Annotations on Musical Scores by Performing Musicians: Collaborative Models, Interactive Methods, and Music Digital Library Tool Development

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Although there have been a number of fairly recent studies in which researchers have explored the information-seeking and management behaviors of people interacting with musical retrieval systems, there have been very few published studies of the interaction and use behaviors of musicians interacting with their primary information object, the musical score. The ethnographic research reported here seeks to correct this deficiency in the literature. In addition to observing rehearsals and conducting 22 in-depth musician interviews, this research provides in-depth analysis of 25,000 annotations representing 250 parts from 13 complete musical works, made by musicians of all skill levels and performance modes. In addition to producing specific and practical recommendations for digital-library development, this research also provides an augmented annotation framework that will enable more specific study of human-information interaction, both with musical scores, and with more general notational/instructional information objects.

Introduction

There is very little formal research on the methods that musicians use to interact with their written music for the purpose of performance. While there have been a number of fairly recent studies in which researchers have explored the information-seeking (Cunningham, Jones, & Jones, 2004; Cunningham, Reeves, & Britland, 2002; Lee & Downie, 2004; Vignoli, 2004), and management behaviors (Bainbridge, Cunningham, & Downie, 2004; van Gulik, Vignoli, & van de Wetering, 2004; Voida, Grinter, Ducheneaut, Edwards, & Newman, 2005) of people interacting with musical retrieval systems, there have been very few published studies of the interaction and use behaviors of musicians themselves. Bellini’s work on digital music stands (Bellini, Fioravanti, & Nesi, 1999) and information management in orchestras (Bellini, Nesi, & Spinu, 2002) mentions musician interviews and observations, but in-depth, published reports of musician behavior and information use do not exist.

The absence of this research is unfortunate, because the information with which musicians most commonly interact, their musical score, is semantically rich yet highly formalized, as well as symbolic and notational. This type of information, which also characterizes dance scores and architectural drawings, often supports teamwork and collaboration. Not only are musical scores boundary objects, they’re action-oriented boundary objects, and examining interaction behaviors of people who work with these information objects provides valuable insight into theories of collaboration, interaction, and reliability. Musical scores are also highly structured and formalized. Studying the users who naturally and regularly interact with this kind of data, albeit not in digital form, may prove valuable for refinement of other systems that deal with shared structured data, like scientific data, GIS, and statistical programs.

The goal of this research project was to explore the ways in which musicians interact with their written music; how a variable work like a performed musical piece is realized for a unique performance; and how musicians’ interactions and interpretations, as evidenced by their annotations on their written music, affect the final product. To achieve that goal, this project regarded the musical score as a boundary object, and viewed the annotations of that score as evidence of a musician’s interaction with it. Further discussion of the goals, methods, and findings from this research can be found in Winget (2006).

Boundary Objects

A boundary object is an artifact, document, or even an idea that helps people from different communities build a shared understanding. Boundary objects essentially provide a common point of reference for conversations and
conventions; everyone can agree that they’re talking about and working towards x, even though they might not be actually thinking about the same specific things. As Star and Griesemer define them in their seminal article, boundary objects “inhabit several intersecting social worlds,” and “satisfy the informational requirements of each of them” (Starr & Griesemer, 1989). Instead of demanding full comprehension by every member of a community, “boundary objects serve as a point of mediation and negotiation around intent.” Prior research suggests that boundary objects are vitally important in the development of common information spaces (Schmidt & Bannon, 1992), and organizational memory (Ackerman & Halverson, 1998). There are four types of boundary objects: repositories, ideal types, coincident boundaries, and standardized forms.

1. **Repositories** consist of objects indexed and cataloged in a standardized way so people from different communities can use them for their own purposes. Libraries and museums, as well as many databases, are good example of repository-type boundary objects.

2. An example of the **ideal-type** boundary object is a diagram or atlas, which doesn’t comprehensively describe the details or specifics of any one locality or thing, but is a generalized abstraction of that thing. Its vagueness, however, is what makes the ideal-type boundary object useful for numerous communities. Essentially, it’s “a ‘good enough’ road map for all parties.”

3. **Coincident boundaries** are ordinary objects that have the same boundaries for all groups but different internal contents depending on the community using it. Geographers will use the state map of California differently than hikers and drivers will, for example.

4. **Standardized forms** are those information objects developed specifically for communication across dispersed communities. These include standardized methods and procedures, forms, and vocabularies that provide common processes, goals, and means of communication to various groups within an organization. (Star & Griesemer, 1989, pp. 410–411).

Depending on the use to which it is being put, the musical score could be interpreted as an ideal-type boundary object; that is, a conductor, a music historian, and an involved listener may all use one score in completely different ways for different purposes, its multiplicity of function providing enough information for each user to happily and productively interact with the object. It could also be considered a standardized-form type, providing standard methods, procedures, and vocabularies to communicate common processes and goals to various groups within a musical organization. Not only are there different orchestras using the same score, but different instruments within one unique orchestra also use different parts of a score for their own purposes. The strings (violin, bass, cello, etc.) work specifically with the strings parts, but they collaborate with the winds (trumpet, oboe), and therefore must have some contact with and understanding of that part of the score as well. At a more atomic level, different players of the same instrument, the first and fifth chair violins for example, have different responsibilities and goals as regards the same part and their interaction with that part is necessarily different. For the purpose of this research project, the musical score was defined as a standardized-type boundary object.

**Annotation Studies**

In the field of information and library science, annotation studies have two major functions. In those technical strands of the field focused on artificial intelligence or knowledge representation, annotations seem to be synonymous with automatically generated metadata or machine-learning applications (Heggland, 2002; Jeon, Lavrenko, & Mannath, 2003; Kunieda & Wakita, 2001). On the more sociological end of the spectrum, annotations are becoming widely recognized as valuable indicators of user interaction with a primary object or text (Whittaker et al., 2004). Most annotation studies in the latter area of research are focused on developing new systems for reading, writing, or interacting with digital data. Many studies focus on readers: for example, Shipman, Price, Marshall, & Golovchinsky, (2003) analyzed law-students’ annotations to determine important parts of a text.

Marshall (1997) conducted studies on the annotation behaviors of college students, finding that annotations serve a number of purposes: First, they’re **procedural signals**, telling the student where an assignment starts and ends, what part of the reading is important (or unimportant), and which sections deserve or require successive readings. Second, annotations are **placemarks**: they reserve quotes or ideas that the student will need to reuse in later in the term. Third, the margins of books are “an in situ way of working problems” (p. 135). Fourth, annotations record **interpretative activity** either getting the interpretation externally—from the lecture—or by careful reading. Fifth, annotations “act as a visible trace of a reader’s attention” (p. 136). And finally, some annotations are merely incidental marks that reflect the **material circumstances of reading**.

Marshall, in addition to writing numerous annotation position papers (1998a, 1998b), has also explored the relationship between personal and shared annotations (Marshall & Brus, 2004), conducting a study that compared students’ personal annotations with related comments they shared with each other using an online system. This study implies that the usefulness of annotations might be less than expected, finding (a) most annotations made while reading were not directly related to discussion comments; (b) some types of annotations, like anchors in text with margin notes, were more likely to become the basis for public discussion; and (c) personal annotations underwent dramatic changes when they were shared with others. Conversely, Wolfe’s study (2000) on the effects of annotations on student readers and writers found that while annotations perhaps did not have a direct effect on output (students did not directly quote their annotations), the process of annotation did seem to have an indirect effect of making the students’ papers more cohesive, better written, and better argued.
Annotations’ Dimensions of Use

Marshall’s annotation framework (Marshall, 1998b) provides a powerful construct for thinking about and studying these artifacts of interaction. She identifies annotations as reflections of a reader’s engagement with a text, which may or may not prove valuable after the reader has finished her commitment to the text.

There are two primary dimensions in Marshall’s framework: formal and informal. Formal annotations are often metadata-like, explicitly defined and meant for public discussion. They have long-term, permanent value, and are not tied to a specific reading or context. They’re formally written and often can be regarded as a form of public authorship. A Variorum Shakespeare Edition would be a good example of a highly formal annotation of a primary text. Informal annotations are tacit, meaning they’re personal; their meaning is ambiguous to someone other than the annotator. They’re primarily a reading by-product, are meant to be private, and often have transient value, although Marshall notes that some students do seek out annotated used books for the added information they contain.

Methodology

This project was exploratory in nature, and had the goal of examining and describing the ways in which musicians interact with and annotate their written music for the purpose of performance. Due to this project’s exploratory beginning, an ethnographic model was employed, using three data-collection points: informal rehearsal observation, semistructured musician interviews, and content analysis of annotated scores. Because this research focused on musician interactions with written music, both the ability to read music, and the fact that the music was formally written needed to be the de facto means of representation and interaction. Therefore, annotation analysis was limited to classically trained musicians playing classical music. Valuable future work could be done on less formally represented music styles or musical styles that incorporate more improvisation, like jazz, folk, and rock. Table 1 illustrates the data-collection grid developed for this study.

Score collection was divided into orchestral and chamber musicians to investigate whether the presence of a conductor or interpretative leader made any difference in the quality and quantity of annotations. An initial pilot study determined that differences in skill level would also be valuable data points; so the different interaction, collaboration, and annotation styles of amateur, semiprofessional, and professional musicians, were recorded.

Observation

Due to the large number of individuals involved in an orchestra, and the number of private, informal rehearsals for any given performance, I determined that it would have been very difficult, if not impossible, to unobtrusively collect conclusive, complete, and reliable data from an observation plan alone. Therefore, this project used observation primarily to frame the issues involved in rehearsal and musical performance, and as an informal and preliminary method for data collection and analysis. The procedure for observational data collection was to observe at least one formal rehearsal for each participating group in the first two weeks of the rehearsal process, one formal rehearsal in the last week before the first performance, and finally to observe one more formal rehearsal after the first performance if that rehearsal took place. Observed rehearsals were typically between one and two hours long, and included all members of the group, whether it was a four-member quartet or a hundred-member orchestra. None of the groups observed in this project held rehearsals after the first performance.

Thematically, observation focused on two issues: communication styles of various members of the group, and the negotiation of differing conceptions of performance, which would often require the group members to make annotations to the music notation. Observation sessions typically involved watching the group leader, either the conductor in an orchestra or the first violinist in a quartet, and noting how the group as a whole managed comments and decisions. After the observation sessions, written notes were transformed to narrative form for later use. These narrative reports, although informal, were valuable in providing a general understanding of the rehearsal and annotation process at the outset of the research study, and clarified initial judgments regarding data collection.

Interviews

Interviews played an important role in this research. During the rehearsal/performance cycle, semistructured interviews were conducted with as many people involved in the process as possible, including conductors, if they were available. Interviews were digitally recorded; they typically lasted forty-five minutes to one hour, and were transcribed later for in-depth analysis. Interview questions were based on the annotation framework set out by Marshall (1998b) and MacMullen (2005), and were an attempt to cover three areas of annotative characteristics: (a) creation and use, (b) object qualities, and (c) meaning and utility. Interviews were semistructured; specific questions changed with each

<table>
<thead>
<tr>
<th>TABLE 1. Data collection grid.</th>
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<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
</tr>
<tr>
<td>Orchestra</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Chamber</td>
</tr>
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<td></td>
</tr>
</tbody>
</table>
| *Shaded rows represent the number of parts collected for each musician type; un-shaded rows represent the number of interviews conducted, and the number of observation sessions is in parenthesis.
individual conversation, but the interview themes remained the same across participants.

**Annotation Creation and Use.** The first set of questions focused on understanding the processes of creating and using annotations: whether annotation creation or understanding requires training; whether the annotations involve coding or a type of shorthand, and if so, how the annotator learned that shorthand; whether annotations are created individually or by decree; and the processes by which creation is managed. Another objective of this set of questions was to learn more about the ways performing musicians use their annotations during rehearsal and performance: who uses the annotations, and how; what processes take annotations as input or produce annotations as output; whether the annotation is part of an intermediate step or an end product; whether the annotation is private or public; whether the musicians recognize any ethical concerns regarding the use of these annotations; and when in the life cycle of the underlying object or process the annotation is created.

**Annotation Object Characteristics.** The second set of interview goals was to come to a deeper understanding of annotations’ object characteristics. Most of these questions were answered by content analysis of the scores, but the interview process did provide the opportunity to review individual annotations with the participant to get further background on the creation, use, and motivation for making certain notes. General goals for this part of the interview included finding out which forms the annotations took; how their form dictated use; whether the annotations require a standard format or style for comprehension; whether there is a controlled vocabulary or domain-specific ontology; whether storage or transformation to a different format allow different kinds of functionality; under which different contexts or conditions an annotation could be considered another type of information object (like metadata, for example); whether the annotation utility is permanent or transient; how the relationship between object and annotation is instantiated; and how the annotation is stored and retrieved under normal circumstances.

**Annotation Meaning and Utility.** The main goal in the interview’s final section was to explore the ways that performing musicians received information from the written music and personalized that information through annotation, and whether those annotations were more important for thinking about the piece, or for physical reminders related to performance. Are the annotations of performing musicians primarily related to intellectual cognition or practical application? Do the annotations have functional utility outside of the immediate context of creation and use? Another theme was to explore the perceived “importance” or “interestingness” of annotations from the performing musician’s perspective.

The interviews provided a broad and deep comprehension of the issues involved in rehearsal, performance, and annotation. Not only did the interviews give a deeper understanding of the processes involved in rehearsal and performance, the information garnered from the interviews provided valuable information in the creation of a relevant framework for content analysis of the scores. Table 2 provides information regarding interviews conducted.

**Table 2. Interviews conducted.**

<table>
<thead>
<tr>
<th>#</th>
<th>Musician type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Professional Quartet (Group Interview)</td>
</tr>
<tr>
<td>2</td>
<td>Amateur Orchestra (Bass)</td>
</tr>
<tr>
<td>3</td>
<td>Amateur Orchestra (flute)</td>
</tr>
<tr>
<td>4</td>
<td>Amateur Orchestra (trombone)</td>
</tr>
<tr>
<td>5</td>
<td>Amateur Orchestra (piano)</td>
</tr>
<tr>
<td>6</td>
<td>Amateur Orchestra (percussion)</td>
</tr>
<tr>
<td>7</td>
<td>Amateur Orchestra (violin)</td>
</tr>
<tr>
<td>8</td>
<td>Professional Conductor</td>
</tr>
<tr>
<td>9</td>
<td>Amateur Orchestra (viola)</td>
</tr>
<tr>
<td>10</td>
<td>Professional Conductor (retired)</td>
</tr>
<tr>
<td>11</td>
<td>Amateur Orchestra (cello)</td>
</tr>
<tr>
<td>12</td>
<td>Amateur Orchestra (percussion)</td>
</tr>
<tr>
<td>13</td>
<td>Amateur Orchestra (2nd violin)</td>
</tr>
<tr>
<td>14</td>
<td>Semi-Professional Quartet (1st violin)</td>
</tr>
<tr>
<td>15</td>
<td>Semi-Professional Quartet (cello)</td>
</tr>
<tr>
<td>16</td>
<td>Semi-Professional Quartet (2nd violin)</td>
</tr>
<tr>
<td>17</td>
<td>Semi-Professional Orchestra (1st violin)</td>
</tr>
<tr>
<td>18</td>
<td>Amateur Quartet (group interview)</td>
</tr>
<tr>
<td>19</td>
<td>Amateur Clarinetist – Member Check</td>
</tr>
<tr>
<td>20</td>
<td>Amateur Violinist – Member Check</td>
</tr>
<tr>
<td>21</td>
<td>Professional Cellist – Member Check</td>
</tr>
<tr>
<td>22</td>
<td>Professional Conductor – Member Check</td>
</tr>
</tbody>
</table>

**Score Content Analysis**

Typically, the documents analyzed in qualitative research include all documents related to the research, such as transcripts of interviews, written open-ended items on questionnaires, personal diaries, observation videotapes, and various other forms of documentation (Saville-Troike, 2003). In annotative studies, in addition to doing document analysis on the output of the data collection, researchers analyze primary documents that have been annotated by research participants (Marshall, 1998b).

Qualitative content analysis focuses on the empirical and methodological analysis of texts within their context of communication. The methodological and empirical rules recall the advantages of quantitative content analysis, and there are a number of specific procedures involved in a robust method (Mayring, 2000):

- **Model of Communication:** before beginning analysis, the researcher should decide which parts of the communication are under analysis; how the interviewer’s preconceptions and biases might influence data collection and the interaction between researcher and research participant; and the context of text production and reception.
- **Category Development:** The documentary material must be analyzed in a consistent manner, following procedural rules.
• *Category Application:* The categories of analysis should be based on the research questions, and refined by the process of analysis.

• *Reliability and Validity:* The content-analysis procedure seeks to be valid across different researchers. There are various methods to ensure this.

**Model of Communication**

In this research project, communication was modeled thus: information travels from the *composer,* who creates and then transforms his “aural vision” to notated form; to the *conductor* (if present), who interprets the composer’s notation and communicates this interpretation to the musicians during the rehearsal process. Musicians, if they are in an orchestra, have the complicated job of reuniting the composer’s written instructions with the conductor’s interpretation, and performing the piece skillfully and reliably. If the musician is part of a chamber group, and hence does not have a conductor, the musician must interpret the composer’s intentions themselves through the collaborative rehearsal process to perform the piece skillfully and reliably.

An added complexity of musical scores is that some composers, or composers from certain historical periods, sometimes did not include expressive notes (like dynamics and articulation) in their manuscripts. In these instances, scholars or editors have added expressive marks in an attempt to clarify the composer’s intention. This is a scholarly, well-documented act, and italicized notes in the score are generally understood to originate from an editor rather than the composer. For the purpose of this study, though, published notes, italicized or not, were considered authoritative and representative of the composer’s intention.

The goal of this research was to understand the interaction behaviors of musicians and their information source, the musical-score boundary object. This research project considered interaction between musician and written music as a form of communication, with the annotations providing evidence of that communicative event, essentially marking spots where some “breakdown” has occurred, requiring clarification, augmentation, or modification of the written instructions.

**Mode of communication: The musical score.** As discussed above, the musical score was considered the primary means of communication across boundaries—it is the means by which the composer communicates with the conductor and the musicians; the conductor with the musicians; and the musicians amongst themselves. On another level, the score is the means by which the composer/musician unit communicate aurally with the audience. There are a number of communicative approaches one can take as regards the score. Goodman (1976) refers to the musical score as a kind of “script,” which includes prescriptive directions, which must be followed to achieve authenticity, and descriptive suggestions, which can be followed given specific contextual situations. Others (Cochrane, 2000) regard the musical score as a set of directions (like directions on how to play chess), which is made up of constants and variables. A valid instance of a performance in this model is dependent on understanding the notational and interpretative conventions allowed by a certain piece. Finally, others (Schmidt, 1997) question the contention that prescriptive documents like dramatic scripts or musical scores actually describe or direct a performer’s behavior in any meaningful or verifiable way.

This research is based on the assumption that the musical score works as a *standardized-form* type boundary object, providing standardized methods, procedures, and vocabularies to communicate common processes and goals to various groups within an orchestra or ensemble. Within an orchestra, the score and the parts thereof provide direction to individual instrumentalists, their section, the entire orchestra, and to the conductor. In a chamber group, the score parts direct the action of the individual musicians. Annotation of these boundary objects tends to support group work, helping with group coordination and mediation between different members of the group.

**Communicators: Musicians.** Within this model, there are a number of primary players, and communication tends to be from the top down: the composer communicates with everyone, the conductor and the musicians; the conductor typically only communicates with the musician-instrumentalists; and the musicians communicate in a feedback loop, communicating with themselves explicitly by writing down notes, and implicitly giving feedback to the conductor in the form of sound. A very basic annotative communication would proceed: The composer (or some representative thereof) says to himself, “I want the piece to sound like $x$,” and writes down those instructions: “$do$ $x$!” The conductor reads the instructions (the score), and makes interpretative decisions based on the context of performance, and either verbally tells the musicians, “$do$ $x$,” or sometimes circulates written notes that each orchestra member must copy to their own score (bowing instructions are a good example of this). The musicians, who have the composer’s notes in the form of the score, and the director’s instructions, say to themselves, “Must remember to $do$ $x$. Must remember to $do$ $x$. Better write that down.”

Figure 1 illustrates a more formal example of this communicative model. There is a published element denoting that a note should be played “$ff$” for “fortissimo” or “very loud.” 2. The musician annotates the score with the “crescendo” symbol, which means, “Gradually get louder.” The two marks, while having nuanced differences in meaning, essentially mean the same thing (“get louder to a certain note”). 3. “MAX” is another reiteration of the original composer’s note “$ff$,” meaning basically, “this note is loudest.” The musician made this note because she was having difficulty remembering which note was loudest, and this distinction turned out to be important for her performance of the piece.

This communicative model allowed for the most reasonable method of data collection and analysis, although it had a limitation of focusing analysis on the performing musician of a chamber group; or, in the case of an orchestra, the
instrumentalists rather than on the conductor or composer. This focus was chosen for two reasons: (a) the performers’ effort was the most apparently evident. (b) The conductor’s annotations were radically different than those of the instrumentalists. Although conductors are considered performing musicians, their “instrument” is the orchestra, rather than a single unique entity. Their annotations deserve further study, but because the original conception of musicians in this study did not include conductors, data collection from that group was not complete or extensive. Conductors were interviewed, however, and their interview data added significantly to the understanding of rehearsal and performance processes, and the development of the music data analysis framework.

Category development. Category development is an enigmatic process. “How categories are defined. . . is an art. Little is written about it” (Krippendorf, 1980, p. 76). Mysterious though it might be, categories should be closely related to, and developed in terms of, the data. Essentially, the purpose of this process is to develop criteria for analysis derived from theoretical knowledge of the issues at stake, the research questions, and the information itself. Based on these criteria, the data from the scores and interview transcripts provided the foundation for category development. The categories were revised and reduced within a feedback loop, and checked for reliability through the use of “member checks”—informal interviews used to check the assumptions, theoretical stances, and ultimately a project’s findings. The member checks performed in the course of this research consisted of informal discussions with music faculty at the University of North Carolina at Chapel Hill, as well as discussions with members of the local music community. The early discussions centered on the categories developed for content analysis of the scores and the interviews. I also performed member checks at the end of the project, to check on the validity and reliability of the findings.

Data-Analysis Framework

Primary analysis consisted of categorizing each annotation in three ways (a) its mode: whether it is textual, symbolic, or numeric; (b) its general purpose: technical, technical-conceptual, or conceptual; and (c) its type, or specific purpose: bowing, fingering, articulation, timing, dynamics, emotive, phrasing, and so forth.

Annotation mode. Annotation mode refers to the representation means used to convey information. Annotations can be textual, symbolic, or numeric. Textual annotations are those that consist of a letter, a word, or words written in the margins. Symbolic annotations are those that consist of nontextual images or symbols, and numeric annotations consist of numbers placed above or below notes for fingering, navigation, or timing instructions. Symbolic and numeric annotations are similar in that they both tend to convey explicit instructions. The symbols and numbers that musicians use to annotate their music are, for the most part, standardized and even to some degree regulated. In the interviews, a number of musicians mentioned that they could tell when an untrained musician had marked up a score, because their annotations were “strange,” or unnecessarily confusing. When created and read by a classically trained musician, they believed that an annotation’s meaning would be explicit and unambiguous. The process by which musicians learn to annotate their music is discussed below.

Annotation purpose. Annotations were also characterized by their purpose. Most often, an annotation’s purpose is closely related to the musical element to which it refers. For example, an annotation that looks like a slash would have different purposes depending on the musical element to which it was referring. If the slash were breaking up an articulation mark, its purpose would be “articulation.” If it were placed above certain notes, it would refer to breaks, beats, or accents, and be classified as “timing/rhythm.” There are three general groups of annotation purpose: purely technical, technical-conceptual, and conceptual.

Technical annotations. Technical annotations were defined as those that are specifically concerned with the physicality of performing the piece: which fingers to place on which strings (fingering), how to hold and pull the bow across the strings (bowing), where to look or what to listen for (attentive notes), what notes to play (pitch), how to begin and end playing those notes (articulation), and how to navigate through the piece (navigation). These annotations have an immediate, physical, and specific meaning. Their purpose is intimately related to performance and reliable repetition. By far the greatest numbers of annotations generally fall into the technical annotations group: bowing instructions first, followed by fingering and articulation. While bowing instructions are specifically tied to stringed instruments, all musicians are concerned with technical playing instructions like fingering, breathing, navigation, and cues. All of these annotations relate to the physical transformation of performance: how to translate what is written into what is played.

Seventy-eight percent of all annotations included in this study were technical in nature. Many of the technical
Annotations produced by project participants were not self-generated, however. In an orchestra, either the conductor or the first chair of each strings section defines bowing instructions, and distributes those instructions among the other players. Breathing instructions for wind instruments are similarly generated. In all but the professional chamber music level the bowing, fingering, and dynamics instructions are defined by an outside entity, either a “coach” an amateur group has hired to give help, or the faculty member in charge of student musicians. Table 3 gives examples of technical annotations encountered in this study.

**Technical-Conceptual annotations.** Technical-conceptual annotations have a level of abstraction not present in the purely technical annotations. While the technical annotations deal with specific fingering and bowing instructions, the technical-conceptual annotations convey information that imply specific technical instructions, like bowing and fingering, but those specific instructions have passed through an abstracting prism of timing or rhythm, or dynamics. Specifically, technical-conceptual annotations include timing/rhythm, dynamics, and contextual information, both representational and informational. Examples are provided in Table 4. While there is a significant physicality present in these technical-conceptual annotations, in that they are conveying a musician action that should be taken, their meaning is less specific, and the execution is not necessarily immediate or precise.

The less formal quality of the technical-conceptual annotations is due more to the elements being annotated than the annotations themselves. The speed at which the piece is played (timing/rhythm), the sound level (dynamics), and the contextual notes are all relatively abstract concepts; it is then no wonder that the annotations of those elements contain a level of abstraction as well. Furthermore, the two major types of annotations in the technical-conceptual group, timing/rhythm and dynamics, are related specifically to group dynamics and performance context. Whereas the technical annotations refer to immediate and personal musical elements like fingering and bowing, cues and articulation, the technical-conceptual annotations refer to musical elements that are dependent on factors outside the musician’s purview, like performance space and the ensemble’s skill-level. Dynamics and tempo, for example, often change given the strengths and weaknesses of particular performance spaces and the ability of the musicians as a whole to play at a certain speed. Whereas the purely technical annotations are quite specific and denote the personal action an individual performer must take to make coordination and reliable repetition possible, the technical-conceptual annotations are more general, and often involve the coordinative and interpretative efforts of the entire performing ensemble.

**Conceptual annotations.** The least common musician annotations are those that are explicitly conceptual, and are at the end of the chain of more physical decisions illustrated by technical and technical-conceptual annotations. For the purpose of this study, conceptual annotations are those that denote emotive or phrasing instructions. Phrasing was defined as conceptual in this model because of its purely conceptual instantiation; drawing parenthetical marks around a group of notes does not have any outward manifestation, it is

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**Table 3. Technical-conceptual annotations.**

<table>
<thead>
<tr>
<th>Type</th>
<th>Modes represented</th>
<th>Transcription example</th>
<th>Example image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowing</td>
<td>Symbolic, Text</td>
<td>v, n “frog!” “Less Bow!” “Save” “UH”</td>
<td><img src="image1" alt="Example" /></td>
</tr>
<tr>
<td>Fingering</td>
<td>Numeric, Text</td>
<td>1, 2, 3, 4, 5 “pinky”</td>
<td><img src="image2" alt="Example" /></td>
</tr>
<tr>
<td>Articulation</td>
<td>Symbolic, Text</td>
<td>Articulation</td>
<td><img src="image3" alt="Example" /></td>
</tr>
<tr>
<td>Cue</td>
<td>Text</td>
<td>“cello” “Andrea” Glasses</td>
<td><img src="image4" alt="Example" /></td>
</tr>
<tr>
<td>Attentive</td>
<td>Text</td>
<td>“solo” “play” “more melodic”</td>
<td><img src="image5" alt="Example" /></td>
</tr>
<tr>
<td>Navigation</td>
<td>Text, Number, Symbol</td>
<td>“V.S.” “turn” Bar Numbers Extensions, arrows</td>
<td><img src="image6" alt="Example" /></td>
</tr>
<tr>
<td>Pitch</td>
<td>Symbolic, Text</td>
<td>Notes, accidentals, arrows “Renaming pitch”</td>
<td><img src="image7" alt="Example" /></td>
</tr>
</tbody>
</table>

---

**Table 4. Technical-conceptual annotations.**

<table>
<thead>
<tr>
<th>Type</th>
<th>Modes commonly represented</th>
<th>Transcription example</th>
<th>Image example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timing/Rhythm</td>
<td>Text</td>
<td>“faster” “break”</td>
<td><img src="image8" alt="Example" /></td>
</tr>
<tr>
<td></td>
<td>Symbol</td>
<td>“rit.” “‘m2” Breaks, ritard</td>
<td><img src="image9" alt="Example" /></td>
</tr>
<tr>
<td>Dynamics</td>
<td>Text</td>
<td>“MAX” “cresc”</td>
<td><img src="image10" alt="Example" /></td>
</tr>
<tr>
<td></td>
<td>Symbol</td>
<td>“&gt;&gt; - cresc”</td>
<td><img src="image11" alt="Example" /></td>
</tr>
<tr>
<td>Representational</td>
<td>Symbol</td>
<td>Showing notes played by another instrument</td>
<td><img src="image12" alt="Example" /></td>
</tr>
<tr>
<td>Context</td>
<td>Number</td>
<td>“3/4</td>
<td>4</td>
</tr>
<tr>
<td>Informational</td>
<td>Text</td>
<td>“Snooziando”</td>
<td><img src="image14" alt="Example" /></td>
</tr>
<tr>
<td>Context</td>
<td>Symbol</td>
<td>“181 time changes!” Cheese</td>
<td><img src="image15" alt="Example" /></td>
</tr>
</tbody>
</table>
simply a way to conceptualize a piece. Table 5 gives examples of common conceptual annotations encountered in this study.

Only 4% of all annotations examined in this study were purely conceptual, and while musicians in each group made them, the orchestral musicians at all levels used them the least. When asked about the lack of conceptual annotations on their scores, the concertmaster for the semiprofessional orchestra said, “The whole point of making annotations is to ensure consistency. You want everyone to know what everyone else is doing during performance, so you have to do the same thing every time you perform. In terms of orchestral performance, interpretation is not the focus” (Interview 17). Although only a small number of annotations from this study were explicitly conceptual, an argument could be made that all annotations are, on some level, conceptual. The professional conductor provided some insight into the intricacies of how explicitly technical instructions implicitly convey interpretative or conceptual information:

When you start something down-bow it’s going to have generally more attack, and more weight, and generally a sense of more accent or beginning to it, because of gravity or coming DOWN. And when you start something up-bow, it’s going to have a less predominant, less dominant beginning of the note, so if you want to start a piece really softly on a long held note, you’ll want them to start it with an up-bow, and then it will sort of sneak in, and as you get down to the bottom of the bow, which is called the frog, the sound will get heavier and more intense. So that’s one thing, the down-bows are generally more accented, the up-bows are less accented. . . . When a note is slurred, it’s going to be very smooth and legato and connected. When it’s not, you’re going to hear the bow changes—they’re going down up, down up, down up. So it’s related to phrasing, it’s related to articulation, it’s related to the character of the piece, and there are all kinds of things one can achieve through bowing changes in terms of your conception of the sonority of the piece, and how you want it to work. (Interview 8).

The content-analysis process consisted of transcribing each annotation on each collected part, recording the bar number, and characterizing each annotation with three levels of description: (a) the annotation mode: text, symbol, or number; (b) the general annotation purpose: technical, technical-conceptual, or conceptual; and (c) the specific annotation purpose: bowing, tempo, dynamics, and cues (among others). Figure 2 shows an example of a marked-up annotated score.

Findings

This research generated a number of findings, but those most relevant to the development of an annotation framework and digital-library tool development are those relating to annotation characteristics, the differences in annotation purpose and use, and the quality of annotations as markers of interaction with boundary objects.
Annotation Characteristics

Annotation characteristics centered on description of annotation purpose, the mode of annotation, and the annotation behaviors of different musician groups across skill level, performance mode, and instrument.

Annotation general purpose. All three types of annotations; technical, technical-conceptual, and conceptual, were used by all of the musicians who participated in this study, but some were used more often than others. Figure 3 shows the general disposition of annotation purpose across all skill levels and performance modes.

Seventy-eight percent of all the annotations observed in this study were purely technical, 18% were classified as technical-conceptual, and 4% were purely conceptual in nature.

Annotation mode. Annotation mode refers to the representational means used to convey information, and was characterized as textual, symbolic, or numeric (described more fully in above). Figure 4 shows the overall annotation mode organized by general purpose. Symbolic annotations made up 72% of all annotations observed in this study, with numeric and textual annotations being evenly distributed (14% and 13% respectively). Seventy-three percent of the symbolic annotations were used to communicate bowing instructions, followed by the technical-conceptual uses of timing (10%), and articulation and dynamics (at 3% each). Numeric annotations are primarily technical, with fingering instructions making up 75% of the numeric annotations, and navigation making up 12%. Textual annotations are more evenly distributed among general purpose annotations, with dynamics and timing annotations making up 54% of all textual annotations, followed by attentive (35%) and emotive (4%) notes.

Figure 4 illustrates that most annotations, regardless of their mode, have a technical purpose. This is most obviously evident for the symbolic annotations, where bowing, pitch, and articulation (all defined as technical) have primarily symbolic representations. Numbers almost exclusively represent fingering and navigation instructions. Textual annotations are more evenly divided between technical and technical-conceptual uses: text can be used to denote bowing (i.e., "frog," "save," "bow") as well as attentive notes ("cue," "cello," "Andrea!"). In terms of the technical-conceptual uses, text was often used to direct dynamics ("loud!" "Cresc") as well as timing ("sloooow," "time change!").

In order to get a better understanding of the annotation strategies of performing musicians, Figure 5 shows the annotation mode broken down by ensemble type.

In terms of the differences between performance groups, Figure 5 shows that the ratios are comparable, with symbolic annotations making up between 65% and 85% of a groups’ overall annotations, followed by numbers and text. However, even though the numbers are roughly similar, the nature of the annotations differs between musician types. For example, less than 1% of annotations made by orchestral musicians had conceptual uses, regardless of the mode. Bowing instructions, articulation, cues, and navigation predominated in orchestral

![Image](124x87 to 484x368)

FIG. 3. Annotation general purpose across skill level and groups.

1886 JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE AND TECHNOLOGY—October 2008
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parts, whereas the mode and general purpose was more evenly distributed for those annotations made by chamber musicians. This finding supports a statement made by the professional violinist in the first interview, who said when asked about the relative dearth of conceptual annotations on orchestral parts, “Well, an orchestral musician would be laughed off the stage if he tried to emote through a performance. It’s just not the job of an orchestral musician” (Interview 1—First Violin).

Annotation quantity. One of this study’s less intuitive findings is that, at least for the chamber musicians, professional musicians make more annotations than do their amateur counterparts. Figure 6 shows the average annotations per bar of music by musician skill level and performance mode. These numbers were calculated by dividing the total number of annotations made by a group by the total number of bars in the score. For example, the professional chamber group had a
total of 5263 annotations spread over 3396 bars of music, for an average of 1.55 annotations per bar. This number represents an average and does not represent the annotation habits of individual musicians, or the annotation characteristics of a particular piece.

This idea goes against received wisdom that more skilled users have less need for annotation support. In order to explore this idea more fully, average annotations per bar of music were calculated for individual chamber musicians at different skill levels. Figure 7 illustrates that in all cases the professionals chamber musicians make more annotations than do their nonprofessional counterparts, although in the case of the first violin, the professional only makes nominally more annotations than the semiprofessional. The second
violin consistently makes more annotations than any other instrument, although the difference is more pronounced in the professional group.

Because it was impossible to collect the complete set of scores from the amateur orchestra, and the professional orchestra received scores that had already been marked up by the semiprofessionals, it was difficult to generate reliable and conclusive findings regarding annotation quantity for the orchestral group. However, it is possible to distinguish some tentative trends in orchestral musicians’ annotation behavior. First, as Figure 6 illustrates, orchestral musicians annotate far less than do chamber musicians. This is true at both the professional and semiprofessional level, but is inconclusive (because of incomplete data collection) for the amateur orchestra. Also, orchestral musicians’ annotations were consistent within each instrument group. For example, all first violinists (except for the concertmaster) had obviously copied annotations from each other (and made no other changes), as did all cellists (except for the soloist), trumpets, bass, violas, tubas, and others. Finally, while the chamber musicians’ annotations were generally clumped around sections of the piece where something difficult was happening, orchestral musicians’ annotations were more evenly distributed throughout the piece.

Annotation Utility

The purpose of exploring the object characteristics of musicians’ annotations was to come to a more complete understanding of their utility and use. Musicians believe an annotation’s meaning to be explicit. There were three related interview questions that addressed this issue: (a) Do you think you would use your annotations again if you were performing this piece after a long break, or would you erase them and start from scratch? (b) If you were to get sick and could not perform, would your annotated part be useful for someone else trying to take your place? (c) Would you find it interesting to look at the annotations of a world-class [violinist, cellist, etc.]?

Personal reuse. When asked whether they would use their own annotations again in the future, all of the professional participants, including the professional conductor, said that they would. “Oh yes, definitely. In fact, we’ve performed this Schubert before, years ago, and my annotations are still good.” (Interview 1—Violin).

Some of the amateurs were also positive they would use their annotated parts again. “In fact I had a whole box full of Xeroxes of things I’ve done and things that I’ve used, reused and brought to other people … Yeah. Oh, yeah. Definitely.” (Interview 11). But a lot of the amateurs tended also to qualify their answers, because their performance practice is not as stable as is that of the professionals: “In theory? Yes. In reality, usually, it’s somebody else’s music so you never get the same one back. But in theory, yeah, that would be nice not to have to go through and figure things out again.” They also mention the fact that their annotations would only be useful if they were working under the same conductor, “Oh, yeah, with the same conductor. I’m sure a lot of the things would stay the same” (Interview 2). But if the conductor were to change, “It might save you time and it might lead you astray, if the conductor decided to do it differently the next time, or if someone else was conducting you. I don’t tend to erase my marks on anything that isn’t rented, though.” (Interview 4).

Almost all of the musicians interviewed in this study would save their annotated parts if they had the opportunity, although the less involved amateurs tend to recognize that their unstable performance practice would make reusing old annotations unlikely.

Stranger reuse. Most of the musicians thought that another musician would find their annotations useful if the situation arose. A few musicians qualified their answer, stating that only an experienced, classically trained musician would find their annotations useful: “Yeah. I mean … not a high school kid [their] first time—yeah, somebody could follow what I’ve done.” (Interview 2).

Interest in experts’ annotations. People seek out the annotations of expert practitioners because of the insight their annotations provide into the workings of an interesting mind. “And you have not read Joshua Reynolds / they say, until you have read him / enwreathed with Blake’s furious scribbling” (Collins, 1998). When asked if they thought it would be interesting to look at the annotated parts of famous musicians, participants in this study were almost unanimous in their desire to look at these annotations, and had varying reasons for wanting to do so. A few mentioned that it would be a good learning experience: “To compare what he’s done, or she, to what I might do or to try something that I’d look at it and say, ‘Oh, that looks—I would never do that’ and then try it and see if worked out really well. That would be kind of cool. Almost like getting a little bit of a lesson from a famous person” (Interview 7). Some said it would provide interpretive stimulus: “So anything you can learn about how a successful tubist interprets a certain section of music would be helpful to you as an audition aid, and then it would also give you just more insight into what they were thinking about when they approached a section.” (Interview 4). One participant said that it is possible to know what the annotations would be from listening to the music: “It’d be fun. Not that you can’t just get it by listening to them but when they’re playing with a whole orchestra, sometimes you don’t hear all the nuances of what they’re doing back there in the back and especially in a recording, you know.” (Interview 11).

The semiprofessional second violinist for the chamber group suggested that these annotations would be useful for study and reflection but not for performance purposes: “Yes, actually I’m playing the … my stand partner [in the orchestra] has photocopies of somebody who’s famous, and he’s telling me all about it, and he’s sent me PDF files of a couple of pages, and it’s really interesting because he [the famous person] has marked out and put in his own notes [i.e., he’s...
changing the pitch]! Because it was so many notes, I wouldn’t want to play off of that.” (Interview 16).

Musicians who participated in the follow-up interviews to check the reliability and validity of findings were also interested in saving the annotated parts of famous, or personally important, musicians. They mentioned that they still have all of their own annotated parts, sometimes dating back twenty or thirty years, and in some cases have saved the annotated parts of their teachers upon death or retirement. “They’re so precious to me,” said one interviewee (Interview 20—member check). Another, a faculty member in the music department, mentioned that when his mentor retired from the university and his music collection had been donated to the library, this faculty member had gone and photocopied all the annotations before they were erased (Interview 21—member check). The smallest, seemingly most inconsequential marks had a lot of value to these musicians.

Musical Scores as Boundary Objects

Boundary objects were defined above as artifacts, documents, or ideas that help people from different communities build a shared understanding. As regards this research, the concept of boundary objects was useful in conceptualization of project-participant interaction procedures and goals, as well as the development of theories related to the communication among members of the group, their means of learning that communication style, and their attitudes toward sharing information with group members and nonmembers.

Because data collection was focused on group rehearsal rather than individual time spent interacting with the score, it is difficult to definitively and completely describe individual musician interaction with the score. However, in terms of group work, data collection was authoritative, and provided a multifaceted insight into the methods and procedures by which musicians interact with their boundary object, the musical score.

Amended communication model. The communication model used at the outset of this research project had artistic intention traveling straight from the authoritative voice of the composer or editor through the conductor, if there was one, to the musicians. Musicians’ annotations on the score were primarily considered a means to practically instantiate the directions from the composer for a particular performance context. Although the line of communication still stands: composer (and/or editor) → conductor → ; musician, viewing the score as a standardized-form boundary object expands the communication model. Instead of directions simply traveling in a hierarchical fashion from the composer to the musicians, with the musicians attempting to carry out those directions, with the musical score as a standardized-form type boundary object, the information, procedures, and methods for achieving goals become a point of discussion among musicians.

The annotations in this augmented model represent a more complex interaction between musicians than had been supposed at the outset of this project. The original communication model conceived of annotations primarily as a personal directive to “get it right.” Although annotations still have personal ramifications, the importance of “getting it right” is better understood in light of coordinative group work rather than as an individual task. A member of an ensemble does make annotations in order to play correctly, but only because other members of the group rely on consistency in order to achieve reliable group performances over time.

This amended model can help explain the difference in annotation frequencies mentioned in the section on Annotation Quantity (above), as well as the radically different character of conductors’ annotations, mentioned in the section on Annotation Object Characteristics (above). The musicians who participated in this study did not annotate solo work as much as they did the group work, even if it was a particularly difficult solo. Participants said that this was because they were “free” to do whatever they wanted when working alone (Interview 1—Cello). This tendency isn’t only true for chamber musicians; orchestral musicians who play solo parts did not annotate those parts except to mark the spot where the rest of the orchestra joined their playing (illustrated in Figure 8). Furthermore, whereas orchestral musicians made annotations steadily throughout the course of the piece, the chamber musicians could sometimes go for forty or fifty bars between annotations, and then heavily annotate a particular phrase or set of phrases. As observed during the rehearsal process, these instances of busy annotation were generally sections where something difficult was happening, like a time change, or a distinct pause followed by all musicians starting exactly together. Difficult sections happen in orchestral work too, but instead of the instrumentalists working those problems out together and using the score as a point of discussion, that job is handed off to the conductor, who makes those notes, and takes responsibility for interpretative decisions, as well as leadership.

Annotation style: Dependent on personal preference? At the beginning of data collection, in the first interview, the violist for the professional chamber group said that he thought most musicians fell into one of two camps annotation-wise: those who do not like surprises and hence annotate everything, and those who prefer to rely on their memory and annotate far less. He thought this was simply a personal preference, and at face value, this seems true. However, three findings from this study suggested that personal preference might not be the only explanation for annotation quality, quantity, and characteristics (hereafter called annotation style): the first relates to the differences in annotation behaviors between chamber and orchestral musicians, the second is related to the role of the second violinist in chamber groups; and the third is related to the amount that the more skilled musicians annotate as opposed to their less skilled counterparts.

Chamber versus orchestral musicians. This research found that the chamber musician participants annotated much
FIG. 8. Part annotated by solo cellist in semiprofessional orchestra. The down-bow at bar 31 is the only annotation near the solo, and marks where the rest of the orchestra joins in.

more profusely than orchestral musicians did (as evidenced in Figure 6). This might be due to personal preference, as data was only collected from one group of each kind. It might also be due to the typical ways that each group interacts with their score/boundary object. During observation, the chamber groups seemed fairly democratic. They rehearsed together as a group, they discussed decisions, and they worked out problems among themselves. When there was a coordinative question, the professional group had a copy of the score available for perusal. Intuitively, one would think that this sort of decision-making process would result in more annotations because the process is ongoing and iterative; the findings support that intuition. Orchestras, on the other hand, were observed to have a less open culture. The conductor, in charge of interpreting the piece, communicating those interpretations, managing collaborations among sections, and leading rehearsals, makes all decisions for the group, and there is very little, if any, discussion of those decisions. Conductors give notes during rehearsal for the whole ensemble to follow, they decide on bowings and breaks, and hand out the notes to section chairs to then hand out to their colleagues. Intuitively, one would suppose that the orchestral interaction model would lead to far fewer annotations, because the musicians may be less invested in the final product, and they have less input than their chamber-musician peers. Again, the findings support that intuition.

The second violinist. Within chamber groups, the second violin annotated an average of 20% more than any other instrument (cf. Figure 7). Figure 9 provides an illustration of a typical phrase as annotated by the four professional chamber musicians.

This image illustrates the nature of the second violin’s annotations in comparison to the rest of the group. While the first violin, viola, and cello have relatively few annotations; the second violinist has marked up almost every note in bar 299, and added attentive notes and cues in the margins between staves. Because annotations were more prevalent in coordinative situations like the one illustrated in Figure 9, and because of the heavy annotation practice of the second violinist, there was a suggestion that the second violin might have more responsibility for the smooth functioning of the group as a whole. When asked about the profusion of second violin annotations, the professional first violin player had two explanations: First, the second violin is often responsible for thematically and functionally tying together all of the other instruments. Because the second violin both backs up the tempo set by the cello and supports the melody played by the first violin, the second violin has more information to keep track of, and more responsibility for “getting everything right.” The second violin is the glue that holds the quartet together. Everyone depends on the second violin being consistent, and because annotations help to ensure consistency, the second violin annotates more than everyone else.

The second explanation offered by the first violinist compares the second violin’s playing responsibilities with those of the first violin. The first violin generally plays the melody, which is easier to memorize, and less dependent on successful interaction with other members of the group. Furthermore, all of the other instruments in a chamber group have a responsibility to follow the first violin’s lead. The need to annotate is therefore less urgent for the first violin than it is for everyone else in the group, but especially the second violin, who does not primarily play the melody, but instead backs up and manages interaction among the different instruments.

Because the first violin’s responsibility within the group is to lead rather than to manage the collaboration, that instrument tended to have fewer annotations than other members of the group. The musician tasked with managing the collaboration, the second violin, often had many more annotations as anyone else.

Skilled musicians. This research had the counterintuitive finding that at least among the chamber musicians, the more skilled musicians annotated more than did the less skilled.
Professional chamber musicians annotated the most, with 1.55 average annotations per bar of music, semiprofessional chamber musicians annotated second with 1.04 average annotations per bar of music, and amateur chamber musicians were third, with 0.43 average annotations per bar of music (illustrated in Figure 6). Because it was impossible to collect all of the parts from the amateur orchestra, and because the semiprofessionals had already marked up the parts used by the professional orchestra, it is difficult to reliably make this assertion for the orchestral musicians. While there was little explicit explanation for this skill-based discrepancy from the musicians themselves in the interviews, there was a sense that the musicians who were more invested in success were more likely to annotate. The concertmaster for the semiprofessional orchestra felt that the act of annotating had a direct correlation with better performance, that his orchestra “would be better if more people made annotations,” and had recently been on a campaign to put sharpened pencils in everyone’s music folders. Furthermore, when asked how likely they were to bring a pencil to rehearsal, those musicians who mentioned informal, private rehearsals were likely to reply, “I’m 100% likely to bring a pencil to rehearsal” (Interview 11), or “I’d be embarrassed if I didn’t have a pencil with me at rehearsal” (Interview 13). On the other hand, those musicians who said they played music mostly “for fun” (Interview 4) were unlikely to be prepared to make annotations: “I usually borrow a pencil from someone behind me;–but the other day no one had one, so I just had to try to remember” (Interview 7).

Learning annotation techniques. Another surprising finding was that, for the most part, musicians were not formally trained in music annotation techniques. This was surprising because of the unambiguous nature of the annotations, their explicit and specific meanings, and the fact that most musicians said that they thought they would understand someone else’s annotations, as theirs would be understood by someone else. Because annotations were so common and consistent, it would be reasonable to assume that annotation behaviors are taught in a standardized way, but this is not the case. Many musicians reminisced about childhood experiences of having their teachers reach over their shoulders to mark up their scores, and that was the only conscious memory they had of learning annotations.

If musicians are not taught how to make these marks, how are they so standardized? How do musicians know to use the same symbols to represent the same concepts across different times, geographical spaces, and contexts? A likely answer might be related to the fact that scores are standardized-form type boundary objects. Instead of thinking about a specific score as a boundary object, and the ensemble as the group being bound together by their interaction with it, imagine that the concept “the score” is a boundary object, tying together all musicians. This might account for the strange and recurrent response to an interview question regarding whether other people would be able to understand their annotations, that only “musicians” would be able to understand musician annotations. So in that case, all members of the group, meaning all musicians, would understand the vocabularies and interactive styles developed to communicate common goals and processes. All musicians, then, would understand not only the primary communicative methods represented in the score, like how to read music; they would also understand the more
informal or secondary communicative methods that surround the score, like the annotations one puts on the score.

Once members have learned the primary vocabularies and processes, further formal training would no longer be necessary because these secondary techniques and vocabularies build upon primary concepts and terms. Annotations are built upon vocabularies and concepts already represented in the musical score itself. With only a few exceptions (eyeglasses, stars, arrows), musicians do not invent their own annotation language. All of their representation modes build upon the preexisting language of musical notation. Instead of asking the simple question, “How do musicians learn to annotate?” the question becomes more about the process of interaction: “How do musicians’ interaction styles support coordinative processes, and how is that coordination achieved?” This research question is being addressed in my current work.

Annotation and sharing. When asked about annotation utility, the musicians who participated in this study responded that their annotated scores continue to have value indefinitely. They have personal value, in that the musicians would use their annotated scores again, and they have external value, in that the musicians share the information contained in the annotations with their peers. A number of the musicians who participated in this study also saved annotated scores from their mentors and teachers, and a few had sought out the annotated scores of other musicians. All participants said that looking at the annotated scores of famous musicians would be interesting.

These findings generally support the idea that musician annotations are created through the problems or breakdowns in communication that happen in their attempt to work together to perform a musical piece. Musician focus is on collaboration, coordination, and interaction. Musicians also tend to gladly share their music and annotations with others. This sharing can be intentional, as in giving master classes, or donating annotated parts to a library or archive after retirement; or it could be unintentional, as in sending rented scores back to the agency without erasing the annotations, which happens fairly often. Although there are privacy issues involved, not one of the musicians interviewed for this study mentioned any concerns about privacy. Musicians might be unconcerned about privacy issues as regards their annotations for two reasons: the first is that group work and coordination depend on the ability to share; sharing is just part of being an ensemble player.

The second explanation might be related to interpretation and annotation purpose. Although musicians and other artists cannot give their work away if they want to make a living at it, in terms of annotations, they already do. Although it is difficult to believe that someone could know what all the annotations would be on a given piece of music simply by carefully listening to a recording of it (Interview 11), it is plausible that a well-trained musician would be able to intuit a significant portion of them. Musicians might be unconcerned about the privacy issues related to sharing their annotations because the product of those annotations is right there for listeners’ ears to hear, in their performance. There is no need to be concerned about sharing annotations because they are simply the particulars of a performance.

By considering the musical score as a standardized-form boundary object, five trends emerge from the data: (a) chamber musicians annotate more than orchestral musicians, (b) second violinists tend to annotate more than all other musicians in a chamber group, (c) as a group the more skilled musicians make more annotations than do the less skilled musicians, (d) annotations are not formally taught or learned, although their form is standardized, and (e) annotation form is in fact so standardized that the concept of sharing is redundant if the piece is performed. These trends provide more insight into the interaction style of people interacting with these types of information objects than if we were to simply declare that “personal preference” is the reason for these differences in annotation style. By focusing attention on the communicative methods and procedures employed by users of boundary objects, the questions one can ask become more pointed and may provide more concrete answers about how standardized the annotations actually are and how widely understood and useful someone else’s annotations might be, and allow for a deeper exploration of the historical precedents and methods of interaction with these powerful information objects. Whereas the questions for this research study, because of its exploratory nature, were primarily descriptive, subsequent studies can ask more in-depth questions about the nature of a group’s interaction with their boundary-object artifact, and the standardized methods and procedures used by the group members to interact among themselves.

Augmented Annotation Framework

One of this research project’s principal findings is that musician annotations have a distinctively technical or physical purpose. A majority (78%) of annotations across skill level and performance mode are related to performing a physical action. This might be due to the different nature of the primary interaction, and should be included in any model of user-interactive behavior. Not only are musical scores notational and symbolic, they are also structured and instructional. Because they are boundary objects, musical scores provide common rules and methods by which multiple people in multiple contexts can carry out complex procedures and achieve reliable results given different contexts and goals. Additionally, musicians annotate musical scores using a largely symbolic system that is passed down orally and physically, and is derived from the language and structure of their primary artifact, the musical score. Finally, the structured and notational character of the data allows for a standardized and consistent approach to the instructions contained within.

Dance scores, architectural drawings, dramatic scripts, and scientific lab notebooks are similar to musical scores in their notationality, structured quality, and use patterns, and might provide valuable sites for future researchers interested in the annotative behaviors of people who interact with highly structured, nontextual, and notational data on a daily basis.
Although her model is practical and useful for the structured examination of text-based annotations, Marshall’s framework (Marshall, 1998b) somewhat limits the study of objects that are neither primarily textual nor have textual annotations, and whose annotators do not have the same end goals or interactive methods as do those users who are working alone with a text-based entity. Specific limitations in Marshall’s annotation framework include the process of characterizing the annotation form itself, specifying the author’s purpose for annotation, and defining the annotation’s context of use. For example, Marshall’s framework for defining an annotation’s purpose is based on the premise that the annotator is intellectually interacting with a text for the purpose of comprehension or later regurgitation (for a test or paper, for example). This is not the case for musicians or other people interacting with notational prescriptive documents. A musician does not read his part so much as he uses it. Therefore, the impetus behind the primary interaction is action rather than thought, and the annotations reflect that difference. To more fully capture, describe, and support the interactive methods used by different kinds of people interacting with different kinds of texts for a myriad of reasons, an augmented framework was developed (illustrated in Figure 10). This augmented framework includes: a refined definition of annotation mode, because not all primary documents are text, and not all annotations are textual; an expanded examination of annotation purpose or primary interaction purpose; and a more concise definition of performative annotations, which supports the examination of context of use in order to elucidate the more overt physicality to which musicians’ annotations refer.

Marshall’s framework currently consists of two dimensions: formal and informal. Instead of focusing on the formal/informal distinction, this augmented model begins by addressing the annotation’s initial context of creation. Marshall addressed this context of creation in her “reading by-product/writing by-product” dichotomy, but this distinction is based on the user doing primarily internal or intellectual work. Whether the primary context of use is intellectual or performative would be a more informative primary distinction. Figure 10 attempts to codify this new axis framework.

This reorganized and amended framework still has a distinction between “formal” and informal annotations, but that distinction is secondary to the consideration of an annotation’s context of creation and use. If, for example, the primary impetus for interacting with a score is intellectual, for music theory, editing, or historical reasons, interaction with that artifact will be essentially different than if performance is the primary impetus. Figure 11 shows an example framework classification for an emotive annotation analyzed in this study. Figure 12 shows an example framework classification for technical (bowing) annotations analyzed in this study.

This augmentation of the framework allows for more in-depth analysis of annotations produced in an active context of creation. Classifying performative annotations in this way would allow for a deeper understanding of their use and function, and help in development of systems that would support their utility. This framework provides a standardized method of approaching those different interactions.

If the primary interaction is determined to be performative, further analysis of the technical/conceptual dichotomy is appropriate. If the primary interaction is intellectual, one goes on to work on the formal/informal dichotomy. While the technical-conceptual model developed from this project’s data seemed to be robust and allowed for a fine degree of analysis, it was developed primarily for musical scores. Whether

![FIG. 10. Augmented annotation model.](image)

![FIG. 11. Example framework classification; conceptual-emotive annotation.](image)

![FIG. 12. Example framework classification; technical-bowing annotations.](image)
the model could be generalized for use on other performative artifacts has yet to be determined.

**Digital-Library Tool Development**

Although the primary motivation for this research was to develop and augment existing theory, it has also uncovered two sets of recommendations for digital-library annotation-tool development.

The first major set of recommendations concerns the performative-intellectual distinction addressed above. The physical and technical nature of the musician participant’s annotations on musical scores suggests that people who are interacting with performative artifacts like musical scores need systems that support action rather than support the artifact itself. Instead of allowing for a static and text-based intellectual interaction with the artifact, digital-systems developers who want to build systems that support more diverse uses of their collections need to provide functionality for numerous, easily relatable and highly adaptable interactions.

Another recommendation related to the performative-intellectual dichotomy is related to the mode of annotation. Most of the annotations analyzed in this study reflect the language/symbol system of the primary artifact. Systems that support music performance specifically should provide a menu of musical symbols as a first-line annotation. Although there were some annotations (glasses, stars, exclamation points, individual textual phrases) that were not based on elements already present in musical notation, those could be easily added to a system. In the case of musical scores, the primary language is formal and mainly symbolic, but it might also be numeric or text.

Digital annotations should also be easily differentiated from the primary artifact. This is not a new recommendation (Marshall, 1997), but it is important for the functionality of annotation systems, so it should be repeated as often as possible. Musicians implied that, during performance, they use their annotations as if they were landmarks rather than as specific instructions, and that they strove, through rehearsal and repetition, for independence from the primary artifact, the score. Further research, including eye-tracking studies to see where musicians really do look during performance, would provide more insight into actual musician use of the score and the annotations. Again, Marshall (Marshall, 2005) has already alluded to this “landmark” functionality, but it would be interesting to see if there are differences in the use of “geographical marker” annotations by performative/intellectual workers versus those working with text, images, numbers, or symbols. As regards this recommendation, for the important “landmark” functionality to remain, annotations must be easily differentiated from the primary document.

Systems that support performance or action should allow microlevel anchoring of annotations. In the case of music, microlevel refers to individual notes or similar elements within the score. The technical annotations analyzed in this study referred for the most part to individual musical elements within the primary artifact. Comparatively few annotations were focused on providing general notes for phrases or sections of a piece.

Performative artifacts, most notably musical scores and dramatic scripts, remain primarily analog because of the mobile nature of rehearsal and performance, and because the physicality of the representation is important. Music is published on specially sized (larger) paper to enhance ease of use. Musical notes need to be easily discernable in half-light and at a glance, and they cannot emit light (it would be distracting for the audience). While there has been promising work done on digital music stands (Bell, Blizzard, Green, & Bainbridge, 2005), it is unclear that, given the limitations of existing tools and projection techniques, music annotation systems would in the near future be realistic for general performance use. Annotation systems would be useful for the relatively static rehearsal period, though, and musicians could print out their annotated scores when performances began, and the digitally stored annotations could provide valuable and interesting data for study of performance practice, music history, or criticism.

The second major set of recommendations regards developing a system architecture that would support annotation preservation, collaboration, and dissemination. Because there are few annotation systems in existence that support performative artifacts, these system recommendations are necessarily descriptive rather than prescriptive.

**System users should be able to access previous users’ annotations.** Almost all of the participants in this study said that they thought it would be interesting or useful to look at the annotated parts of other musicians, specifically those musicians who were important to them, like former teachers, or famous musicians. Because the more skilled musicians in this study made more annotations than did the less skilled musicians, annotation could be seen as an element of skilled practice. In addition to helping musicians learn the piece by highlighting difficult passages, demonstrating specific physical performance strategies, and illustrating individual interpretations, seeing the annotations of more skilled performers might also model positive annotative behavior for the beginning musician. Although this research does not answer the question as to why professional musicians annotate more than amateurs, or what effect extensive annotation has on comprehension or performance, the fact remains that the professional musicians who participated in this study annotated more than nonprofessionals. Further research might shed light on the effect of annotation on performance success, interpretive complexity, comprehension, and continuation in the field.

**Ability to “push” annotations.** There is a huge dissemination problem in orchestral performance contexts. The conductor and concertmaster decide on the bowings for the strings sections, and then they have to distribute those annotations to fifty or sixty people, ensuring that each of those people take the time to reliably mark the instructions on their individual copy of the part. It is a very messy process.
In this situation specifically, the ability to push annotations to the entire group would be wholeheartedly welcomed. On a less institutional note, a number of participants, but specifically the semiprofessional concertmaster for the university symphony orchestra, equated annotation with success (Interview 17). If the conductor or concertmaster could “push” annotations out to the rest of the orchestra, that theory could be tested. This would indicate the need for definition of hierarchical groups or roles: conductor, concertmaster, section chairs, and individual chairs.

**Conclusion**

This research provided in-depth analysis of over 25,000 annotations made by musicians of all skill levels and performance modes. Additionally, rehearsal observation and detailed interviews provided context with which to meaningfully interpret the data. This research provided comprehensive analysis on basic annotation characteristics, the purposes and motivations for making those annotations, and the knowledge necessary to create and use those annotations. This study resulted in three major accomplishments:

1. By looking at musical scores as boundary objects, this research enhanced the ability of future researchers to ask meaningful questions about the interactive and methodological approaches users take when working with them.
2. By exploring symbolic, notational, performative artifacts, this research has augmented and reorganized the existing framework for analysis of annotations to be more inclusive of all types of interaction, within different types of context of creation and use.
3. By examining and describing annotation characteristics, this research has provided specific and practical digital-library tool recommendations for those developers who are interested in supporting more diverse interactions with their collections.

These findings may open the door for more research in information science, specifically in human-information interaction studies. Musical scores represent a treasure trove of research opportunity, but other formalized performative artifacts like recipe cards and dramatic scripts are interesting as well. Digital versions of performative artifacts like architectural drawings and dance scores offer the opportunity to study these situations in the digital realm.

Providing the ability to annotate primary data will become more and more important for the success of any digital system, and this project has resulted in a number of specific and identifiable recommendations to make digital systems more useable by specialized users like musicians.

Finally, with the development of annotation tools becoming more common on the Web, the need for basic research is still strong. Augmentation of the existing annotation framework originally developed by Marshall (1998b) will allow for more thorough description and comprehension of these results of human-information interaction. Not only will this new augmented framework allow for a finer level of detail on already studied primary artifacts, it provides a framework and impetus for people who are thinking about studying annotations of structured, nontexual, performative artifacts.

Not only has this research project produced specific and practical recommendations for digital-library development for performative and general systems, it has provided an augmented framework for interaction and annotation studies. By providing a description and overview of the annotation behaviors of musicians interacting with their primary information artifact, this research has uncovered further questions regarding human-information interaction and methods by which they can be studied.

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