Report from the Field

Hypertext Explorer: A Research Simulation of Critical Editing for the Humanities

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Critical Editing and Interpretation

Every work of literature is a dynamic entity reflecting the changes that accrue during its developmental history. One of the tasks of textual scholarship is critical editing (Greetham, 1994) to analyze the evolution of the work throughout its nascent versions, to elicit meaning behind the changes "as though resident 'in' the work, or evoked through 'reader-response,' or deconstructable through a process that would reinstall a structure of intelligibility at a higher, more critical level" (Samuels & McGann, 1999, p. 26).

For example, one view commonly entertained, even by some scholars, is that people are born with fixed abilities that are resilient to change (Dweck, 2000, 2008). Dweck (2008) has referred to this attitude as the "fixed mindset." The fixed mindset hypothesis implies that a scholar's study of an author's creative achievements constitutes an unmasking of the author's fixed and inevitable creative style. But is this view realistic? Robert Sternberg (2005) (acclaimed scholar of "successful intelligence") has argued that research reveals the achievement of expertise results not from some fixed ability that we are born with, but rather from "purposeful engagement" (p. 17) and persistence, a "growth mindset" that relies on reflective practice and formative development (Dweck, 2008). Furthermore, we are social beings and do not express our creativity in a vacuum. Rather, we create within a social context that is consequential, often complex and chaotic, probably formulating many possible paths for the author's development and works. Therefore, creativity is not a process in pursuit of some fixed Aristotelian goal (the artist's fixed ability and meaning) but instead is a dynamic exploration of possibilities emergent from many influences discernible by critical scholarship (Buzzetti & McGann, 2006; McGann, 2001; Samuels & McGann, 1999).

Texts, Technology, and Humanities Education

The emergence of the digital revolution elicited concerns from some humanists that valued features of the book and traditional texts would be compromised by their rendition in the new digital format. McGann (2001) made a compelling case in *Radiant Textuality* that this was not the case, but with the caveat that "the general field of humanities education and scholarship will not take the use of digital technology seriously until one demonstrates how its tools improve the ways we explore and explain aesthetic works—until, that is, they expand our interpretational procedures" (pp. xi–xii).

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Hypertext Explorer **Project**

We have taken as a rallying cry McGann's appeal to develop electronic textual editing technology that "expand[s] our interpretational procedures." In this report, we discuss the development of such a tool, designed to improve education in critical editing, a digital learning environment called *Hypertext Explorer II*. The first *Hypertext Explorer* was a prototype with limited capabilities, created for evaluation of the substitutive hypertext concept (Buckley, 2001, 2002; Buckley & Ross, 1999; Ross & Buckley, 2001, 2004). However, *Hypertext Explorer*'s further development was slowed when Apple Computer switched from Motorola to Intel processors and abandoned the "Classic" operating system that our authoring tools (HyperCard, then SuperCard) required. After retooling our authoring environment and skills, we developed *Hypertext Explorer II* (in MetaCard, which evolved into Revolution, and finally into LiveCode) to provide a much more refined instrument. These authoring environments are two related families of object-based, X-Talk scripting applications that we found very facilitating because the scripting languages were all very English-language oriented and relatively unstructured, while supporting hypertext and database functionality, and graphics. We also switched from SuperCard to the MetaCard-derived application family because SuperCard is a single platform tool (Macintosh-only) while the newer authoring environment is platform agnostic with the ability to distribute products for Mac, PC, Linux, and Unix computers and iPad and Android tablets.

Major Goal 1: Breaching a Cognitive Barrier

The core challenges that we sought to address are related to structural constraints of critical editions that we believe constrain learning opportunities, such that students are often, perhaps typically, prevented from having a rich investigative experience of the process of critical editing. This is because editorial editions can make daunting demands on working memory and imagination (e.g., mental substitution of text in the story by variant text noted in the apparatus).

Although texts are very volatile environments when viewed over their developmental history, any one instantiation of the work has a static structure, is a snapshot in time, and does not reveal much about its history of past changes and their causes. Also, despite the existence of devices like prefaces, acknowledgments, indices, annotations, etc. that provide some assistance in interpreting the text's content and history, opportunities for readers to interact with the text are limited.

Critical editions provide much more information about the interpreted meaning of the text and its history of change. Critical editions characteristically include an eclectic version of the text, with an appended index-like editorial apparatus that characterizes the details of a work's history and changes. Consulting the apparatus at the back of the book, the reader finds a list of all the different versions of an individual passage. Here is the obstacle. In order to exploit the editorial apparatus, the user must find the correct record, memorize (or copy) the alternative version of this variant and return to the main text, where in his mind's eye he must substitute the alternative variant from the apparatus for the reading of the clear text, then try to imagine the meaning of the change in the context of the surrounding text. This is a tall order for human working memory, whose minute carrying capacity is the reason we limit phone numbers to 7–10 digits. This is a demanding task for experts, but it can be a prohibitively difficult task for novices, perhaps effectively

excluding many students. Therefore, the traditional formats of critical editions and their editorial apparatuses can impose cognitive obstacles that make it difficult for students to emulate a critical editor's investigations of an author's work and its history of change.

Substitutive Hypertext

To mitigate the cognitive barriers to participation by novices, we introduce a kind of hypertext: substitutive hypertext. Substitutive hypertext essentially replaces the editorial apparatus with a method of direct observation, alleviating the requirement (1) to memorize variant strings from the editorial apparatus and then (2) to imagine their substitution for the original string in the clean text (Figure 1, row 4). The substitutive hypertext does this by replacing the current variant of the passage with its alternative variant, eliminating the need to consult an index-like apparatus somewhere else, or to memorize text, or to imagine what it would look like. The variants are marked and set off with delimiters to identify the borders of the variant and which one is in play, square brackets for the earlier version of the variant string and pointed brackets for the later one. Clicking the hypertext again toggles the variant's displayed content, from the early version, to the later version, to both variants side by side for comparison (see Figures 1 and 5), and back again.

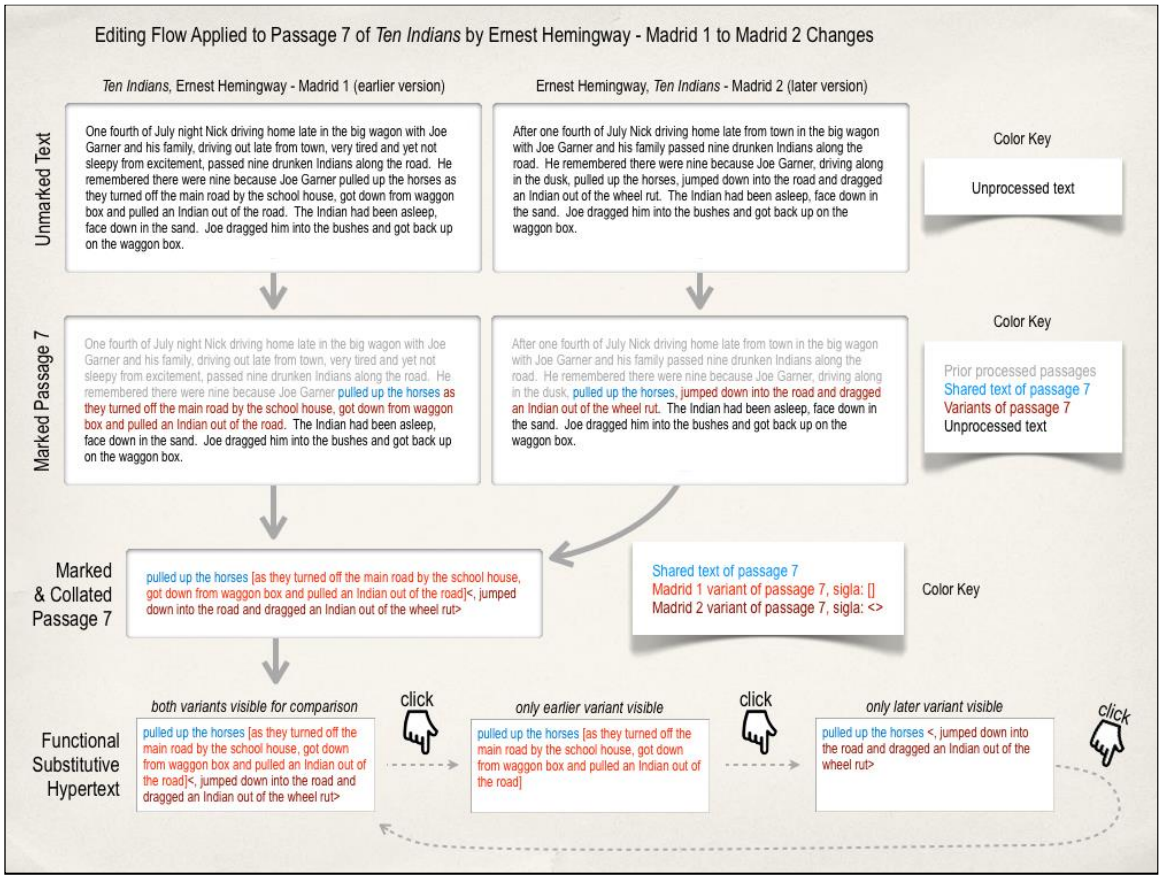

Figure 1. Diagram of the transformations of texts summarized in Figure 2.

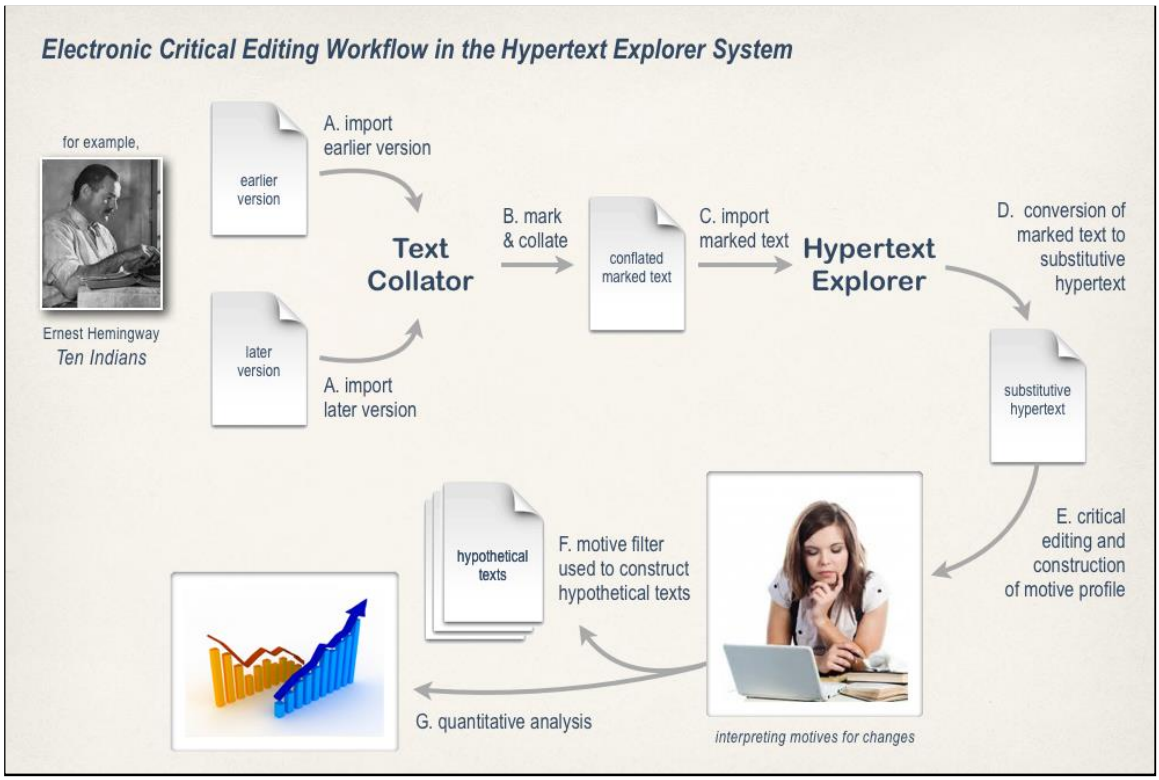

Figure 2. Diagram of digital critical editing workflow within *Hypertext Explorer*.

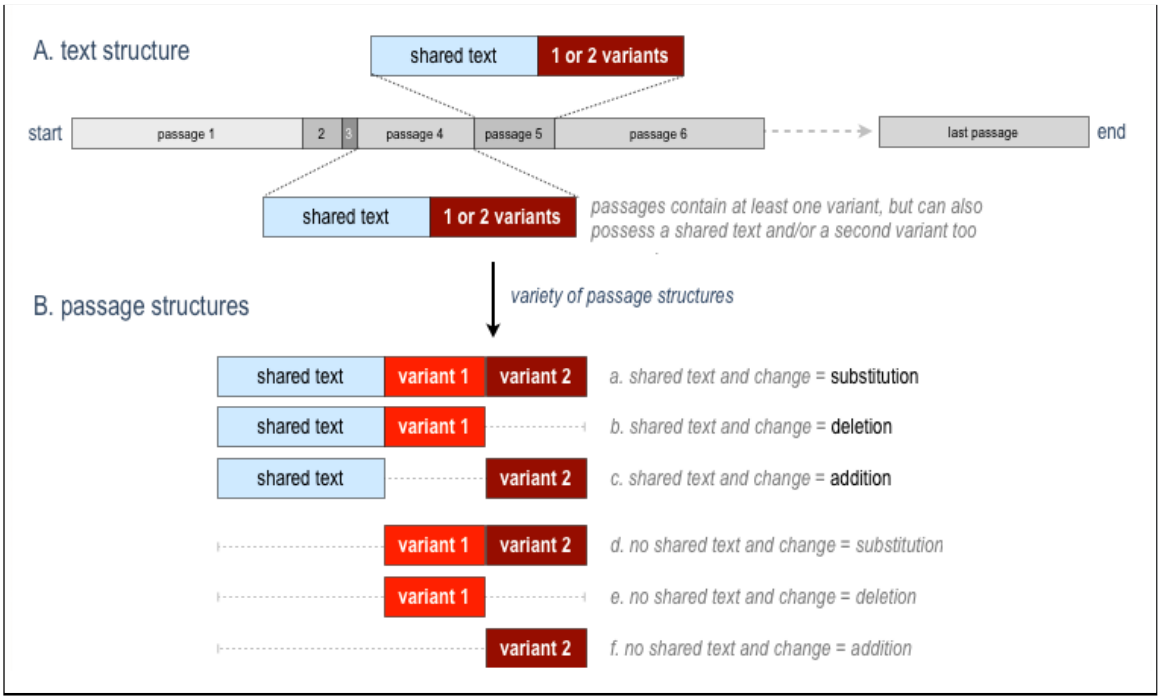

Figure 3. Diagram of text and passage structures.

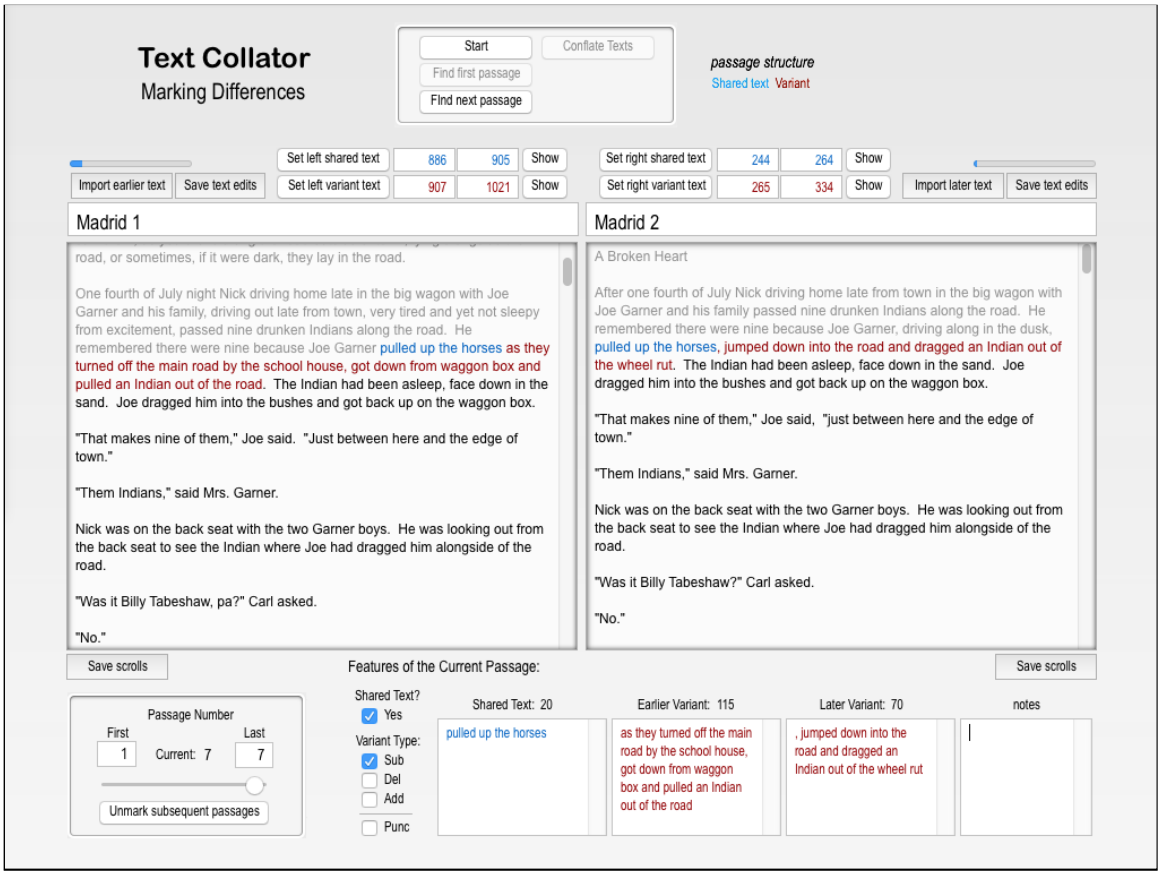

Figure 4. *Collator* interface, illustrating examples of simple passages.

Construction of Substitutive Hypertext

Substitutive hypertext must be constructed from the two clean texts being compared (Figure 1, rows 1–3). The software system does this with two component applications, *Collator* and *Explorer* (Figure 2).

Collator imports the original plain texts (see Figure 1, row 1). The program then compares these earlier and later versions of the work, identifying where the texts are identical and where text strings differ, parsing the texts into a parallel series of passages from the beginning to the end of the documents. Each difference between the texts is featured within a separate passage, so if there are 50 differences between two documents, there will be 50 passages (see Figure 3A). The regions of identical text between differences we refer to as "shared texts" and regions that differ we refer to as "variants." In the convention we have adopted, the shared text of a passage always precedes its variant.

Passages mature through three stages (simple passages, complex passages, and substitutive hypertext passages) in their processing (see Figure 1, rows 2, 3, and 4 respectively). When first delimited by *Collator*, each passage is present as a sister pair of simple passages, one passage from each of two documents (earlier and later versions). For example, on any particular passage the earlier document version can be said to have the composition: *shared text* [*earlier variant string*], and its sister will be: *shared text* [*later variant string*]. At this point, this passage therefore has two instantiations. These passages could be described as exhibiting simple passage structures because neither passage refers to both variants (e.g., see Figure 4). Finally, *Collator* merges both marked documents into a

single conflated marked text, producing a complex passage structure that describes both documents in one representation: shared text [early variant string] <later variant string> (e.g., see Figure 5). This conflated marked text is *Collator*'s final product, which is exported to *Hypertext Explorer*, where it is converted to substitutive hypertext (Figure 1, row 4; Figure 2D; Figure 6).

It is our hope that the availability of substitutive hypertext will open access to the investigative learning spaces of critical editing for students who might otherwise have found an editorial apparatus's heavy demand for memorization and mental textual substitution arduous and even obstructive. Still, the ability to enter the investigative space with substitutive hypertext does not ensure a powerful learning experience.

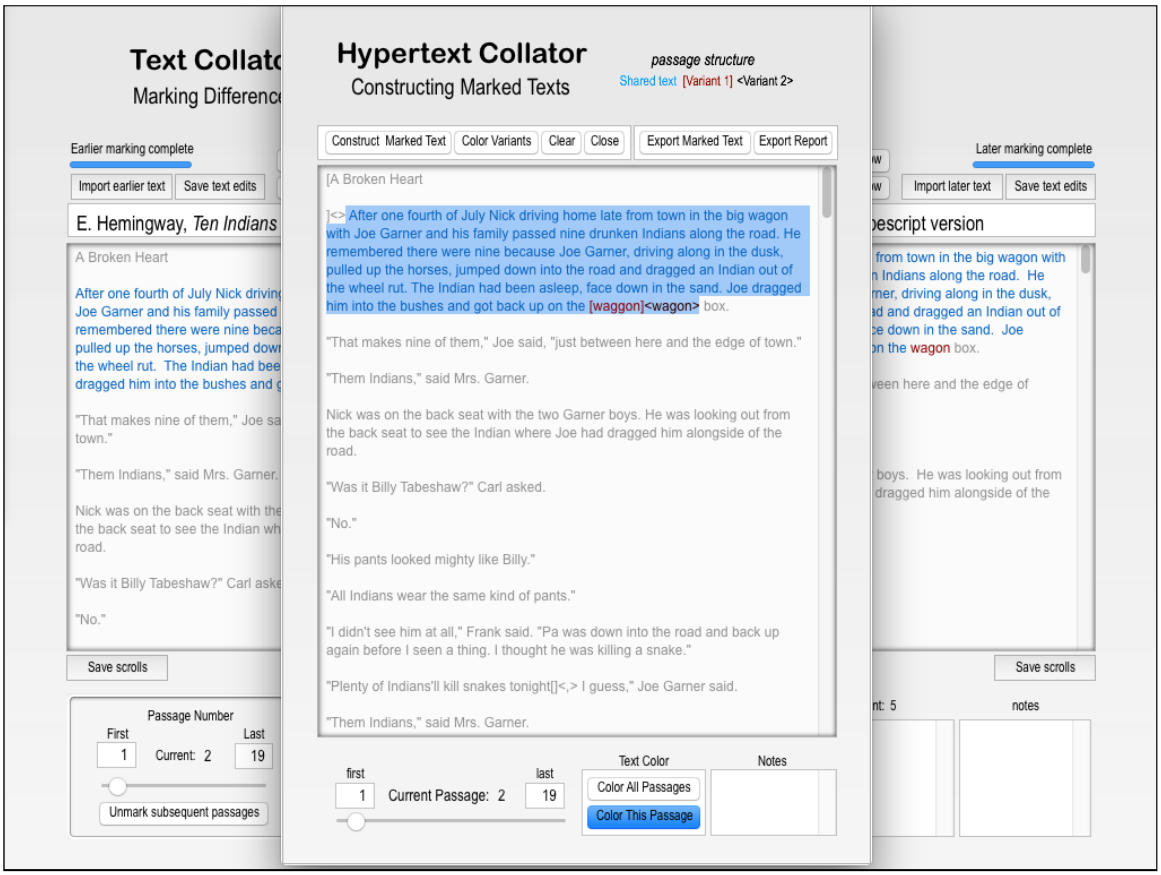

Figure 5. *Collator*: Conflated marked text with complex passage 3 selected.

Major Goal 2: Hypertext Explorer *as a Scaffold for Learning*

At the turn of the century, Steven Pinker reflected on the achievements of the learning sciences in the Decade of the Brain (1990s) (Jones & Mendell, 1999) and estimated that 95% of what we knew about how the brain functions in learning had been acquired only in that formative decade (Pinker, 2002). Since then, a flood of insights about learning has emerged from related research. In particular, the design of *Hypertext Explorer* has been strongly influenced by results that reveal that investigation, expertise, and transfer are mediated by the brain in ways not anticipated before. The structure of a critical editing experience lends itself well to application of constructivist principles intended to promote

learning with understanding, once the cognitive barriers of heavy memorization and mental text substitution are mitigated by substitutive hypertext. For example, as students progress through the series of passages in the work, they are engaged in a recursive process of meaning-making (attributing motives: e.g., were the author's changes influenced by collaboration with an editor? a perception of censorship? were the changes an exercise of free choice?) and writing (arguments explaining attribution hypotheses) in the exercise of critical inquiry (National Research Council [NRC], 2000; Samuels & McGann, 1999).

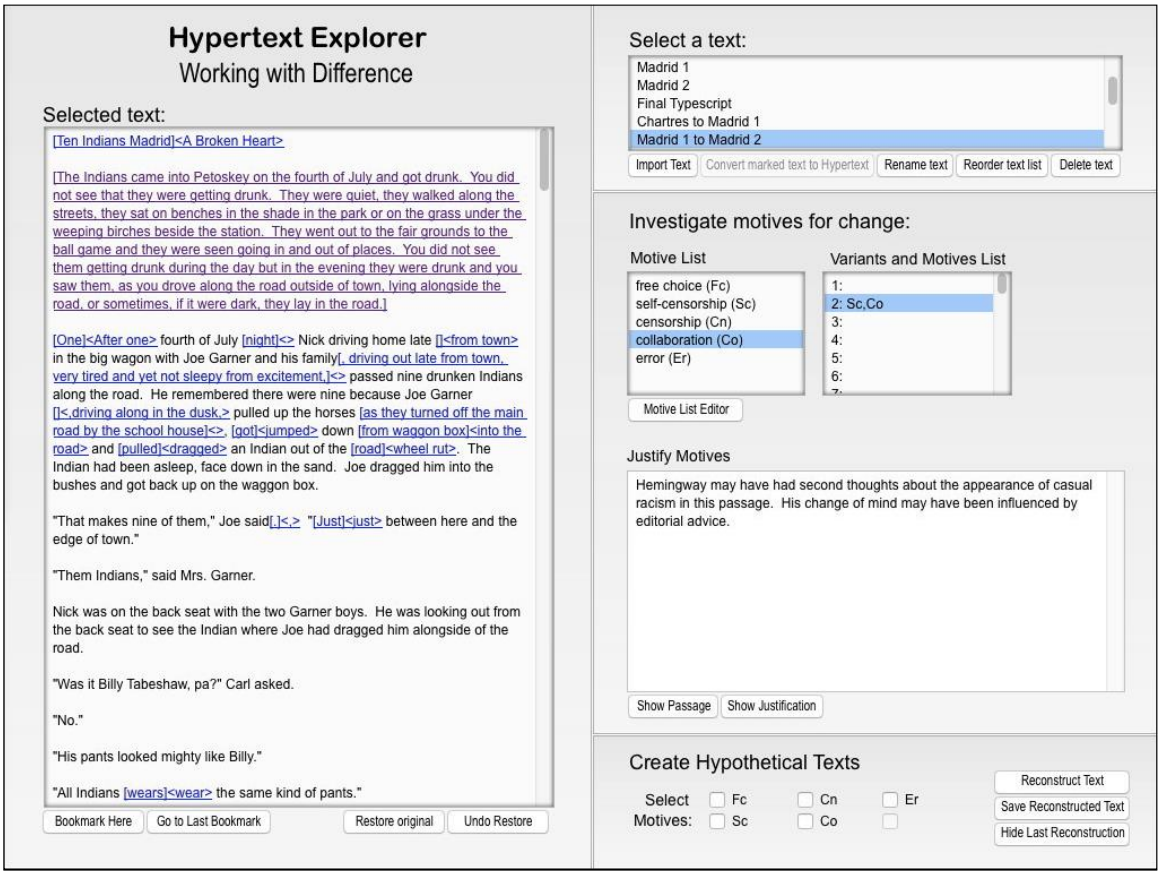

Figure 6. *Explorer* interface: substitutive hypertext and motive system.

Critical Inquiry: Conducting Investigations

Hypertext Explorer is a research simulation intended to provide students with an authentic experience of the process of scholarly investigation in literature. By "authentic" we mean that the investigative experience is open-ended, working on real-world literary texts so that the student investigator experiences conditions somewhat similar to those addressed by a professional, with inherent nuance, contextual uncertainty, inferential ambiguity, and no clear right answer in easy sight (Bean, 2011; Kurfiss, 1988).

Recent cognitive research indicates that human brains may not be innately well prepared to conduct investigations (Geunther, 1998). It may be that critical parts of the brain that we use for inquiry have evolved from perceptual regions of the brain. As it monitors our surroundings, the perceptual brain routinely protects us from cognitive overload by drawing conclusions subliminally, on the fly, without considering alternative

explanations or waiting for suitable evidence to weigh alternatives. For example, when descending a staircase we don't stop to consider what else this step-like device may be or to collect evidence to corroborate our inference; our perceptual machinery rapidly draws the right inference and directs us to take a step without distracting our consciousness. However, critical inquiry demands mindful engagement rather than subliminal conclusions. This means that evidence-based inquiry is not our default behavior but rather must be learned. We must learn to seek alternative explanations and how to use evidence wisely (Kurfiss, 1988). Therefore, sophisticated epistemological practices emerge only from extensive practice. For this reason, *Hypertext Explorer* is designed as an investigative simulation, encouraging students to emulate the process of scholarly research. The main question that *Explorer* asks is "what motivated authors to make the changes they did from one version of a story to the next?" As students advance through the story from one variant passage to the next, they are constructing a motive profile that hypothesizes possible causes for the observed changes. Furthermore, each declaration of a passage's possible motives for change requires a justifying short essay (in the "Justification" field) that requires the student to argue the case for this interpretation. Inasmuch as the student exercises a "motive attribution" and "justifying explanation" cycle for each passage in the texts being examined, this motive system provides continuous reflective practice in critical inquiry and, in particular, critical editing. As we shall discuss shortly, story-telling (e.g., the justification essays) is a crucial aspect of meaning-making in new learners (Willingham, 2009).

In open-ended investigative activities like research simulations, assessment of learning outcomes is challenging. Authentic simulations work best with minimal structure so that the problem space is not unduly circumscribed ("ill-structured" problems [Kurfiss, 1988]) and clues are not given away prematurely. *Hypertext Explorer* gets around this quandary by integrating a formative assessment process based on development of the motive profile and its associated justifications. This system contains a record of the student's thinking and work, enabling the instructor to "listen in" on student activity to better understand the student learning experience while the learning is taking place. The student work can be exported at any time to capture this record for evaluation.

Lastly, when two stories have been marked into a complete series of passages, the student has an opportunity to construct hypothetical stories to test their inferences. The student does this by specifying which motive or motives will be authorized for substitution. Hypothetical stories begin with the first version of the story as the base, to which substitution of the authorized passages will be allowed. This adds another level of critical inquiry and reflective practice for the investigator, examining the impact of the selected motives on the story's aesthetic effects.

Pursuing Transfer: Teaching so That Students Learn with Understanding

The 1990s' emerging understanding of how the brain functions in learning induced the National Academy of Sciences to disseminate a major report to spread the news: *How People Learn*. Concerned that many faculty might balk at being called to inform themselves about the ambitious progress in the learning sciences, the Academies concentrated on a major executive goal: "transfer," also referred to as "learning with understanding." Transfer refers to the level of learning that enables students to apply formal learning experiences to later learning and real-life applications (NRC, 2000, 2001, 2005). Transfer had long been

identified as a core objective in educational design, but successful implementation seemed an elusive goal until the late 1990s when the underlying cognitive mechanisms for transfer were revealed by investigators comparing how novices and experts learn and process information differently (NRC, 2000).

The central principle that emerged is that learners must construct knowledge in order to make meaning. However, there is not just one pathway for learning, there are two, one practiced by novices and the other one practiced by later learners, especially those pursuing expertise in a persistent and effortful manner. The goal is the same in both systems: meaning-making. But meaning is achieved by different paths and with different efficacies by novices and more advanced learners (NRC, 2000; Willingham, 2009).

Early Learning

Novices rely on the language centers of the left hemisphere. This system does not require prior knowledge, but its ability to solve problems is limited by the shotgun approach it takes to finding solutions. It seeks all possible answers but lacks a device to identify which is correct, in contrast to evidence-based inquiry. The key to making meaning for novices is storytelling. Stories provide a framework of meaning for the known facts. Storytelling is vital to the learning of novices (Willingham, 2009). In *Hypertext Explorer* the key storytelling occurs when students justify their attribution of motives—why did the author make these changes?

Later Learning

The "later learning" system is brought about by recursive engagement with the "big ideas" being addressed. Prolonged iterative exposure to key learning objectives in the domain cause the brain to switch the region and the manner in which the domain is processed, moving it from the language centers of the left brain to the perceptual centers of the right brain. The later learning system exercised by the perceptual brain is the pathway to expertise, and extraordinary learning outcomes are possible if pursued with long-term, mindful engagement. This is because of the remarkable manner in which the perceptual brain describes our surroundings. Rather than simply paint an image of our surroundings, the perceptual brain analyzes and models our environment, and the rules of the model are extracted to construct a computer-like, rule-based knowledge system, a conceptual framework that is the basis of expertise and transfer (NRC, 2000).

Cognitive development of expertise for transfer requires prolonged engagement, typically about ten years for maturation of full expertise. This may be why undergraduate and graduate programs together take about ten years to complete. There is value in this kind of learning, even in its earlier stages before full expertise emerges. Students are able to develop their skills in the kind of reflective learning practices that characterize the later learning system. Dweck (2008) referred to this reflective learning posture as the "growth mindset." Learning is perceived as a process of formative development, an unfolding journey more than a destination sought. Of special note is the development of metacognitive skills, the ability to think about what one is thinking about, to be able to monitor the progress of one's learning and other endeavors. The development of metacognition creates a new capacity for the learner, adaptive expertise. Consider an example from the NRC's (2000) report *How People Learn*. Two history professors and a cohort of upperclass history undergraduates were tasked to analyze one of the biggest and

most nuanced problems that faced President Lincoln. One professor was already an expert in this domain, a Lincoln scholar, and his analysis was immediately and deeply effective. The other history professor was not an expert in this domain, and his analysis was more superficial and tentative and not very different from what the undergraduate majors derived. The second professor and the students were invited to study the question further on their own time and report back, which they did. The students' final responses were not a great advance over their earlier effort, but the professor was able to grapple with the problem much more effectively and derived a report that shared much in common with the expert's. What was different about the second professor from the students was that he had developed metacognitive skills and adaptive expertise in his scholarly training as a historian. He had learned how to learn and had acquired the ability to pursue a new question diligently to some level of expertise.

The Feature Set of the Hypertext Explorer *System*

Hypertext Explorer is designed to promote improved student access to critical editing investigative experiences in a research simulation for the humanities. Scholarly experience with critical editing, critical thinking, and explanatory writing are promoted in a process of meaning-making in which students seek to infer the causes that induced the work's author to make changes from one version of the work to the next. The student's core activities revolve around their construction of a motive profile with imbedded short essay justifications of why those inferences are warranted. Ultimately, when the profile of motives and their explanations is complete, the student can further test her interpretations by construction of hypothetical new stories in which the only changes allowed from the first version are in those passages authorized by a selected motive, as attributed by the student. This represents a kind of experiment, a testing of student hypotheses.

Overall, the student experience of marking the texts and inferring a motive profile is a highly recursive cycle in the critical editing experience in *Hypertext Explorer*. The iterative cycle of drawing motive inferences with interpretive justifications immerses the student in a prolonged experience of explanatory storytelling, an important experience for engaging novices and for promoting cognitive development of expertise and transfer.

One feature that we have not discussed at all is the marking of texts incidentally, which produces quite a lot of data that relate to the size and position of text strings (e.g., shared texts, variants and passages), the characterization of passage types (e.g., as substitutions, additions, or deletions), and more. There is not room to discuss these emerging quantitative analyses here, but we will report on them in another communication. They are interesting windows into the author's editing styles.

Lastly, an ancillary application, *Text Collator*, is provided. The reason for this is three-fold. First, although we consider that the use of substitutive hypertext in critical editing is a powerful learning experience, the marking and collating of clean texts is also a powerful and complementary way of experiencing critical editing. It provides a more intimate initial exploration of the texts. *Collator* and *Explorer* together provide the fullest experience of this kind of investigation. Second, *Collator* was developed so that instructors wanting to use *Explorer* on material of their own choosing could mark and collate their own clean texts. Third, as we have developed *Collator* it has also become a major goal to ensure that *Collator* might serve as a research tool in textual scholarship.

The Two Cultures

This work is the product of a collaboration between a humanist (Ross) and a scientist (Buckley). The project was initiated by a shared interest in applying new insights into how people learn and how better to engage our students in scholarly investigation and critical inquiry. The opportunity that brought about this insight emerged from a FIPSE-funded effort to introduce faculty (74 of them eventually [Klonoski & Buckley, 1994]) to advanced learning technology by inviting them to design and to help author research simulations to use in their teaching. Topics were chosen because they were important and challenging for students, inviting hands-on problem-solving experiences facilitated by the technology. *Hypertext Explorer* began this way, as a research simulation intended to improve the investigative learning experiences of humanities students.

For we the authors, our collaboration has always been pursued in a spirit of scholarly fellowship across the two cultures, with a satisfying conviction that we were responding to Snow's (1959) concerns in a constructive manner. The links were natural enough for us. One of us is an evolutionary geneticist and the other is a literary scholar—the topic of how information changes over time is one that resonated for both of us. Both our disciplines are interested in studying how sequences of language characters change (human alphabetic characters versus nucleotides). Both of us are interested in understanding how environmental factors mediate the transformation of information over time. Indeed, there emerged parallels in major concepts—it proved helpful to think about the variety of passage structures by adopting genetic concepts (see Figure 3B), classifying passages into "substitutions" (one string replaces an earlier one), "additions" (where a new string emerges where none existed before), and "deletions" (where previous strings have been removed). Our shared interest in the pedagogy of "learning with understanding" (transfer) and its application to learning investigative experiences was enriched by thinking of it on a broader scholarly canvas of science and the humanities. We have sought to bridge the gulf between the two cultures, and the shared 20-year venture has been one of the most rewarding experiences in our professional lives.

Acknowledgments

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