research confirms that contextual information is important to users of preserved digital objects, regardless of the technical approach that is used.

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Three types of contextual information were particularly critical for the subjects in our experiments: information about the context in which the objects were originally created and used; information about the purpose and audience for the materials; and information about the original computing environment. Typically, archival finding aids provide information about the creators of materials in collections and the context in which the materials originated, as does the finding aid for the Duderstadt Papers. Our findings suggest that contextual information about the creators, uses, and provenance remains important for interpreting and using digital archival materials.

In addition to providing the types of contextual information typically found in archival finding aids, our research also suggests that archives should provide users with basic information about the computing platforms that were used to create digital collections. Given that we provided no contextual information about the various computing platforms, software applications, or formats, the subjects had to resort to their own knowledge, experience, or assumptions. Not surprisingly, many of their assumptions were wrong. Subjects frequently underestimated the degree of functionality available in software at the time the documents were created and lacked knowledge of when different versions of operating systems and software applications were released or upgraded. This type of contextual information will become even more important as users, over the course of time, become less and less likely to have had firsthand knowledge or experience with obsolete computing platforms.

Future Directions

This exploratory study offers a foundation for further research with different types of digital materials, larger subject pools, and different methods. We encountered several issues that we did not anticipate in the original project design, such as the variability in the quality of emulators, the differences that subjects would observe, and the type of logic they would apply to judging authenticity and making choices about formats. The methods we used are effective for gaining deep insights into subjects’ perceptions and behavior, but they do not provide a basis for broad generalization. The small number of subjects further limits our ability to generalize about these studies. We only tested two types of digital information, an interactive computer game and textual documents. It is possible that image materials, interactive multimedia documents, databases, and other genres would produce different results. We also need further research on a wider variety of digital object types before we can decide how to set parameters around the aspects of “look and feel” that warrant preservation.

Deromedi and Steiner, "Finding Aid for James J. Duderstadt Papers."