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Annotations, in the form of markings and comments on the text, are often part of scholarly work. Digital platforms increasingly allow these annotations to be shared in group and public environments. To explore scholars' current behavior and attitudes toward shared annotations, semi-structured interviews with 11 doctoral students in the life sciences were conducted. The findings suggest that socio-cognitive processes are integral to scholars' creation and use of shared annotations. This paper discusses common themes from the findings and their implications for effective design of annotation systems supporting scholarly communication.

Headings:

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SHARED ANNOTATIONS: ATTITUDES AND BEHAVIORS OF SCHOLARS

by
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Introduction

Annotations have a long history, existing alongside written texts throughout the ages. In modern times, annotations have moved along with content into the digital realm. Currently, most word processing and reading software programs (e.g., Microsoft Word, Adobe Acrobat) incorporate annotation tools; web applications for annotation are also on the rise (e.g., Reframe It, Diigo). Annotations are often for personal use, but they may also be made available to others. While sharing annotations is not a new phenomenon – annotated paper documents have historically been circulated amongst groups or communities (Agosti, Bonfiglio-Dosio, & Ferro, 2007) – digitization opens up the possibility of increased sharing as readers can easily annotate a common electronic text in a group or public scenario. Through the click of a button, online readers can now often attach their thoughts to the original content of blogs, news articles, commercial product listings, etc. Scholarly platforms have also begun offering the ability to comment, with some incorporating in-text annotation tools. For example, the Public Library of Science (PLoS) allows readers to add notes to a published article by selecting text. With more opportunities for scholars to interact through shared annotations, there is the potential for a significant impact on scholarly communication. In assessing the effects of technological affordance, we must also understand the socio-cognitive processes involved. Thus, this study explores scholars' attitudes and behavior related to making and reading shared annotations.

This paper aims to contribute to the existing knowledge on shared annotations. Related work includes research on shared annotation for collaborative learning (e.g., Su, Yang, Hwang, & Zhang, 2010), collaborative authoring (e.g., Neuwirth, Kaufer, Chandhok, & Morris, 1990), and work group coordination (e.g., Cadiz, Gupta, & Grudin, 2000). These studies have provided preliminary evidence for the use of electronic annotation systems in supporting learning and work outcomes. Work particularly relevant to this study examines the socio-cognitive processes of annotators and readers. Studies have found differences in how students annotate in personal versus shared conditions (Marshall & Brush, 2004; Qayyum, 2008). The work of Wolfe (2008) indicates that the presence and valence of annotations have an effect on readers' reactions. In a study of shared annotations made on paper maps, students took socio-cognitive considerations into account in making and interpreting annotations (Congleton, Cerretani, Newman, & Ackerman, 2009).

Generally lacking from these studies is an explicit focus on scholars and their use of annotations, as noted by Palmer & Cragin (2008): "Annotation work is of growing research interest, especially for application to the development of reading devices and writing software … but little work has yet been done specifically on their unique contribution to the production of scholarship" (p.188). It can be assumed, however, that scholarship stands to gain from shared annotation. Much technical work has focused on using shared annotations to improve retrieval and navigation of content (e.g., Farzan & Brusilovsky, 2005; Bradshaw & Light, 2007). Yet even simple interaction with shared annotations promises significant returns from the exchange of knowledge and facilitation of collaboration (Gazan, 2008). Both these indirect and direct benefits are relevant to

scholars, but they are contingent on scholars making and reading shared annotations. It is therefore crucial to assess the attitudes and behaviors of scholars as creators and recipients of shared annotation.

The current study complements previous research with an in-depth investigation of the socio-cognitive processes concerning shared annotations in scholarly settings. Definitions for this paper's use of terms are as follows. "Socio-cognitive processes" are cognitive acts that have a social aspect. One example is the decision-making that goes into making an annotation with the awareness that it will be read by others. Another is taking into account information about who made an annotation in order to assign it value. "Scholars" are those who are professionally engaged in research and academic pursuits. Examples of "scholarly settings" are journal clubs in a university department, communication venues of scholarly e-journals, and open online forums on scholarly content. "Shared" refers to the condition in which annotations are accessible to others besides their creators. "Annotations" are markings (e.g., highlights) or comments made by a human agent that exist within or attached to the text, whether in paper or digital format. This working definition excludes tags and social bookmarks (note that some do refer to these as annotations). Furthermore, this paper is concerned with annotations as content rather than as metadata. It should be noted that this paper takes a simplified view of annotations, leaving intricacies of meaning and application to other authors. (For an overview of approaches, see Agosti et al., 2007.)

Semi-structured interviews were chosen as the method of this study in order to gather data based on real-world annotation experience. The sample of 11 doctoral students in life sciences (primarily biology-related fields) allows a targeted look at how

scientists approach annotating for others and reading the annotations of others. The results suggest that socio-cognitive processes have a fundamental role in scholars' attitudes and behavior toward shared annotations. Findings align with previous work and have a number of design implications. This paper begins with an overview of scholarly annotation, followed by a literature review on studies pertaining to shared annotations.

Overview of Scholarly Annotation

Annotations exhibit considerable variety; Marshall (1998) provides a set of 7 dimensions covering a range of forms, functions, and roles. Many of these annotation types may be relevant to scholars, for example, in the administrative processing of documents, in the coordination of work tasks, or in engaging with a text. The last of these is the focus of this paper due to the prominence of reading in scholarly activity. The scholarly profession is one that calls for "active reading," which involves critical thinking often by way of annotation (Adler & van Doren, 1972). Furthermore, annotation is not the mark of a particular school of thought or generation of scholars; it is one of the "scholarly primitives," defined as "some basic functions common to scholarly activity across disciplines, over time, and independent of theoretical orientation" (Unsworth, 2000). This section provides a concise overview of the history of annotation and potential scholarly uses of annotation, demonstrating annotation's lasting value to scholarship.

Brief History of Annotation

Annotations have been part of the scholarly record perhaps from its very inception. The "gloss," a term derived from the ancient Greek, was used by the Alexandrine poets in particular for supplementary explanations of locutions. The term was later employed in the Byzantine era and Middle Ages to refer to "an interlinear or marginal note to a biblical or juridical codex" (Agosti et al., 2007, p.4). "Scholium," another term of ancient Greek origin, denoted personal notes later amended by subsequent readers. A "postil" referred in the Middle Ages to "a short annotation— often a marginal or interlinear note—to a text, handwritten by a scholar or by the authors themselves to express observations, explanations, or criticisms" (Agosti et al., 2007, p.5).

Over the years, various other terms have been associated with annotations, from simple "notes" to Coleridge's coining of the term "marginalia" (Jackson, 2002). The historical uses of annotations have also made them objects of scholarly research. For example, Jackson (2005) examined approximately two-thousand annotated books to in order to better understand British readers in the Romantic Age. Likewise, Sherman (2008) evaluated annotations in thousands of printed books as cultural artifacts of Renaissance England; at that time, students were expected to annotate a text in order to have a "fruitful interaction" (p. 4). The marginalia of famous thinkers, such as William Blake and Charles Darwin, has also been collected and published (Jackson, 2002).

Though modes of text have progressed from handwritten to print to electronic, reading and annotating continues to receive attention. Annotation was included in Vannevar Bush's forward-looking vision of the Memex (Bush, 1945); furthermore, hypermedia researchers "have always considered private annotations (comments) a basic right for hypermedia readers as well as a basic tool for collaboration and exchange of ideas" (Bieber, Vitali, Ashman, Balasubramanian, & Oinas-Kukkonen, 1997). The software industry has also come to recognize that reading and annotating are more prevalent among users than authoring documents (Brush, Bargeron, Gupta, & Cadiz, 2001). Supporting annotation has become a goal of many scholarly digital initiatives as well. In 2009, the Open Annotation Collaboration was awarded $362,000 from The Andrew W. Mellon Foundation to develop a cross-web framework for sharing digital annotations by scholars (see http://www.openannotation.org/). Along with the push for the development of annotation tools, investigations into scholarly information behavior provide evidence that annotation use is still fairly widespread among scholars. Brockman,

Neumann, Palmer, & Tidline (2001) conducted semi-structured interviews as well as case studies of humanists and findings indicated the continued significance of reading along with notetaking, often in the form of annotations. Likewise, a survey of academic scientists found that two-thirds annotated 10% or more of articles in their personal collections (Hemminger, Lu, Vaughan, & Adam, 2007). As annotation has a number of potentially useful functions for scholars, its continued pervasiveness among both humanists and scientists is not surprising.

Scholarly Functions of Annotation

Annotating is not a requirement of being a scholar, but it is a common tool of the trade. Several studies have brought to light why scholars find annotation useful. A study of graduate students conducting research in libraries identified annotating as an information recording technique, along with note-taking and photocopying (O'Hara, Smith, Newman & Sellen, 1998). Students cited several benefits of annotation, including selectively decreasing the volume of material for review and allowing for easy comparison to the source text. In a survey of annotation behavior in academic settings, "responses revealed four primary uses: to remember, to think, to clarify and to share" (Ovsiannikov, Arbib, & McNeill, 1999, p.336). Marshall (1997) also observed a number of different functions of annotation in her study of used textbooks, which informs the following classification. The categories presented here are a preliminary attempt to identify the main functions of annotations that could be relevant to scholars.

Structuring for review. Scholars may annotate to help structure their later review of the text, similar to notetaking. For example, underlining may indicate important material for comprehension. Marginal notes may outline a paper's argument as it

progresses. An annotation placed at the head of the document may provide a quick summary of the entire text. Closely related to the function of structuring for review are "procedural signals," which refer to "annotations in anticipation of future attention" (Marshall, 1997, p.136). In this type of annotating, students mark sections for rereading or cross out sections no longer needed. Likewise, scholars may bracket material for reexamination or use symbols to indicate that certain passages are irrelevant to their purposes.

Marking for future use. In addition to selecting text for later review, annotations may mark material to use in the future. These "placemarks" may flag terms to memorize or text to quote (Marshall, 1997, p.237). To illustrate, a scholar might highlight academic jargon or underline a passage to paraphrase in her next article. Scholars might also annotate material for potential application; for example, a scientist may make a note of methodology procedures to employ in her own research. Circling references for further reading is another potential type of marking for future use.

Applying the text. Marshall notes that some annotations are "an in situ way of working problems," (1997, p.135). She gives the example of a student solving a homework problem next to the instructional material. Scholars might also apply equations or theories to their own work within the text; this type of annotation could range from open brainstorming to formal analysis. Models or visual diagrams of interactions described in the text may also fall under this function.

Interpreting the text. Annotations may also provide interpretations of the text. These may be attempts to clarify the text's language, comprehend its meaning, or analyze its implications. These may be some of the more interesting annotations for in them "we

may find both the sublime and the silly, the insightful commentary, and the documented misreading" (Marshall, 1997, p.136). Scholars' interpretative annotations may enrich their personal understanding and inform their discussions with others. For example, a scientist might make comments on an article in preparation for a journal club meeting. Or a teaching scholar may use annotations to develop lecture notes.

Personal functions. Marshall mentions a couple of other functions that can be considered personal in nature. Annotations may be "a visible trace of the reader's attention," for example, a reader may underline as he progresses through a dense text (Marshall, 1997, p.137). Some annotations are also simply "incidental reflections of the material circumstances," which are products of the reader's environment rather than of reading the text (Marshall, 1997, p.137). These personal functions are less likely to be of benefit to other readers.

Shared functions. The annotation functions discussed thus far have been primarily personal in nature, though some have potential use to others if shared. Interpretative annotations may be especially enlightening to other readers. Common annotation types that have not yet been discussed include praise, criticism, supplemental information, and questions. These types of annotations may be made for private use, but are also well-suited for sharing. For example, readers may be interested to know if others agreed or disagreed with the text, or found certain points commendable or objectionable. Information that is appended to the text might provide others with valuable context for understanding. An annotator may also ask a question in a shared setting hoping for an answer from the author or other readers.

The sharing of annotations has the potential not only to facilitate the exchange of knowledge, but to encourage dialogue and foster a sense of community engagement. As Gazan (2008) states, "Ideally, annotations can make learning and knowledge discovery feel less like a solitary pursuit and more like a collaborative effort" (Introduction, para. 1). As a tool for scholarly communication, shared annotation may reveal the thoughts of close and distant colleagues, indicate who is in agreement or disagreement with whom, and provide a forum for discourse. It is yet another way to document and propagate the "social life" of a text, as the significance of a work is always a matter of cultural negotiation (Brown & Duguid, 1996).

This overview has given historical context to the use of annotations and identified a number of functions that have potential utility to scholars. It is clear that shared annotations continue to offer benefits relevant to scholarly work. Of interest to this paper is how those shared annotations are created and used by scholars. The next section reviews previous work in order to shed some light on the socio-cognitive processes involved.

Literature Review

This literature review discusses prior research relevant to the current study; it is structured along the two main lines of inquiry: (1) How do people annotate for others? and (2) How do people process the annotations of others? Answering what is known about these questions suggested facets of behavior and related attitudes for investigation in the current study.

Scope of the Literature Review

The literature on annotations is wide-ranging, with only a small subset directly addressing human interaction with shared annotations. Qayyum (2008) groups existing studies into literary and historical investigations of markings made on paper documents, reading-to-learn research in educational psychology, collaborative authoring studies, and research examining marking types, characteristics, and uses. In its application as metadata, the discussion on shared annotations often overlaps with that on social bookmarking and tagging. This literature review will limit its focus to those studies that offer direct insight into the behavior of those who create annotations for others and those who read the annotations of others. Furthermore, it will not address research on shared annotations that facilitate collaboration amongst co-authors (e.g., Neuwirth et al., 1990) or co-workers (e.g., Cadiz et al., 2000) due to the practical and applied nature of those annotations. The current study is primarily interested in annotations made while reading published work as part of scholarly activity. The literature review primarily looks at academic contexts; annotations made in the context of learning could be considered as having some similarity to those made for scholarly review.

How Do People Annotate for Others?

When people annotate with other readers in mind, it is possible that they adjust their annotation style for the intended audience. This section focuses on annotators' behavior in shared settings. To begin, however, it is useful to examine how people annotate for their own personal use.

Annotating for one's future self. People often annotate for their own future selves, but these selves may have much in common with others. In a study of used paper textbooks in a university setting, Marshall (1997) found that annotations made by students took a number of forms, each suggestive of a distinct function (as discussed in detail in the Overview section). Her analysis indicates that the potential future usefulness of a personal annotation varies by its particular form and function. For example, highlights that call out important text or notes that interpret the material may assist the reader when revisiting the document. On the other hand, highlighting that is simply an artifact of reading or notes that are irrelevant to the content at hand will be of little worth upon second reading. Another study also observed that some annotations lacked continued value; certain markings made by researchers in a reading group seemed to represent "an unselfconscious engagement with the text, rather than the result of a fully formed interpretation of the material" (Marshall, Price, Golovchinsky, & Schilit, 1999, p.81). Participants themselves were unable to later explain why they made some of these annotations. Thus, it seems that the usefulness of annotating as part of the reading act must be separated from the usefulness of annotating for future use.

Those annotations that could serve one's future self might also turn out to be helpful to others. Knowing what others found important in the text or how they

approached the material may provide the next reader with valuable insight. From the textbook-buying observations of Marshall (1997), it is clear that some students are aware of the potential value of annotated copies. Students especially sought used copies with annotations that were problem-working or interpretative of the material. While it is assumed that the annotators did not attempt to make their annotations useful to future owners of their textbooks, these annotations were appreciated nonetheless.

Personal vs. shared annotations. In the case of annotations made for personal use, any benefit to subsequent users is usually an unintended byproduct. When people make annotations in shared settings, on the other hand, usefulness to others may be intentional. Thus, a comparison of personal annotations and shared ones can help us better understand annotation behavior.

As discussed previously, some annotations made for personal use hold promise for subsequent readers, while other annotations may not transfer their value when shared. It seems that users themselves recognize this and may modify their annotation style in shared settings. Marshall and Brush (2004) compared annotations that 11 students made for themselves on hard-copy reading material with annotations these students made for sharing with others on a digital copy of the same reading material. In interviews, some participants described changing their personal annotation behavior with an eye toward completing the sharing task. Even with this reported effect, only 24.7% of personal annotations were at all related to those digitally shared with others. Furthermore, personal annotations that were subsequently shared were often transformed – only 8.3% of the shared versions had content that was "more or less verbatim of paper annotation" (Marshall & Brush, 2004, p.354). Transformations of annotations as they went from

personal to shared included expanding the content, changing the content to make it more intelligible, and adding content to what was an anchor-only annotation (i.e., simply marking of the text). 80% of anchors also underwent changes, with shared versions in general being "more precise, singling out the specific text that triggered the comment" (Marshall & Brush, 2004, p.354). On whole, these findings indicate that people annotate differently for others than they do for themselves, and specifically that people attempt to make annotations intended for others more comprehensible.

Yet the results of another study of personal vs. shared annotations are not as clear. Qayyum (2008) conducted a study with nine students making annotations for individual use only and nine students sharing their annotations with others in the group. All students read and annotated the same documents in an electronic format. Students made twice as many markings of all types in the shared setting than in the individual setting, with changes in the distribution of highlighting, underlining, symbols, and base markings. An increase in the number of short sentences and notes in the sharing condition was thought to be indicative of users wanting to communicate with others; however, there was a lack of "conscious effort to make the comments self-explanatory in sharing situations" (Qayyum, 2008, p. 589). Furthermore, the content of shared comments rarely addressed others directly (e.g., by engaging in discussion, replying to others); rather students primarily used comments to emphasize text and flag material for discussion. Thus, the shared setting appeared to affect students' overall approach in the number and types of annotations that they made, but make only a minimal difference in their commenting behavior.

Due to small sample sizes limiting the generalizability of these studies, further research is warranted to confirm differences in annotations made for personal vs. shared use. However, these studies provide some preliminary evidence that shared settings impact annotation behavior. The next set of studies take a closer look at the socio-cognitive process of annotating for others.

Socio-cognitive dimension. Unlike annotating for oneself, annotating for others is a social act. Attempts to make annotations more comprehensible (Marshall & Brush, 2004) and increases in the more communicative forms of annotations (Qayyum, 2008) suggest that people take others into account when annotating in shared settings. Though the focus of this paper is on text documents, a study on map annotation (Congleton et al., 2009) provides relevant insights into the social aspect of shared annotations. In this study, 27 graduate students were tasked with annotating paper maps of the local area, which would then be shared with other students. Feedback from interviews of participants indicated that they made annotations based on their personal experience and considered the impression of them that would be left on others. Furthermore, participants attempted to make annotations that would be useful for their audience, including those geared toward novelty as well as toward utility. These considerations point to an annotator's social perspective when annotating in a group setting.

How Do People Process the Annotations of Others?

The flip side of how people annotate for others is how those others interpret the annotations. Even when annotations are knowingly shared, without direct feedback, annotators may be unaware of how their creations have been received by others. This

section of the paper discusses findings pertaining to how readers react to others' annotations and make sense of them.

Preferences of form. In the studies discussed earlier, annotators seem to have opinions on what type of annotations will benefit others (Congleton et al., 2009; Marshall & Brush, 2004). But what do readers actually find useful? In the study by Qayyum (2008), textual notes were most desired by readers of shared documents, while they preferred other types of marking be kept to a minimum. This finding is similar to others; in one study of an experimental annotation system, the highlighting of others was reported to be "the most annoying feature of the system" (Nokelainen, Kurhila, Miettinen, Floreen, & Tirri, 2005, p.767). While studies are investigating the usefulness of building recommendation systems based on consensus among people's highlights (e.g., Bradshaw & Light, 2007), extensive underlining or highlighting that marks reading progress rather than meaningful selection can be distracting (Marshall, 1997). Thus, textual notes and comments appear to have the most potential for direct benefit to other users. The next section addresses some of the kinds of comments that other users find most helpful.

Reactions to comment content. Wolfe (2008) points out that "most research has evaluated annotation systems based upon the comments that readers produced … rather than examining the effect that encountering others' annotations might have upon learners' reading practices or their perceptions of the primary text" (p.146). Thus, Wolfe conducted several studies along this line of inquiry. In one, seven students followed think-aloud protocols while reading a document marked with pro and con annotations. Among statistically significant findings, students made more comments on annotated

than non-annotated paragraphs, and more comments on paragraphs with both pro and con annotations than on paragraphs with only pro annotations. Furthermore, paragraphs without annotations elicited primarily comments attempting to comprehend the text (65%), while paragraphs with both pro and con annotations elicited more comments evaluating the text (55%). In post-interviews, students indicated that those annotations that disagreed with their personal opinion were more helpful in processing the materials.

In a second study by Wolfe (2008), one group of students was given a document with pro and con response content in the form of in-text annotations and another group of students was given the document with same response content in the form of essays (one pro, one con) appended to the end of the document. Each group was then asked to write an essay; essays were rated and compared across groups. Both self-report from questionnaires and essay ratings from instructors indicated that the annotation group was less likely to rely on summarizing the document material, a novice writing strategy. This finding was in line with the think-aloud protocol study, in which annotations appeared to encourage students to shift their reading strategies from comprehension to reflection. Wolfe's research suggests that the presence of in-text comments does influence the ways in which students think about reading material. Furthermore, the type of comments (i.e., pro/con, extent of agreement with personal opinion) had an impact on students' reactions. The strictly dichotomous nature of the comments in these studies, however, is not fully representative of the range of comment content readers are likely to come across in most shared settings.

Learning effects. It is also worthy of note that essays by students in the annotation group were not rated significantly higher than those in the appended group,

with the author surmising that "this may be because argument quality encompasses factors such as clarity of phrasing and organization that are unrelated to the type of critical thinking and perspective-taking annotations appeared to provoke" (Wolfe, 2008, p.160). This finding echoes that of two studies on collaborative learning, in which the experimental group (which used the annotation system) scored higher than the control group (which did not use the annotation system) on post tests overall, yet there was a lack of a significant difference on exam scores between the experimental and control groups (Hwang,Wang, & Sharples, 2007; Su,Yang, Hwang, & Zhang, 2010). In both studies, this result was attributed to the likely high motivation of students in each group to do well on exams. Thus, while annotations appear to facilitate learning by some indicators (i.e., reading and writing strategies, post-test scores), the final learning product may not be significantly improved.

Whether or not shared annotations can boost grades, students have reported valuing others' annotations via a range of mediums, from paper-based textbooks (Marshall, 1997) to video lectures (Bargeron et al., 2002). Students' attitudes toward experimental annotation systems for collaborative learning have also been overwhelmingly positive based on questionnaire results (Hwang et al., 2007; Nokelainen et al., 2005, Su et al., 2010). Yet, it is unclear from these studies how much the positive reception of collaborative learning systems is related to the shared condition of annotations. In one, all questionnaire participants "reported that comments made by other learners promoted their learning in some ways" (Nokelainen et al., 2005, p.767). These results have a potential bias, however, as the response rate to the post email questionnaire was about 50% and it is possible that those who had a more positive experience with the

system were more likely to have responded. It is also interesting to note that this study's questionnaire results indicated that "self-made highlightings and comments were experienced to be more useful than those made by other learners" (Nokelainen et al., 2005, p.768). That is, while reading the annotations of others was valued, it was not as valued as making one's own annotations.

In sum, while there is some indication that others' annotations support learning, just to what extent they do so is debatable. Studies of shared annotation systems for collaborative learning have not clearly separated out the effects of making annotations oneself and the effects of interacting with others' annotations.

Socio-cognitive dimension. Interpreting one's own annotations may require reflection on one's former self (e.g., asking "What was I thinking when I marked that?"); processing another's annotations may call upon socio-cognitive skills. In particular, readers may weigh an annotation depending on who made it. For example, one student interviewed in the textbook study "considered purchasing annotated books if she knew who the annotator was, and that the annotator was 'really smart'" (Marshall, 1998, p.45). Likewise, in the study by Qayyum (2008), readers indicated they would assign more or less significance to an annotation if they were familiar with its creator. In the map annotation study (Congleton et al., 2009), readers also reported employing prior social knowledge of the annotator to help them assess annotations. Furthermore, when the annotator was not known personally, some map readers constructed a characterization of that annotator based on the overall annotated map in order to make a judgment about whether that annotator's selections would be relevant to themselves. These studies suggest a number of possible questions to pursue in future research: Do readers note who

made the annotations? Do annotations by certain others carry more weight? Do readers form impressions of others through annotations?

Summary

This literature review has demonstrated that shared annotations have aspects that qualify them as distinct from annotations made for personal use. When people annotate in shared settings, the implied presence of others is reflected in their behavior, affecting the form, function, and content of the annotations. When readers encounter shared annotations, they make sense of them as the creations of certain others. To understand the phenomenon of shared annotation, the socio-cognitive processes of creators and readers must be considered, yet the existing literature only skims the surface. Thus, the current study further examines these processes with a focus on scholars.

Method

Semi-structured interviews were employed to investigate scholars' behavior and attitudes toward shared annotations. The interview method was deemed a suitable choice as it granted potential access to scholars' thoughts and feelings, which would be difficult to ascertain solely through observation, content analysis, or surveys. Due to the exploratory nature of the study, interviews were also chosen to draw on participants' real-life experiences. Semi-structured interviews were an ideal format to ensure coverage of topics and allow for follow-up. The research was conducted as part of a larger investigation on annotations undertaken with my advisor; this paper reports on only a portion of the interview results, specifically the sections on making annotations for others and reading the annotations of others. The interview also covered annotation interface preferences, context and factors of annotation use, and issues related to the use of open annotation in peer review and scholarly publication. Work on the full dataset is forthcoming.

Sample Population

The population of interest was scholars, such as doctoral students, post-docs, academic faculty, and researchers. Undergraduate and master's students were not included due to their limited experience and increased likelihood of non-academic career goals. Attainment or current pursuit of the Ph.D. was made a requirement for participation in order to draw participants with adequate experience and scholarly orientation. Other qualifications advertised were experience making annotations on scholarly articles and experience sharing annotations with others. A recruitment flier was distributed through various departmental listservs for doctoral students and the UNC

Mass Email System (which is opt-in only for informational emails). Compensation for participation was a cash payment of $30. The recruitment target for the study was 20 participants. At the time of writing this paper, recruitment for the full project is ongoing. For this paper, analysis will be limited to a subset of 11 completed participants, eight females and three males, with ages ranging from 22 to 32. All were doctoral students in the life sciences (primarily biology-related fields). Self-reported years in the field ranged from 1 to 7 years.

Study Procedures

Interview questions were based on themes that arose during the literature review and an investigation of current annotation systems. (See appendix for the Interview Guide.) Questions and study procedures were extensively pretested; five pilot runs were conducted and informed iterative revisions. Following institutional review board (IRB) approval, participants were recruited and scheduled for sessions. Participants were interviewed either in library study rooms or their offices on UNC campus. At the beginning of each session, written consent was obtained from the participant, including permission to audio record the session. Audio recordings were digitally stored in password-protected files to protect the privacy of the participants and will be destroyed at the completion of the entire study. Audio recordings of the interviews were reviewed for note taking, with the majority of responses paraphrased rather than transcribed word for word. The full interview consisted of seven sections and took about one to one-and-a-half hours to complete; this paper limits its analysis to two of the sections (the fifth and sixth in the sequence).

Results

Given the highly structured nature of the interview, answers were analyzed on a question-by-question basis. Questions with possible yes/no answers were assessed for affirmative or negative responses, allowing for qualified answers (e.g., "depends," "somewhat"). All responses were also coded following a grounded theory approach, with common factors and themes identified by comparing answers across the entire sample. As inquiries were open-ended, participants were not systematically asked to consider all aspects of a question. Thus, response percentages for factors and themes are potentially under represented. Also, as participants generally lacked experience sharing annotations on published work, answers must be regarded as speculative.

Making Annotations for Others

This interview section inquired about scholars' attitudes and potential behavior in making annotations for others. Table 1 gives an overview of the main results. Reported percentages (rounded to whole numbers) are the proportion of participants out of 11 giving the stated response. Looking across questions, there is high agreement among participants; noteworthy is the low number of negative responses. Yet each response set also exhibits a range of factors and themes; more detail on these is given in the following summaries.

Table 1

Summary of Results for Interview Section on Making Annotations for Others

Question	Affirmative Response	Qualified Response	Negative Response	Major Factors & Themes
1. Describe the differences in the annotations you make (or think you would make) when making annotations just for yourself versus annotations that will be read by others in small groups, large groups, and the world.	8 (73%) would have differences in shared annotations	3 (27%) thought only somewhat different	0 (0%) thought there would be no differences	• Formality/ clarity • Quantity • Function • Audience/ context
2. Do you think others actually make use (or would make use) of your annotations?	3 (27%)	8 (73%)	0 (0%)	• Audience/context • Form • Function
3. Do you (or would you) consider how your annotations might affect your reputation or how others perceive you?	8 (73%)	2 (18%)	1 (9%)	• Audience • Fear of looking stupid • Being more careful
4. Have you ever (or would you) edited or withheld an annotation because of concern over how it will be received by others?	6 (55%)	5 (45%)	0 (0%)	• Audience • Political consideration • Editing for clarity • Withholding certain types • Retracting
5. Do you (or would you) prefer to make your publicly shared annotations anonymously or with an identifier associated with you?	10 (91%) preferred identifier	0 (0%)	1 (9%) preferred anonymous	• Negative associations with anonymity • Importance of accountability • Value of identification • Replies
6. Would you make annotations if they were for a very large group where you don't know most of the members? Or on the open web (e.g., PLoS)?	6 (55%)	5 (45%)	0 (0%)	• Expertise • Relevance • Large group vs. open settings • Motivation

Question 1: Describe the differences in the annotations you make (or think you would make) when making annotations just for yourself versus annotations that will be read by others in small groups, large groups, and the world. Eight participants (73%) thought that the annotations they would make for others would be different than the ones they make for themselves. The remaining three (27%) felt that shared annotations would be more or less similar to their private annotations, but still indicated that there would be some changes. Major differences included the formality/clarity, quantity, and function of annotations. Some participants also took into account the audience or context.

Formality/clarity. Seven participants (73%) made comments related to the formality or clarity of their annotations. Four of these participants indicated that annotations for themselves would be less formal, for example, written in shorthand or with incorrect grammar. Two participants would attach explanatory comments to their highlighting or underlining. Another participant was also concerned that her shared annotations were clear and to the point.

Quantity. Six participants (55%) indicated that they would make fewer annotations when sharing with others. One in particular thought he would make fewer highlights and fewer comments, but the ratio of comments to highlights would be higher when shared.

Function. Two participants (18%) specifically mentioned that the function of the comments would change in shared settings. One participant would not share comments that cleared up definitions. Another would focus more on making critical comments than simply restatements to facilitate recall.

Audience/context. Four participants (36%) listed the intended audience or context as a factor. One would make more detailed, technical, and critical comments for a small group, while in a global context would make comments for a broad audience about why the paper was important. Another mentioned that she would take into consideration the audience's interests or purposes in reading the paper. If it was a platform in which other people could reply, one participant said she would suggest questions or concerns about the paper. Another thought she did a better job when annotating for peer review than in a classroom setting where she was more unfamiliar with the subject matter.

Question 2: Do you think others actually make use (or would make use) of your annotations? All participants felt that their annotations could potentially be beneficial for others, but eight (73%) qualified their answer. The three participants (27%) who answered affirmatively had the following reasons – one based his answer on how useful he found others' annotations, one had received feedback that her comment was helpful in an online forum, and one thought she did a good job of summarizing a paper through her annotations. Among qualified responses, a common factor was the audience or context. The form and function of annotations also played a role for some participants.

Audience/context. Eight participants (73%) felt that the usefulness of their shared annotations would depend on variables related to the audience or context. Three thought that their annotations would be more useful to other graduate students or in small group settings such as lab or class. Three suggested their comments would be better received if others perceived them as having expertise, while three others thought that more experienced readers would be likely to disregard their comments. Additionally, two

participants had some doubts about the usefulness of their annotations in shared settings because other readers might have different interests.

Form and function. Two participants (18%) made comments related to an annotation's form or function. One mentioned that highlights would be less helpful, while comments that made a new connection or provided a different angle on the text could be of use. Another mentioned Faculty of 1000 as being useful in giving overall evaluations of a paper.

Question 3: Do you (or would you) consider how your annotations might affect your reputation or how others perceive you? Eight participants (73%) would consider how their annotations might affect their reputation or how others perceive them. Two (18%) said their level of consideration would depend on the audience or context, for example, they would be less concerned if sharing with other graduate students. One participant (9%) said she didn't care, as her opinion they could take it or leave it. One common concern (6 participants, 55%) was fear of looking stupid or a desire to present oneself as intelligent. Three participants (27%) indicated they would be more careful in the accuracy or phrasing of their comments in shared settings. One participant also expressed reservations about expressing criticism openly due to the "cliquish" nature of science and the possibility that the authors would later be reading her papers.

Question 4: Have you ever (or would you) edited or withheld an annotation because of concern over how it will be received by others? Six participants (55%) thought they would edit or withhold some annotations in shared settings due to concern over how others might receive the annotations. The remaining five participants (45%) indicated they would edit or withhold annotations depending on who was in the group or

whether it was a public forum. For example, they might be willing to share certain comments with friends but not their Principal Investigator or the author of a paper. One participant said she would want to be politically careful, while another didn't feel she had the cred yet to be publicly critical. Three participants (27%) said they would edit for clarity. Four participants (36%) would withhold certain types of comments – one participant each mentioned strong criticisms, comments that are irrelevant to a larger audience, restatements of the author's text, and uncertain analysis. Two participants (18%) mentioned wanting the ability to retract a comment, say if later they answered their own question.

Question 5: Do you (or would you) prefer to make your publicly shared annotations anonymously or with an identifier associated with you? Ten out of 11 participants (91%) preferred to use an identifier or their name, rather than make annotations anonymously. Only one participant (9%) preferred to make public annotations anonymously, citing privacy concerns on the internet. Two participants (18%) expressed negative associations with anonymity, for example, feeling others might employ it to make ignorant or offensive comments. The importance of accountability was also a factor for two participants (18%). Another two participants (18%) indicated that they would not share comments that they were not willing to put their name on. Two participants (18%) mentioned that it was valuable to know whose opinion was being expressed. Another two participants (18%) would want to be named in part so that others could reply to them. In addition, two participants (18%) mentioned that anonymity would be acceptable or helpful as part of the journal peer review process (note this is typically done anonymously and not in a public forum).

Question 6: Would you make annotations if they were for a very large group where you don't know most of the members? Or on the open web (e.g., PLoS)? Six participants (55%) said they would consider sharing either in large group or open settings in the future, while the remaining five (45%) also indicated that they would consider it but had more reservations.

Contextual factors. Four participants (36%) felt they would consider commenting if or when they had a certain level of expertise to offer. Three participants (27%) thought the paper would have to be extremely relevant or have a direct impact on their work in order for them to comment. One participant (9%) said she would participate in information sharing openly, for example pointing out a related paper, but wouldn't voice criticisms publicly.

Large vs. open sites. Three participants (27%) were less likely to contribute to the open web. One participant expressed a preference for participating in elite sites (e.g., F1000). Another participant would share in a large group setting such as a subscriber-only journal, but felt that sharing with the whole web was a bit irrelevant. A third participant thought that sharing on the open web wouldn't be as useful, as his comment might just be one of many.

Motivation. Four participants (36%) made comments related to the motivation to participate in large or open settings. One participant mentioned as an incentive the opportunity for dialogue, that is, being able to ask questions as a reader or reply as an author. Another participant thought she might be motivated to share if she was aware of a community that did so. Similarly, one participant hadn't realized that she could share openly, as she didn't know anyone who shared annotations in larger settings or the open

web. Another participant would only consider sharing if required, asked, or paid to, feeling that people would be cheating themselves out of reading the paper.

Reading Others' Annotations

The interview also included a section on scholars' reactions to and opinions about reading others' annotations. The results (summarized in Table 2) show fairly clear groupings, generally indicating positive perceptions of annotations and the importance of attribution information. Again, a number of factors and themes emerged for each question and are described in detail in the following summaries.

Table 2

Summary of Results for Interview Section on Reading Others' Annotations

Question	Affirmative Response	Qualified Response	Negative Response	Major Factors & Themes
7. Do you find (or think) reading annotations on an article made by others is (would be) useful?	6 (55%)	4 (36%)	1 (9%)	• Other perspectives • Quantity • Quality • Form • Function
8. Do you (or would you) pay attention to who made the annotation (in small groups/large/open settings)?	6 (55%)	4 (36%)	1 (9%)	• Group size • Quality of content • Processing integration • Interpersonal relationships
9. Does (or would) knowing who made an annotation affect how you receive it?	9 (81.81%)	1(9%)	1 (9%)	• Known bias • Rank
10. Does (or could) reading the annotation affect your impression of the person who made it?	2 (18%)	8 (73%)	1 (9%)	• Sufficient number of comments • Negative behavior • Mediating factors
11. What do you think when others' comments are anonymous? (When appropriate/inappropriate?)	6 (55%) had negative associations with anonymity	3 (27%) had fluctuating opinions	2 (18%) had a neutral response	• Less merit • Used for criticism
12. Would an article having lots of annotations make you more interested in reading it?	4 (36%)	6 (55%)	1(9%)	• High readership • Level of discussion • Type of comments

Question 7: Do you find (or think) reading annotations on an article made by others is (would be) useful? When? Does the form, function, quantity, or quality of annotations make a difference? Six participants (55%) felt that others' annotations were useful overall, and another four (36%) qualified their response. The one participant (9%) who did not feel that others' annotations were useful said she would not be swayed by anyone else's opinion and that it took too much time to pay attention to other people's annotations. Six participants (55%) felt annotations could be useful in providing another perspective, as others might point out something they missed or hadn't considered. Some participants also acknowledged factors that mediate annotations' usefulness. Three participants (27%) mentioned quality as a factor; a novice comment or a generic remark might be less useful. Quantity had an impact for three participants (27%); too many annotations could detract from their overall usefulness. One of these participants also preferred short over lengthy comments. Two participants (18%) indicated that the form of annotation is of consequence, specifically that comments are more useful than markings (e.g., highlights, underlines). One of these participants felt this way because highlighting is more personal in nature and doesn't convey what the reader thought about the text. Two participants (18%) also made comments related to the function of annotations. One felt the most useful comments were evaluations that addressed why the paper was worth reading. Another most valued summaries of main points.

Question 8: Do you (would you) pay attention to who made the annotation (in small groups/large/open)? Six participants (55%) indicated that they would pay attention to who made an annotation, while four participants (36%) said it would depend on the context. One participant (9%) wouldn't pay attention to attribution information;

she also didn't trust people to honestly represent themselves on the web. Group size was a factor, with 5 participants (45%) indicating they would pay attention to annotation creators in small group settings. Two participants (18%) thought they would pay attention foremost to the quality of an annotation; one participant said some extreme in content (e.g., stupid, interesting) would make him note the annotation's author. Five participants (45%) mentioned noticing the creator as part of processing the annotation. Two of these participants indicated that they noted who made an annotation to assign it value or decide whether to even read it. In addition, two participants (18%) felt it was interesting to see "who says what about whom" in the field, with one mentioning that she would take enemies or collaborators' comments "with a grain of salt."

Question 9: Does (or would) knowing who made an annotation affect how you receive it? Nine of the 11 participants (81.81%) indicated that knowing who made an annotation would affect how they receive it. One participant (9%) thought the quality of content was a more important factor. One participant (9%) said that he just reads the comment. Three participants (27%) mentioned taking into account any known bias of the annotation's author, for example, if he or she is a competitor, collaborator, or someone with a preference for certain methods. Four participants (36%) indicated that they considered the rank of the annotation's author, for example, expert vs. novice or professor vs. student peer. One participant also thought it would be "neat" if one could see all the papers that someone thought worthy of comment.

Question 10: Does (or could) reading the annotation affect your impression of the person who made it? Of the 11 participants, two (18%) thought that reading another's annotations would generally affect their impression of that person, while one

(9%) thought it would not. For the remaining eight participants (73%) it would depend on a number of factors. Three (27%) indicated they would need to read a sufficient number of comments by the person before forming an impression. Four (36%) indicated that negative behavior (e.g., aggressive or unconstructive comments) would worsen their impression of the person. Another participant commented that her opinion of the person probably couldn't help but be affected if she disagreed with his or her annotations; on the other hand very insightful comments would impress her. One participant noted that the rank of the annotator would mediate the effect of unintelligent comments, as she would have higher expectations for an expert than a novice grad student. Furthermore, two participants (18%) indicated that their judgment of the person wouldn't be seriously affected, one because she recognized that people don't spend a lot of time and thought on annotations and the other because she allowed that there are always places where people are not necessarily going to be at their best.

Question 11: What do you think when others' comments are anonymous? (When appropriate/inappropriate?) Six participants (55%) had a predominately negative view of anonymous comments, three (27%) had answers dependent on the context, and two (18%) were fairly neutral in their response. Six participants (55%) would give anonymous comments less merit or be suspicious of them. One participant stated that it was a way for people to make uneducated comments and defeated the purpose of the system. Three participants (27%) mentioned there could be times when anonymity might be more appropriate, for example, for journal reviews or criticisms in certain contexts. Of the two participants (18%) who did not have particular reactions to anonymity, one had typically encountered anonymous comments that were relevant to the

article and the other thought anonymity didn't matter as people might not honestly identify themselves anyway.

Question 12: Would an article having lots of annotations make you more interested in reading it? Out of 11 participants, four (36%) thought that an article having lots of annotations would make them more interested, and six (55%) thought it would depend. Only one participant (9%) answered in the negative; he thought just the actual content of the paper would get his interest. Six (55%) would be interested in articles that appear to have high readership or to be generating a lot of discussion. One of these participants noted, however, that some fields are more popular and some topics more likely to incite comments. Five participants (45%) thought their level of interest would depend on the type of comments, specifically positive rather than negative.

Discussion

The interview results suggest several major conclusions about scholars' attitudes and potential behavior toward shared annotations. For one, annotating in large group or open settings is not currently prevalent among life scientists, although participants expressed a willingness to participate in the future. Annotating for others is different than annotating for oneself; participants would edit or withhold many personal annotations in shared settings. Participants did not believe that shared annotations would always be of use; perceived usefulness varies with the context and specific features of the annotations. Who created an annotation can also be of importance; participants would weigh attribution information in evaluating annotations and would be concerned about their own reputations when sharing annotations. Each of these findings is discussed in turn and put into the context of the literature when applicable.

Annotations in Large Group or Open Settings

While all 11 participants said they would be willing to consider sharing annotations in large group or open settings in the future, none of them normally do so. The bulk of annotating done by study participants was for individual use. Even when annotations were made in preparation for small group settings (e.g., class, journal club), participants would usually communicate their comments orally rather than share them through a physical or digital copy of the text. Shared annotations were primarily done as part of the collaborative writing or pre-publication peer review process; annotating published work was typically a private affair. Nor does this small sample seem to be misrepresentative of the larger population; online scientific publishing platforms have yet to exhibit high levels of shared annotation. An analysis of BioMedCentral shows that

only 2% of papers published from 2002 to July 2008 were commented on, with one-third of comments coming from the authors themselves (Adie, 2008). PLoS ONE has seen more activity, with user-submitted comments appearing on 18% of papers from December 2006 to August 2008; 40% of the comments were from authors (Adie, 2009). *Nature's* 2006 open trial of peer review was discontinued due to a lack of valuable comments (Greaves et al., 2006). As observed by Michael Nielsen, scientists' adoption of online commenting has been slow:

> The Nature trial is just one of many attempts at comment sites for scientists. The earliest example I'm aware of is the Quick Reviews site, built in 1997, and discontinued in 1998. Physics Comments was built a few years later, and discontinued in 2006. A more recent site, Science Advisor, is still active, but has more members (1139) than reviews (1008). It seems that people want to read reviews of scientific papers, but not write them. (Nielsen, 2008, A failure of science online: online comment sites section, para.1)

Motivational factors. Nielsen attributes the lack of participation in part to its low priority; commenting takes away time from writing activities that lead to grants and tenure. Neylon & Wu (2009) also note that while programmers who comment on sites such as Stack Overflow garner recognition that can have real impact, scientists do not receive comparable credit for their contributions. That the incentive model can work, they argue, is demonstrated by the post-publication peer review site F1000: "Being able to place 'Member: Faculty of 1000' on your CV is incentive enough to encourage contributions of sufficient quantity and quality" (& Wu, 2009, The Trouble with Comments, para.4). Interestingly, a couple of interview participants mentioned Faculty of 1000 as a site they had or would be willing to take part in. Participants did not, however, remark on the absence of credit for comments; other various factors affected their motivation. They were not likely to comment on just any article; it would have to be

relevant to their own work. Also, as students, some felt that they lacked the expertise that would make their comments valuable to the larger scientific community. With experience, these individuals may become more willing to contribute to open dialogue. Little awareness of scholarly sites offering shared annotation tools also came into play; as doctoral students, they may yet have had only limited exposure to more open communication forums in their field. Without incentives or a sense of community engagement, however, it is questionable whether these scholars will seek out opportunities for shared annotation on a larger scale.

Fear of criticizing. Another potential barrier to participation is fear among the scientific community of openly criticizing one another. As expressed by an interview participant: "I think people are very hesitant to point out flaws publicly in the scientific community unless there is a large base of evidence for why that person was wrong, because it's a small world and you don't want to make enemies." Both Nielsen (2008) and Neylon & Wu (2009) acknowledge that scientists may be afraid to endanger the advancement of their own careers. Ill-received comments could later affect an author turned peer reviewer in judging the annotator's scientific work. Furthermore, as many scientists are dependent on research funding (including peer-reviewed grants) to continue their work, they may be concerned about alienating those who may hold the purse strings in the future. Nor is anonymous public commenting a widely accepted solution to this problem, as will be discussed in a later section.

Comments as a metric. While commenting is increasing, it is still the exception rather than the norm. Thus, it is currently a poor reflection of use when compared to other article-level metrics (e.g., downloads, bookmarks). For example, *Nature's* 2006 trial of

open peer review "received a healthy volume of online traffic …. However, this reader interest did not convert into significant numbers of comments" (Greaves et al., 2006). Interview participants indicated that the converse may be true -- a high number of comments could drive reader interest. As one participant put it, "you want to see what all the fuss is about." Positive user evaluations especially would make interview participants more likely to read an article. These findings indicate that users would employ a "bandwagon heuristic," allowing the opinions of others to influence their behavior (Sundar, 2008). Thus, it makes sense that recommender sites such as Faculty of 1000 have found a market. Most e-journals, however, currently see few comments of substance and therefore those articles with the greatest number of comments are not necessarily the most widely discussed or popular content. As Priem and Hemminger (2010) note, "the extent to which article comments reflect impact remains an open question" (4.4. Comments on articles, para. 4). A few preliminary investigations have been done with F1000. In the area of neurobiology, the average F1000 rating for an article correlated strongly with its journal's impact factor ("Revolutionizing," 2005). A comparison of F1000 ratings for ecological publications with their citation rates found that ratings did not reflect the high impact of a number of articles (Wardle, 2010). For now, user comments and expert ratings are more of supplement than a substitute for traditional metrics.

The trend toward more digital science publishing and greater integration of social tools increases the potential for shared annotation. Yet, a cultural shift will also have to occur before scientists feel comfortable opening up annotations that they now keep to themselves or within a small circle of colleagues (Neylon & Wu, 2009). Lack of

incentive and fear of reprisal appear to still hinder more widespread adoption. Even without these barriers, "participation inequality" is the norm of user-generated content, with 90% lurking, 9% contributing occasionally, and 1% making the majority of contributions (Nielsen, 2006). As Neylon and Wu (2009) point out, "This breakdown need not be a bad thing—on any given article you want the people who care and who have the expertise to be providing critical commentary" (The Trouble with Comments, para.5). Yet as readership for most scientific publications will always be relatively low, especially in more specialized fields, most articles will ever only see a small number of public comments, if any. Personal annotations on these same articles may be ample, but these are unlikely to be transferred over to shared settings, as discussed next.

Differences When Sharing Annotations

All participants believed there would be some differences in how they annotate for others versus themselves. The key findings have some support from other studies, with a few noteworthy differences that are possibly due to differences between students and scholars.

Editing for clarity. A common theme was the need to edit personal annotations before sharing them with others; for example, participants indicated that they would replace shorthand with complete sentences or add a comment to explain a highlight. Likewise, in the study by Marshall and Brush (2004), only 8.3% of those annotations that existed in both personal and shared conditions were transferred over word for word; most were expanded upon or clarified in the shared condition. In contrast, the students in Qayyum's 2008 study seemed not to try to make their comments more comprehensible when shared. As these students were annotating in preparation for class discussion,

however, they may have had less incentive to edit than scholars whose annotations reflect their professional judgment.

Variances in function. Some interview participants felt that the function of their annotations would differ under shared conditions or would vary with the audience. For instance, personal annotations might focus on understanding the text (e.g., writing in definitions), while annotations made for a global audience would offer more critical evaluation. While there was a lack of function differentiation for comments in Qayyum's 2008 study, this may be due in part to the sameness of purpose in the personal and shared conditions (i.e., preparing for class discussion).

Quantity of annotations. Slightly over half of interview participants mentioned that they would share fewer annotations than they would make for themselves. This finding is at odds with other studies: Qayuum (2008) reported that students made double the amount of annotations in the shared setting versus the individual setting. In the study by Marshall and Brush (2004), some students made more annotations in the shared condition, while others made more in the personal condition. It seems that whether the number of annotations increases or decreases in shared settings is determined in part by personal disposition and context. As both of these studies were in classroom settings, it is possible that other settings would be less conducive to greater sharing. One interview participant spoke from her experience with group editing: "I am a lot more choosy about what I comment on simply because I know that there are X amount of people making comments and if I make 20 comments people are going to be mad…because if everyone made 20 comments then that would be insane." Thus, one incentive to make fewer annotations in shared settings is not to overburden other readers.

Withholding. Along with making fewer annotations, interview participants also indicated that they would withhold some annotations in shared settings. Similarly, in the Marshall and Brush (2004) study, annotators withheld the vast majority of annotations made for personal use -- only 24.7% of them had a counterpart in the shared setting. Interview participants gave a number of reasons to withhold specific annotations, including not wanting to openly criticize, irrelevance to others, or uncertainty about an interpretation. A couple of participants also preferred to have the option to retract a comment later if their understanding or opinion changed.

In general, participants indicated that they would be more careful with their annotations in shared settings. Group size and membership were also factors. For example, a scholar might be less careful with trusted colleagues, more careful with superiors, and the most careful in public forums. The perceived need for more carefulness with shared annotations might be a potential barrier to adoption. Some of this carefulness (e.g., withholding criticism) can be attributed to the closed culture of science, as discussed previously. Annotators may also be careful out of concern for their reputations (see later section Reputation Effects). Certain types of carefulness (e.g., editing for clarity, withholding potentially irrelevant comments), however, is in the service of making annotations more useful for others. The perceived usefulness of annotations is examined further in the following section.

Usefulness of Shared Annotations

Most interview participants believed that the annotations they shared would not always be useful to others, and vice versa that others' annotations would not always be useful to them. Factors affecting perceived usefulness included the quantity, the quality,

the form, and the function of annotations. The context or audience also had an impact on how beneficial participants felt shared annotations would be.

Quantity, quality, form, and function. Interview participants were specifically asked to consider these factors and some did note their effect. A high quantity of annotations potentially detracts from their usefulness; too many annotations can be burdensome on the reader to process, contributing to information overload. High quality annotations are categorically more useful than low quality annotations; not surprisingly, several participants associated quality with greater levels of experience or field expertise. In terms of form, a couple of participants noted that comments potentially have more use to others than simple highlighting or underlining. Comments provide greater information, while highlighting can be distracting and its purpose difficult to assess. Similarly, participants in other studies expressed a preference for comments over highlighting (Qayyum, 2008; Nokelainen et al., 2005). As for function, annotations that provide another perspective had considerable value among participants. Likewise, in a study by Wolfe (2008), students reported that annotations that differed from their personal opinion were more useful in facilitating their thinking about the text. Summaries and evaluations were other types of comments that participants mentioned as particularly helpful.

Audience/context. The specific audience and context for shared annotations also moderated perceptions of usefulness. Several participants felt that sharing annotations would be more useful in small groups, such as lab or class. As these small groups often have a common purpose and are composed of known others, annotations would have more context than in large group or public settings. A couple of participants also expressed a preference for receiving others' input through mediated scholarly forums

(e.g., Faculty of 1000) rather than through the open web. They were doubtful of the usefulness of open sites where anyone might comment, including readers without a scholarly background. As the next section discusses, participants generally put stock in who made an annotation.

Importance of Creators

Annotations, of course, have creators as well as content. Interview participants indicated that in general they did pay attention to who created an annotation, however, more so in certain contexts. When noted, attribution information can influence how much an annotation is valued or how it is interpreted. Anonymity also has a potential impact on a reader's reception. Furthermore, as it is conceivable that annotations may reflect well or poorly on their creators, interview participants were concerned with how the annotations that they make might affect their reputation.

Context. Who made an annotation might be more noticeable or of interest in certain contexts. Some participants indicated that were more aware of annotation authorship in small group settings. When participants are limited in number and personally known, it may be easier to associate them with their comments. An individual's comments in a small group setting may also have greater context or more direct relevance to a reader than those made in larger forums. On the other hand, when there are many potential participants, attribution information might be used to prioritize the reading of comments. In more open settings, who made an annotation might also be of interest; for example, big names in the field might draw a reader's attention.

Role in processing. Some interview participants indicated that they would use attribution information in determining the value of an annotation; for example, a novice's

comments might be dismissed as less important than an expert's. A few participants also mentioned that known biases, as well as connections to the author (e.g., competitor, collaborator), could shape their interpretation of an annotation. Other studies have also indicated that readers sometimes weigh creator attributes in evaluating annotations. For example, one student preferred to buy textbooks annotated by someone she knew to be intelligent (Marshall, 1998). Familiarity with an annotator made readers more prone to value or devalue an annotation (Qayyum, 2008). Social acquaintance with an annotator also informed participants' assessment of map annotations (Congleton et al., 2009). Taken together, it is clear that attribution information can have a critical role in the processing of annotations.

Anonymity vs. identification. While knowing who made an annotation can have an effect on how a reader receives it, not knowing who made an annotation can also have an impact. Some interview participants would give less credit to annotations made anonymously. Likewise, in one study of collaborative learning, students reported not reading anonymous comments (Hoadley, 2002). Other interview participants had the perception that anonymous comments were more likely to be inappropriate. Evidence for this assumption is provided by a study of an online community of practice, in which anonymity correlated significantly with quality and flaming was reduced from 11% to 2% when the option of anonymity was removed (Kilner & Hoadley, 2005). While a few participants mentioned contexts or settings in which anonymity could be appropriate (e.g., peer review), identification of the annotator was generally valued. All but one participant expressed a preference for attaching an identifier to their public annotations rather than posting them anonymously. The importance of accountability was one reason

given for identifying oneself, which is not surprising given academia's emphasis on citing sources.

Reputation effects. Assuming that annotators would be identified, the majority of participants expressed concern over how their annotations would reflect upon them in shared settings. Similarly, in a study on annotating maps (Congleton et al., 2009), graduate students reported considering the image of themselves that would be formed by their annotations. As mentioned previously, the judgment of others was one reason that interview participants would edit and withhold annotations in shared settings. Several interview participants conveyed uneasiness over transferring their personal annotations to shared settings as they may write down stupid questions or uncertain interpretations when annotating privately. Interview participants also indicated that their impression of a person could potentially be affected by his or her annotations, however, it appeared that annotations would have to be ample or extreme (e.g., offensive) to elicit a reaction. Others recognized that annotations are not necessarily reflective of a scholar's best work, as he or she may put in little time and effort into them. Due to the often informal nature of annotations, it is likely that they would be given less weight than formal reviews or response papers. While scholars seem generally self-conscious about their reputation via annotations, the level of concern and whether it is justified is difficult to assess with the limits of the data.

Summary of Discussion

Due to the exploratory, qualitative nature of this study, conclusions are tentative; however, many of the findings have a strong resonance with the existing literature. For example, interview participants' inclination to edit and withhold annotations in shared

settings echoes the results of Marshall and Brush (2004). Their preference for shared comments over highlighting concurs with other studies (e.g., Qayyum, 2008), as well as their appreciation for other perspectives (Wolfe, 2008). The study by Congleton et al. (2009) also substantiates the role of attribution information and the consideration of reputation effects suggested by interview participants. Furthermore, interview participants' lack of participation in large or open settings parallels the dearth of annotation activity found in online scientific publishing platforms. All of these findings have implications for design to better support the sharing of annotations among scholars.

Design Implications

One application of this study is the formulation of goals and design recommendations for shared annotation systems. These are summarized in Table 3, followed by discussion of each area with design implications.

Table 3

Summary of General Design Recommendations

Goal	Design Recommendation
Encourage shared annotation in large group or open settings	• Provide incentives • Mediate potential reputation harm • Create a sense of community • Practice user-centered design
Smooth transition between private and shared settings	• Set default as private • Customize sharing options • Facilitate editing and withholding • Allow retraction of annotations
Maximize utility of shared annotations	• Incorporate filtering • Provide quality indicators • Label function/valence of annotation • Minimize highlighting/underlining • Enable dialogue, support reply threads
Increase site credibility and support reader assessment	• Discourage anonymous posting • Provide identifying information for annotators

Large Group and Open Settings

Though it remains to be seen whether open annotation will become widespread among scientists, it is likely that more online scholarly platforms will offer what has become a standard Web 2.0 tool. To encourage user adoption, digital venues would do well to provide incentives, address concerns, and employ user-centered design. Reputation enhancement can be a motivator, but potentially more so when linked to actual influence or rewards. Risk of reputation harm is an obstacle to participation that cannot be easily mitigated without broader systemic change; however, sites can act as frontrunners of a more openly critical culture. For large group or open settings, developing a sense of community may be vital to encouraging contributions and trust in them. The design effectiveness of an annotation tool is apt to be context-specific. For example, is the aim to support detailed understanding of the text, offer general reviews, or both? User investigation can reveal the kinds of shared annotations users are most interested in making and in reading on a particular site. Effective interface features can then be designed accordingly.

Private to Shared Settings

As there are key differences between annotations made for personal use and those made for shared use, in systems that allow for both, the recommended default is for annotations to be private. Users often alter personal annotations in shared settings to make them more clear or appropriate for that particular audience. Thus, users should have the option to edit or withhold personal annotations before they are transferred over to a shared setting. Furthermore, users might want the ability to customize their sharing rather than, for example, only having the option of private or public. For some systems, it might

also make sense to give users the ability to edit or delete annotations at a later time. Providing advanced user controls such as these may alleviate some concerns over sharing.

Maximizing Utility

The primary intention in sharing annotations is that they be used by others. Thus, designers should concern themselves with maximizing the utility of shared annotations. Filtering mechanisms are likely to be beneficial in several aspects. They can reduce the quantity of annotations to a manageable range, and may be especially valuable in large scale systems. Filtering can assist readers in quickly identifying quality annotations, for example, as indicated by user ratings or an annotator's experience level. Readers may also find it helpful to filter annotations by function, using context-relevant terms (e.g., technical edit, summary). While identifying annotations that would provide an individual user with a different perspective might be difficult, labeling comments with values (e.g., pro/con) or title headers might help alert users to various viewpoints. One benefit of having a shared system is the opportunity for dialogue with others; designers may want to specifically include features that enable discussion (e.g., threaded replies). To further boost perceptions of usefulness, systems might restrict the use or minimize the appearance of highlighting and underlining.

Increasing Source Credibility

Whether to allow anonymous posting should be carefully considered as scholars value being able to identify an annotation's creator. To increase source credibility, systems might require that annotators log in with an identifier or real name. Certain sites (e.g., The Third Review, http://thirdreviewer.com/) may choose to allow for anonymity to

give scholars a place to critically comment without fearing repercussions. The placement of attribution information should be prominent, facilitating a reader's initial assessment of an annotation. Helpful identifying characteristics are context-dependent, but might include an annotator's background, rank, affiliations, and competing interests. Again, filtering mechanisms are desirable, as readers may be interested in the annotations of a particular individual or type of user profile.

Other Considerations

This discussion has been limited to design implications directly related to the interview data on making and reading shared annotations. In implementing a full system for annotation, a number of other considerations would have to be taken into account. As these issues are beyond the scope of this paper, the reader is referred to other authors. For an e-learning annotation system, Glover, Xu, & Hardake (2007) propose essential and desirable requirements, both conceptual and technical. Hemminger (2009) discusses representation, storage, searching, and user interface functionality for a global shared annotation system.

Limitations and Future Work

The major limitation of this study is that interview participants had little to no experience with shared annotations on published work. As previously discussed, this concurs with the low participation rates seen in online scholarly venues for shared annotation. The hope was to attract more active participants by listing "experience sharing annotations" as a qualification on the recruitment flier; those recruited, however, shared only rarely and almost exclusively as part of collaborative authoring or traditional peer review. All answers to the questions of interest thus have to be considered hypothetical. The data gains a certain amount of credibility by being based on scholars' real-world opinions, but participants are not always best able to predict their own behavior. Thus further research, both qualitative and experimental, is called for to confirm this study's preliminary findings.

Another potential drawback is that the sample consisted entirely of doctoral students, who can be thought of as scholars in training. While this allowed an in-depth look at the coming generation of scientists, they are not necessarily representative of their more experienced colleagues. It would be interesting to compare differences in behavior and attitudes across levels of experience, as well as the range of scholarly job positions (e.g., faculty, researcher). The current sample is also drawn solely from life science fields; other disciplines may have their own distinct attitudes and behaviors. Broader disciplinary differences are also of interest; the full study of which this paper is a part aims to collect data from scholars in the social sciences and humanities for comparison with the sciences.

Conclusion

This exploratory study has provided insight into scholars' attitudes and potential behavior as they annotate for others and read others' annotations. Semi-structured interviews with 11 doctoral students in the life sciences afforded a focused look at scientists' approach to shared annotations. Key findings concern a lack of current participation in large group or open settings, differences in how scholars would annotate for others versus for themselves, factors that affect perceived usefulness of shared annotations, the impact of attribution on interpreting annotations, and reputation considerations in making shared annotations. The interview results have a number of design implications for encouraging shared annotations in large group or open settings, smoothing the transition between private and shared settings, maximizing the utility of shared annotations, increasing source credibility, and supporting reader assessment. Further research is needed to confirm the validity of findings and determine its generalizability to a larger population of scholars.

In conclusion, scholars will continue to read and make annotations, though technology may change how they do so. New opportunities to share will arise with the advancement of digital scholarship, but the proliferation of shared annotation is dependent on scholars' behavior and attitudes. If shared annotation is to have a positive and significant impact on scholarly communication, scholars must find others' annotations useful and be willing to make their own quality contributions. This study explores the socio-cognitive processes that underlie scholars' creation and use of shared annotations, offering insight into how they may mediate the success of shared annotation as a tool for scholarly communication.

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Appendix

Interview Guide

Making Annotations for Others

1. Describe the differences in the annotations you make (or think you would make) when making annotations just for yourself versus annotations that will be read by others in small groups, large groups, and the world.
2. Do you think others actually make use (or would make use) of your annotations? (Why or why not? If yes, how?)
3. Do you (or would you) consider how your annotations might affect your reputation or how others perceive you? (How so? Does this change your behavior?)
4. Have you ever (or would you) edited or withheld an annotation because of concern over how it will be received by others? (When? What was your concern?)
5. Do you (or would you) prefer to make your publicly shared annotations anonymously or with an identifier associated with you? (Why?)
6. Would you make annotations if they were for a very large group where you don't know most of the members? Or on the open web (e.g., PLoS)?

Reading Others' Annotations

7. Do you find (or think) reading annotations on an article made by others is (would be) useful? When? Does the form, function, quantity, or quality of annotations make a difference?
8. Do you (would you) pay attention to who made the annotation (in small groups/large/open)?

9. Does (or would) knowing who made an annotation affect how you receive it?
10. Does (or could) reading the annotation affect your impression of the person who made it?
11. What do you think when others' comments are anonymous? (When appropriate/inappropriate?)
12. Would an article having lots of annotations make you more interested in reading it?

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