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This study describes a survey of members of the University of North Carolina at Chapel Hill community. Participation was solicited via the UNC-CH Mass Email System. Subjects included students at all levels from undergraduate to postdoctoral, faculty, staff, alumni, and persons with other academic affiliations.

The survey was conducted to establish baseline data describing what people know about handling and storage of optical digital media (CDs and DVDs). The survey also sought to describe the vectors by which participants gained their knowledge of the topic, and to determine the extent to which libraries have played a role in user education.

The data suggest that survey participants’ knowledge about the topic varies widely, with answers to questions ranging from near-unanimously correct to near-unanimously incorrect. Furthermore the data suggest that libraries have played a small role in user education compared to other influences. Benefits of increased library outreach to users are implied.

Headings:

Optical disks / Conservation and restoration

Surveys / Optical disks

University of North Carolina at Chapel Hill

Use studies / Optical disks

"A Lifetime of Enjoyment": User Knowledge of Best Practices For Handling and Storage of Optical Digital Media

by
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Approved by:

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Diane Kelly

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Chapter 1: Introduction

In the 1980s and 1990s, respectively, compact discs (CDs) and digital versatile discs (DVDs) were heralded as superior storage media to magnetic analog and digital media such as videotape, audiotape and floppy disks. Magnetic storage media had been shown to be inherently unstable, highly susceptible to atmospheric degradation, and prone to mechanical failure (Van Bogart, 1996). Optical digital media were considered to have solved these problems, with the added bonus of greatly increased storage capacity (Arps, 1993). Consumers adopted the new media and libraries followed suit.

At present, the umbrella term “optical digital media” encompasses: manufactured compact discs (audio CDs (sometimes referred to as CD-DAs) and CD-ROMs); manufactured digital versatile discs (DVDs and DVD-ROMs); one-time recordable compact discs (CD-Rs); one-time recordable digital versatile discs (DVD-Rs); rewritable compact discs (CD-RWs); rewritable digital versatile discs (DVD-RWs); nascent media such as high-definition compact discs (HDCD) and Blu-Ray; and the obsolete Laserdisc medium as well as minor variants like CD+G, CD-I and MiniDisc that did not establish an enduring presence in the consumer marketplace (Byers, 2003).

Research on the stability and longevity of optical digital media has shown that in fact they are prone to some of the same mechanisms of decomposition and failure as magnetic digital media, as well as possessing some unique failure mechanisms of their own (Iraci, 2005). CD media, because their data layer is so close to the surface of the

label side, are easily and irretrievably damaged by scratches. DVD media, because of their multilayered composition, are especially prone to delamination. All recordable optical digital media, because they use a layer of dye or chemical substrate to record data, are extremely sensitive to light and heat. All of these formats can be damaged by extremes of temperature, extremes of humidity, and excessive fluctuation of either. These environmental factors, as well as improper storage and handling, can cause discs to warp and crack and their layers to blister or separate completely. Furthermore, once flaws have been introduced to their coatings, discs are susceptible to a variety of forms of decomposition: polycarbonate layers become clouded with crystallized bisphenol, aluminum layers in manufactured discs oxidize, silver layers in manufactured discs oxidize and tarnish, and dye layers in recordable discs dissipate (Byers, 2003; Youket & Olson, 2007). There have also been documented cases of sulfur content in paper booklets and packaging inserts reacting with silver and aluminum layers (Lehman, 1998), and fungi feeding on polycarbonate and aluminum layers (Romero, et al., 2007). Even the hardiest of these media (manufactured audio CDs), given ideal storage and handling conditions, have an estimated failure rate of 25% within 100 years and 75% within 1000 years (Youket & Olson, 2007); with the exception of phthalocyanine dye-based CD-Rs, the estimated life spans of the other types of discs are considerably shorter (Iraci, 2005).

With so many varieties of inherent vice in optical digital media, they have been recognized by libraries and archives as a poor choice for long-term preservation of data, who also saw that improper handling and storage by patrons and LIS professionals alike further lessens their life spans. Poor handling and storage include any behaviors that cause or increase the likelihood of introducing breaches in the outer coatings or within

the layers of discs. In addition to storage and/or use in harmful climactic conditions, methods of improper handling range from the scientific (e.g., storage in chemically harmful enclosures or physically damaging circumstances) to the prosaic (e.g., scratching, stacking, dropping or bending discs; labeling, writing on, or dirtying disc surfaces).

LIS institutions began, relatively early in the history of optical digital media, to educate their staffs about care and handling that would be least harmful to these media (Turner, 1991). Library and information science schools in turn added optical digital media to their preservation curricula (Gracy & Croft, 2006). Many documentations of best practices for handling and preservation of optical digital media have been published by the Library of Congress (LC, 2002), National Institute of Standards and Technology (NIST, 2003), American Library Association (ALA, 2008), National Preservation Office of the British Library (NPO, 2008), and other governmentally affiliated organizations.

Unlike the rich body of empirical research devoted to the issues of inherent vice, however, there is a substantial lack of empirical research on the issues of proper handling and storage by LIS institutions and their patrons. The majority of articles in scholarly publications are reiterations of data published by the aforementioned institutes. It is possible that the LIS field has been content to accept these findings without conducting more research, as it can probably be assumed that the aforementioned institutes had conducted their own research prior to publishing their standards and guidelines. More importantly, there does not seem to be any scholarly literature about the borrowing and usage behaviors of consumers – i.e., library patrons – concerning optical digital media.

It may even be the case that preservation education has gone unstudied due to a perceived obsolescence of optical digital media in the face of digitization and digital preservation. Acting, or rather failing to act, based on such a supposition would actually be more disastrous than a similar abandonment of the preservation of print materials, because while a policy of "benign neglect" is not drastically harmful to print materials, optical digital media naturally decay at a much faster rate without active care. Yet Gracy & Croft, 2006, suggests that even within LIS graduate schools, the issue is not addressed in a significant percentage of academic curricula, leading to a twofold problem: not all LIS graduate students are taught about optical digital media preservation issues; and if they are, it is not clear that they are transmitting this knowledge to the library patrons who borrow and use these media.

The goal of this study is to address the following research questions:

1. What do members of a university community – of whom many are assumed to be library users – know about the proper handling and storage of optical digital media?

2. How did they obtain this knowledge?

The purpose of this study is to gather statistics about (1) user knowledge of issues regarding the handling and storage of digital optical media, and (2) vectors by which that knowledge was obtained. The results of such a survey have not been published in existing LIS literature, so this study aims to provide a baseline for further research.

As this study is primarily intended to gather data about an under-researched topic, there are no formal hypotheses behind the research questions. The general notion behind the first question is that while most users in the chosen university community may have encountered damaged optical digital media – pre-recorded CDs and DVDs that no longer

play properly, recordable CDs and DVDs that can no longer be read by a computer – they may not be aware of the full extent of the impact that their personal usage and storage behaviors have on the longevity of the media. The notion behind the second question is that these same users may have obtained their knowledge less from libraries and more from other, less knowledgeable sources and may have thus potentially been misinformed and therefore misled.

Chapter 2: Literature Review

The literature review for this study is grouped thematically in four sections: (a) Empirical Research Studies of Optical Digital Media Longevity; (b) Guidelines and Best Practices for Handling, Storage and Preservation; (c) Dissemination of Knowledge of Guidelines and Best Practices in Libraries; and (d) Consumer / Patron Knowledge of Guidelines and Best Practices

Empirical Research Studies of Optical Digital Media Longevity

A number of guidelines and recommendations for best practices have been published by the Library of Congress [LC] (2002), National Institute of Standards and Technology [NIST] (2003), and the National Preservation Office [NPO] of the British Library (2008), among other similar institutions, as will be discussed in section B. It can probably be assumed that these institutions had been doing empirical research on optical digital media for years prior, dating to when each of the various media became popular with consumers and thus necessary for libraries. However, this research itself is not available in published form, leaving only the resulting guidelines available to the general public. One must look to more recent studies to find published evidence of ongoing scientific investigation of optical digital media longevity, and specifically the decomposition mechanisms due to the inherent vice of the materials.

One of the best studies is Iraci (2005), a quantitative analysis of the relative stabilities of popular optical media. Iraci subjected audio CDs, CD-Rs made with three different types of dyes, CDR-Ws, DVDs, DVD-Rs, and DVD-RWs to accelerated aging tests, selecting a minimum of 4 discs made by up to 10 manufacturers in each category, for a total sample size of 207 discs. With the exception of the audio CDs, which were purchased "as is" from used CD retailers (and thus potentially weakened by mishandling), the discs were all purchased new, and repeating blocks of data were written to the recordable media until their full capacity was reached.

The samples were aged for 2000 hours (84 days) in the harshest aging conditions described in the ISO 18927 standard (2002): 80°C and 85% RH. Since accelerated aging cannot predict lifespan in years, the importance of the study is what it reveals about the different species of media relative to each other: 72% percent of a certain type of CD-R (phthalocyanine dye) survived the testing process unharmed, for example, while others survived in lesser numbers (38% of audio CDs) or failed catastrophically (0% of single-sided/dual-layer DVDs, azo dye CD-Rs, and DVD-RWs) (p. 146). The difference in performance between the three different dye types used in CD-Rs (likely thought of as "one" singular medium by consumers) is staggering. Accompanying the statistical analysis are numerous photographs of visibly decomposed sample discs, giving the article educational value for a nonscientific audience as well.

Youket and Olson (2007) also performed accelerated aging tests on optical digital discs, as part of a years-long overarching study by the Library of Congress to determine the direction(s) of their long-term digital preservation plan. Their study subjected only audio CDs (CD-DAs) to accelerated aging at 80°C and 60% RH, for intervals up to 1000

hours (42 days). The results allowed them to extrapolate that on average, 25% of audio CDs will fail due to inherent vice within 100 years, with an addition 50% failing within 1000 years, making audio CDs unsuitable for long-term storage of data.

Failure rates and mechanisms due to inherent vice continue to be a fruitful area of research, with the general focus gravitating towards recordable media, as their popularity with consumers – and in libraries and archives – increases. Empirical research articles published in the past 7 years include: Hartke (2001) (CD-Rs); Hartke (2002) (CD-Rs); Dobrusina, Ganicheva & Tikhonova (2004) (CD-Rs); Slattery, Lu, Zheng, Byers & Tang (2004) (CD-Rs and DVD-Rs); and Dobrusina, Ganicheva, Tikhonova, Velikova & Zavalishin (2008) (DVD±Rs). It is worth noting that some of these studies are more empirically valid than others: the above mentioned 2004 and 2008 papers describe research experiments in full detail, whereas Hartke's papers only present summaries of results without detailing methodology (and are also published in a journal, Medialine, which is wholly owned by Hartke's for-profit Media Sciences, Inc.).

Guidelines and Best Practices for Handling, Storage and Preservation

The obvious predecessor to preservation guidelines for optical digital media is Van Bogart (1997), cited frequently enough to be considered the "bible" of magnetic tape preservation. Along with numerous illustrations, Van Bogart explains the chemical and physical composition of magnetic tape (its inherent vice) as well as the potential for damage wrought by storage and playback mechanisms when used both properly and improperly, thus introducing human handling and use as a vector. While the scope of the paper is restricted to magnetic tape media, it lays the groundwork for later studies of

other magnetic media including hard disks and floppy disks; though optical media have a clear advantage in terms of reduced likelihood of damage incurred by playback mechanisms, they are equally susceptible to damage incurred by improper handling and storage. Also, the tape materials Van Bogart focuses on (chiefly audio tape and video tape cassettes) are analogous to the materials that the current study centers around (chiefly CDs and DVDs) in that they make up the bulk of portable digital media collected by libraries and borrowed by patrons. Digital data stored in other media is outside the scope of this study, and has been and continues to be better approached in studies of a different focus.

Byers (2003), is the preeminent example of storage and use guidelines for the library and information professional. Published under the auspices of the Council on Library and Information Resources [CLIR] and NIST, his *Care and Handling of CDs and DVDs* is four times the length of Van Bogart (1997), and significantly more advanced in terms of research, depth, presentation and ease of use. Spiral-bound and meant to be consulted as frequently as necessary, this guide contains a clear table of contents, a thorough glossary, and an excellent bibliography; it is handsomely illustrated with cross-sections of different types of discs, tables of performance data and optimal storage conditions and procedures; and it features prominent sidebars highlighting the major "don'ts" of optical digital media care. It is also freely available online. In short, although its 2003 publication date puts it behind the curve of recent developments like Hi-Definition CDs and Blu-Ray DVDs, it is an ideal one-stop shop for learning about usage and storage of optical digital media. In a perfect world, Byers's guide would be in every

patron's home; more likely, its subtitle – *A Guide for Librarians and Archivists* – has ensured that it is in almost none of them.

Byers's guide is ripe for repurposing as a patron/consumer document, and indeed NIST has a one-page Dos & Don'ts sheet excerpted from Byers (2003), freely available on its website (NIST (2003)). Many other federal guidelines have been created and made available online (for example, LC (2002), NPO (2008), and ALA (2008)). Though they do not describe their research, as mentioned previously, these institutions are in general agreement with the fundamentals of optical disc care, such as:

-- Scratches to the top (aluminum) side of CD media are much more damaging than scratches to the clear plastic underside, whereas DVDs are less damaged by scratches since their data layer is sandwiched between clear plastic layers.

-- Bending optical discs of any type can lead to delamination and cracking.

-- Adhesive labels of any type are liable to react chemically with optical discs, disrupt their balance during playback, and (on CD media) tear the data layer off the disc.

-- The only safe place to mark an optical disc is on the clear plastic center region where no data is stored; the only safe marking utensil is a water-based marker.

-- Extremes of temperature and humidity, and/or constant atmospheric fluctuations, will hasten the rate of decomposition due to inherent vice, as with all organic material.

-- Recordable digital media, being dye-based, are easily degraded by exposure to light.

The list goes on. It should be emphasized that this information is freely available and presented in a clear and easily understood manner by numerous agencies.

Dissemination of Knowledge of Guidelines and Best Practices in Libraries, Archives, and LIS Schools and Institutions

Hedstrom (1998), published one year after Van Bogart's guidelines for magnetic tape media, is a widely cited clarion call for digital preservation. The author likens benign neglect, a practice sometimes acceptable for printed materials, to a "time bomb" for digital materials (p. 191). She warns of the fragilities of digital media (inherent vice, improper handling and storage, and – a third damage vector – corruptibility of the digital data itself) and the strategies necessary for long-term preservation (maintenance of playback mechanisms, migrations to new generations of hardware/software, conversion to new media). Hedstrom has more questions than solutions, but her summary of the present and future issues for digital preservation is quite thorough for its time, and her paper has been frequently cited and often included in LIS course syllabi.

Patkus (1998), published in the same year, approaches the issue of preservation (of all library materials, not just optical digital media) from a different angle. The author advocates the idea that preservation of library materials is a fundamental part of collections security, not an afterthought or a separate issue. "One of the security risks to collections that is most often overlooked," she writes, "is frequent handling, both by staff and by users" (p. 82), and that "[o]nce staff members are educated about why rules are necessary, hopefully they will be able in turn to educate users" (ibid.). She discusses

possible tools for user education and outreach, including workshops, videos, posters, bookmarks, exhibits, skits and interactive displays and computer programs (p. 83).

Patkus's suggestions seem feasible and potentially very effective. It is thus dispiriting to see that five years later, the need for more was still present. Marcum (2003), writing about "research questions for the digital era library," casually mentions (only once), "Also, we need new research into the preservation of digital resources […]" (641). A symposium held in 2003 by the Association of Research Libraries [ARL] featured as one of its seminar sessions a "Pictorial guide to sound recording media" (Stauderman (2003)), wherein no fewer than 50 distinct sound recording media, from wax cylinders to DVD-RW+s, were discussed; yet a later session on "Risk reduction through preventative care, handling, and storage" (Lewis (2003)), while covering a broad spectrum of library and archives best practices, addressed the issue of library "Personnel" in one brief paragraph.

There is perhaps growing recognition within the LIS profession that storage and handling are as important to media longevity as combating inherent vice. Teper (2005), admits:

> Too many unknowns remain to assume that digital imaging provides an improvement in ensuring the longevity of printed information. Media decay, technological obsolescence, and *human fallibility* continue to render the practice of benign neglect a failure, despite its dubious success with print resources. (p. 33; emphasis mine).

On the other hand, Gracy & Croft (2006) suggests that there may be insufficient awareness of preservation issues regarding digital optical media within the LIS profession. In this study, the authors analyzed LIS school curricula to obtain a picture of what students are learning, and specifically to measure the extent to which preservation

(of all forms of media) was being taught to graduate students as of 2003. Of the 41 schools surveyed, only 27 offered “introductory” preservation courses, with far fewer offering more advanced courses (p. 281). Only 10 of 41 LIS graduate schools required a preservation course; another 9 “recommended” it (p. 282). Regarding digital optical media specifically, of the schools who did offer preservation courses, 75% covered “magnetic and optical media” in their course instruction (p. 284).

If the data are reliable and valid and can be extrapolated to 2008—if only 66% of LIS graduate schools offer preservation courses, just under 50% make them a degree requirement, and 25% do not teach preservation of optical digital media—the disturbing implication is that despite the availability of institutional literature about optical digital media, a substantial number of LIS graduates may not be exposed to any during their education. It then follows that a significant number of library workers may not be equipped to educate their patrons about the proper care and handling of optical digital media.

Outside of LIS schools and “in the trenches” in libraries and archives, there is a need for institutions to be more aware of the handling and storage of their optical digital media holdings. Yet condition surveys of optical digital media holdings are absent from LIS literature, though there are clear precedents in the form of condition surveys of other media. Ward & Teper (2005) is an exemplary study of damage caused to printed library materials by student use and handling in an undergraduate library. The authors examined a statistically significant sample of 385 of the 200,000 books in the Undergraduate Library at the University of Illinois at Urbana Champaign, approximately half of which date from the 1960s and 1970s, and most of the other half from the 1980s, 1990s and

2000s. They tabulated various types of physical damage to the books, and circulation data for each title. The results showed, in part, that among this sample of books, nearly half of which had only circulated once in the past 5 years, 11.17% had torn covers, 9.61% had loosened text blocks, and 1.04% had detached boards; thus only 78% of this at-maximum-40-years-old collection had no structural damage (p. 21). Within the books, the statistics were more alarming: 58% had damaged pages, 47.5% had been marked by students, 36% had stained pages and 6.5% had water damage (p. 22).

The Avery Fisher Center at New York University undertook a similar analysis of their videotape (VHS) collection, documenting damage to a sample size of 634 tapes (De Stefano & Jimenez (2007)). Their results showed much less damage to the collection than Ward and Teper (2005) though the authors admit there are significant mitigating circumstances: the AFC is a closed collection, the staff observes clear handling and storage standards (p. 67), and statistics on replacements to irreparably damaged tapes were not available.

These two studies are obvious groundwork for similar assessments of optical digital media collections. Such studies would be easy to construct, given the above examples and the availability of "how-to" condition survey guides such as Gregory (2006). However, Ward & Teper claim to have encountered a similar difficulty in finding precedence for their 2005 study (p. 13), indicating that perhaps it is wrong to assume the "obviousness" of such collection surveys. Indeed, they note that "[t]he one topic" pertinent to user treatment of library materials that appeared with regularity in their literature review "was the topic of theft and mutilation," (p. 13) a finding that mirrors that

of the current literature review. Two examples of such articles about theft and mutilation of library materials are Trinkaus-Randall (1998) and Curry, Flodin & Matheson (2000).

Consumer / Patron Knowledge of Guidelines and Best Practices

Given the lack of comprehensive knowledge of optical digital media preservation issues within libraries and the LIS field, it is not surprising that little has been written about patron knowledge and/or behavior. Annett (1997) describes one library's policies and means of educating users in the handling of audiovisual materials, both magnetic tapes and optical digital discs. The policy of the Santa Monica Public Library (Ca.) was to provide a double-sided flyer (similar to the NIST excerpt from Byers (2003)) to new borrowers of AV materials. Additionally, CD cases were stickered with handling instructions. The library eventually phased out the stickers in favor of posted signs, citing one reason as being that "CDs have been in the marketplace more than a decade, and staff believe that the public no longer needs such basic case instruction as they did when the format was new" (187). This is perplexing, considering that Annett then states, conversely, "many [patrons] still believe the adage first touted by the recording industry about CDs as a virtually indestructible medium" (ibid.). It is encouraging to encounter a librarian who realizes, to some degree at least, that there is ignorance among their patrons about optical digital media. It is even more disheartening, then, that this article dating from 1997 is perhaps the only academically published paper documenting library education of patrons in media handling, and that the author herself seems confused about the level of patron education needed.

More prevalent are articles in popular literature about disc storage and handling. Many popular consumer products magazines, such as *PC Magazine*, *MacWorld*, *Stereo Review* and *Wired*, periodically run “Dos & Don’ts” pieces or advice columns detailing safe and unsafe cleaning methods and the like. It is tempting to assume that the quality of information in such articles improves over time, but this is not necessarily the case. As recently as 2004, the Associated Press [AP] published an article about “CD rot” wherein, alongside useful and valid storage and handling tips, interview quotes were exaggerated and/or misrepresented to foster the sense of a consumer-vs.-manufacturer war (Svensson (2004)). For example: a consumer claimed that 15-20% of his CD collection had decomposed to an unplayable degree (a suspiciously high percentage), while a manufacturing advocate claimed that most disc damage is caused by consumers (it is nice to see handling issues acknowledged, but it is employed in the article to gloss over the issue of inherent vice).

The AP article was published in hundreds of newspapers, and it is instructive to see how the information it presented changed for worse and for better in two articles published two months later. One article for *Rolling Stone* (Knopper (2004)) admirably draws on Youket’s authority to elevate the discourse, yet undermines its own veracity as the author has Hartke claiming, “The error correction in those things is so powerful you can actually drill a two-millimeter hole in the thing, and it'll still play” (Knopper (2004)). That quote makes for dynamic copy, but is hardly likely to convince the layperson of its scientific veracity. The other article (Baig (2004)) presents a legitimate discussion of the physical composition of CDs and DVDs and how poor manufacturing (inherent vice) and improper handling can cause them damage, including a full-color cross-sectional

illustration in the manner of Byers—all the more remarkable, considering that the commissioning publication was *USA Today*. Given the lack of LIS literature about patron knowledge and behavior, and the lack of evidence of libraries educating patrons, the author of the current study surmises that whatever patrons do know about optical digital media, they may have learned from popular media sources such as the above. Whether the article they encountered was the one in *USA Today* or the one in *Rolling Stone* could make the difference between the patron treating library discs with respect or with abandon.

Amodeo (1997) posits that the vital connecting piece between senior library staff, who presumably have knowledge of proper storage and handling procedures, and library patrons, who presumably do not, is the library support staff. In that author's library at Loyola Marymount University, the support staff was chiefly student workers; they handled the incoming and outgoing materials more than either senior staff or patrons, and as he puts it, "most student workers are not hired knowing how to shelve a book" (p. 66). Consequently, he argues, their knowledge of proper book handling and storage had the greatest effect of all constituencies on library books. To help educate the student workers quickly and efficiently, new hires were shown the short video *Murder in the Stacks* (Columbia University (1987)) and given a 10-minute preservation talk. They were then required to take a brief multiple-choice quiz as a follow-up. Some of the questions asked were:

-- In the following illustration, which books are shelved correctly?
-- Which of the following are *potentially* harmful to books?
-- Who teaches library patrons how to handle books?
-- Where is a book especially vulnerable to damage?
-- If a book won't fit where it belongs on a shelf, you should…

> --A book retails in stores for $7.95. What does it cost the library to acquire it and make it available for patrons to borrow? (All questions from Amadeo, 1997, pp. 69-70).

The answer to the last question – $35-50 including costs for labeling, binding, cataloging and staff time – surprised most of the students surveyed, and relates to a finding of Hendrick & Murfin (1974) regarding mutilation. In this study of "ripoffs," or students who admitted to tearing articles out of periodicals, "one of the ripoffs interviewed was extremely surprised in learning about replacement costs and […] his attitude appeared to change so much that he might even have been willing to lead a crusade against further ripoffs" (p. 410). The implication is clear that a patron education campaign about replacement costs could reduce mutilation of library materials; this may be generalizable to overall treatment of materials by patrons, and specifically optical digital media. In this and other facets, Amodeo's questionnaire provided a starting point for the construction of the survey instrument of the current study.

Chapter 3: Methodology

This was a descriptive study, intended to collect data pertaining to two research questions (Babbie (2007), p.89). The instrument used to collect the data was a survey resembling a quiz, modeled in part on the example given in Amodeo (1997). A survey with multiple choice questions was thought to be appropriate because it could definitively measure subjects' knowledge about discrete issues related to usage and storage of optical digital media. Given a discrete question, a subject's response would either be correct, partially correct, or incorrect, showing in turn that they are very knowledgeable, partially knowledgeable, or not at all knowledgeable about the specific issue addressed in that question. The researcher strove to present questions as unambiguously as possible, although, based on the standards suggested that Byers, et al., arrived at following others' research on the physical properties of digital optical disks, some questions had more than one correct answer and/or no definitively correct answer, (hence the possibility of the subject being "partially correct").

The survey (Appendix A) was administered online via Qualtrics software, which allowed the researcher to collect data pertaining to his questions while protecting the identities and privacy of the subjects. Using Qualtrics also enabled the research subjects to complete the survey at any time and location of their choosing, with computer and Internet access being the only requirements. To recruit subjects, the researcher submitted an email to the UNC-Chapel Hill Mass Email System, which every member of the UNC-

CH community is subscribed to by default unless they manually opt out. This meant the opportunity to participate in the survey was presented to a broad cross-section of the university community populace, including students of all levels from undergraduate to postdoctoral, faculty and staff, alumni and relatives, and people with other academic affiliations. Participants were free to skip questions and/or stop taking the survey at any time. Two possible rewards, one educational and one financial, were optionally available to every participant in exchange for providing an email address. First, at the conclusion of the study, subjects could choose to receive an email link to a webpage with answers to the survey questions and further information about optical digital media best practices. Second, they could be entered into a random drawing for one of five $20.00 Amazon.com gift certificates as thanks for their participation.

The email solicitation was sent out at 11:00pm on Monday, October 19, 2009. In the first 24 hours, over 450 recipients of the email participated in the survey. Though the researcher initially envisioned that the survey would remain open for a period of two weeks, with a reminder email inducement being sent at the midpoint, he closed the survey 10 days later, at approximately 3:00pm on Wednesday, October 28, 2009, once 800 people had completed the questionnaire. With the addition of 74 participants who completed the questionnaire partially, the total number of subjects was 874.

Chapter 4: Findings and Discussion

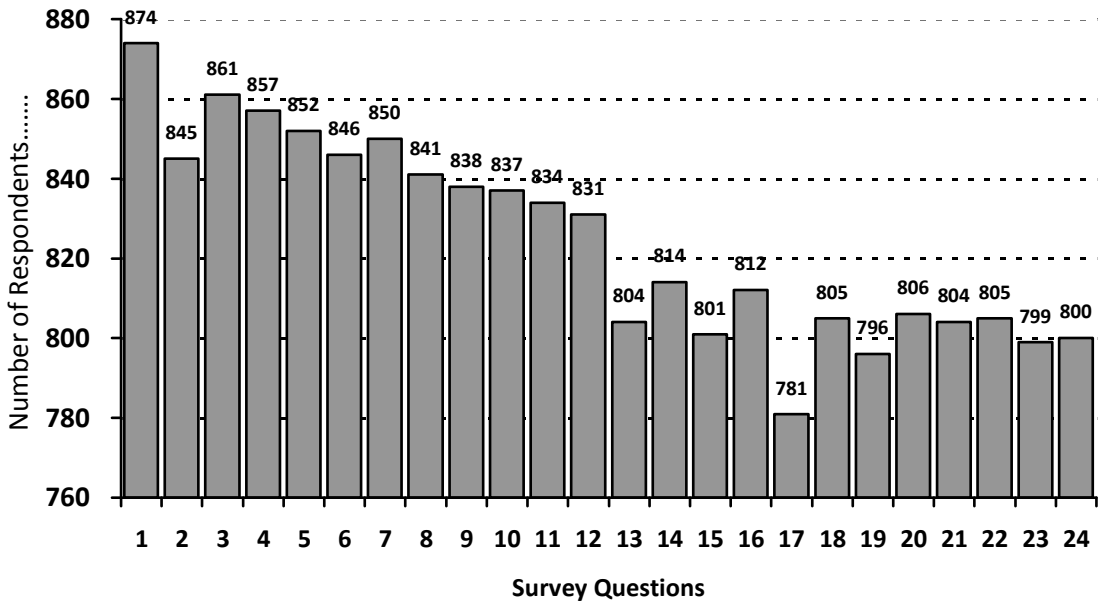
The Findings and Discussion section of this paper is structured in five sections: (a) Participant Demographics; (b) Participant Library Usage and Optical Digital Media Usage in Libraries; (c) Vectors of Participant Education; (d) Participant Knowledge about Best Practices for Handling and Storage of Optical Digital Media; and (e) Participant Desire for Further Education.

The survey instrument and responses are reprinted in full in Appendix A. All survey questions in the following discussion are referred to with the letter Q and the number indicating their position in the survey as it was administered; e.g., "Q4" refers to the question "4. Where is it safest to write on a CD or DVD?" and its responses. While the researcher structured the survey to begin with questions about handling and storage of optical digital media, then follow up with questions about personal education, behavior, and demographics, this paper will discuss the findings in more-or-less the reverse order.

Participant Demographics

In the 9 days and 16 hours that the online survey was active, 800 people fully completed the 24-question survey, and an additional 74 people partially completed it. This resulted in a baseline response of n=800+ for most questions; only two questions (Q17 and Q19) were answered by fewer than 800 participants, and the remainder were answered by 800 or more. Figure 1 shows the number of respondents per question.

Figure 1: Number of Respondents to Individual Survey Questions



With a few notable exceptions, the response rate follows a smooth curve, showing a slight decline in participant interest over the duration of the survey. Participants were free to cease taking the survey at any time of their choosing, so it is not surprising to see this slight attrition rate. More worthy of note are the few questions when overall participation declined below the curve by 8 or more (Q2, Q13, Q15, Q17, and Q19); possible reasons for the reduced participation in these questions will be addressed individually in the following discussion. It can be said with confidence that 800 subjects participated until the very end of the survey, with slightly reduced participation on three questions (Q17, Q19 and Q23).

The results from Q21 show that 70% of the respondents were female and 30% male. The researcher can offer no explanation nor any theories that might address this gender imbalance; he can only wonder about the potential influence of factors such as the overall gender makeup of the UNC-CH community, the wording of the email solicitation,

or a possible greater propensity for women to participate in online surveys, surveys about entertainment media, or surveys about storage media. It must be stated that none of the above could be elevated beyond pure conjecture without further research into those specific areas.

The minimum age requirement for participation in the survey was 18. This age was chosen mostly to expedite IRB approval, although it can also be said that with the exception of a minority of 17-year-old first-year undergraduate students, one would not expect to find persons under the age of 18 in a university community. The responses to Q22 show a diverse spectrum of age ranges among the survey participants, with people falling roughly equally into five groups of about 20% each: 18-22 (corresponding roughly with undergraduate student status); 23-29; 30-39; 40-49; and 50-64. 1% of all participants indicated an age of 65 or older.

In answering the question about UNC-CH affiliation (Q20), participants were encouraged to choose "up to 3" applicable categories, so while the number *(n)* of respondents is 806, the total number of affiliations stated (1170) exceeds this by 45%. The majority of subjects (59%) identify themselves as Staff/Employees of UNC-CH. The next largest category is Students (40% total, stratified into 20% Undergraduate, 13% Graduate and 7% PhD), followed by Chapel Hill/Triangle Area Residents (19%), Alumni (13%) and Faculty (9%).

In the researcher's opinion, the data from Q22 (age) and Q20 (affiliation) show that using the UNC-CH Mass Email System was a successful means of gathering survey responses from the desired broad spectrum of university community members.

Participant Library Usage and Optical Digital Media Usage in Libraries

Q19 asked subjects to describe their usage of libraries. They were free to indicate multiple uses, and did so; the total number *(n)* of 796 respondents described 1963 frequent uses of libraries (1972 responses minus 9 "other" responses indicating "rarely/never"), for an average of 2.47 frequent library uses per respondent. The two overwhelming reasons that participants use libraries are for Personal Reading/Research (69%) and Academic Reading/Research (64%); neither figure is unsurprising in a literate university community. Following these, the most popular reasons for library usage are Internet Access (25%), Group Meetings (24%), Email Access (19%), Other Computer Use (11%), and Business Reading/Research (10%). Only 8% of respondents reported using libraries for Listening to Audio/Watching Video, the type of usage that is most likely to involve optical digital media. It should be noted, however, that the more popularly indicated categories of usage may also involve optical digital media, particularly in the form of CD-ROMs and DVDs. Also of note are 3 individuals who indicated in the "Other" field that they borrow CDs of audio recordings, particularly audio books, from libraries; had this been explicitly presented as an option in the checklist of usage possibilities, it might have garnered significantly more responses. The researcher finds it difficult to conclude much from the responses to this ambiguously worded question and would choose to revise/refine the question in further studies.

On the other hand, the responses to Q18 may indicate that such a desire represents wishful thinking on the part of the researcher. The data from Q18, about the frequency of participants' usage of CDs and DVDs owned by libraries, show that such usage is lower than anticipated. 34% of respondents said they never use library CDs or DVDs, while

29% report using them once per year or less. Only 22% report using library CDs or DVDs 5 times or more per year. Based on these findings, one might tentatively extrapolate that the majority of people in the UNC-CH community do not use optical digital media in libraries more than 5 times per year, if at all.

Vectors of Participant Education

Only one question (Q17) directly attempted to elicit data about the means by which survey participants learned what they know about handling and storage of optical digital media, yet it produced perhaps the richest findings of all the survey questions. Because of the dramatic and unexpected statistical findings, and because of the illuminating variety of write-in responses to the "Other" category, the researcher feels it is important to discuss these data *before* moving on to discussion of participants' actual, factual knowledge, as they will provide valuable context for the latter.

Q17, "How have you learned what you know about handling and storing CDs and DVDs?" allowed for, and received, multiple answers per respondent (1604 answers selected by 781 respondents, an average of 2.05 answers per respondent). Nearly three-quarters of all participants (72%) said they have learned what they know about optical digital media from Family/Friends. This percentage far surpasses the next closest source, Instructions Provided in the Packaging of CDs and DVDs (40%), which in turn is more than double the percentage of any of the other educational vectors. Not counting "Other" for the moment, the most popular of the remaining educational vectors are (in descending order) Newspaper/Magazine Articles (17%), Website Articles (17%), Advice from Salespersons (15%), Advice from Electronics/Repair Technicians (9%), and

Blogs/Online Forums (8%). Libraries are *not* a frequent source of optical digital media handling/storage education for the survey sample, comprising *at best* a combined 10% of participants who were educated by Library Staff, Library Demonstrations, and Library Materials (handouts/flyers/signs); this percentage is probably lower than 10% due to overlap between participants who fall into more than one of these three categories.

Despite the large number of possible responses that could be selected by simply checking a box (11 choices), this question – how people learned what they know about optical digital media handling/storage – received the largest number of write-in "Other" responses (90, or 12% of all participants) of all of the survey questions. Figure 2 (on the following page) is a summary of the "Other" responses, along with direct quotations from the participants.

For the most part, what the above responses have in common is the participants' lack of any kind of formal training or education in the subject. At best, they have learned how to handle and store digital optical media by observing or hearing advice from others, who may or may not be trustworthy sources of valid information; at worst, they have damaged their discs due to misuse or experimentation, or simply assumed that they know best via "common sense." As will be demonstrated shortly by the questions and responses discussed in Section D, common sense is of little help when a user is unaware of basic facts about the physical composition of optical digital media.

A final point to be made about the question of vectors of education is that this survey question received the lowest number of total responses *(n = 781)* of all of the questions. Given the number of write-in responses (12) that explicitly state "I have no real knowledge of this subject" or "I have never received any education/training," and

Figure 2: “Other” Responses to Q17

VECTOR OF EDUCATION ABOUT HANDLING/STORAGE OF OPTICAL DIGITAL MEDIA	**# OF RESP.**
Personal Experience “Mistakes that ruined CDs” “Self ‘taught’”	15
Guessed / Made It Up “I guessed based on the physical nature of a CD” “Guessing on most answers”	13
Received No Training / Have No Real Knowledge “Have never received training, so I am unsure of all the techniques” “I just assume I know how to handle them”	12
Common Sense “What seems reasonable” “I’m not really stupid”	11
Trial And Error / Experimentation “Figured it out myself” “I experimented w/cleaning using liquid car polish – works!”	11
Observation / Mimicking Others’ Behavior “I have seen how libraries label CDs (inner circle)” “Watching salespersons/technicians”	10
Hearsay / Word of Mouth “Once a friend told me it released hazardous materials to break a CD” “Not sure where I heard most of it”	8
IT Professionals / Faculty / Students “I have listened to presentations by students and faculty on the subject” “Preservation classes”	6
Commercial Disc Cleaning Kit Instructions	4
Unclassifiable “Cleaning advice from Netflix” “I originally learned how to handle CDs from a DJ at a radio station”	2
Total “Other” Responses	**90**

given that the questionnaire did not explicitly provide a checkbox where participants could indicate the same, it seems likely that the low response rate to this question could be due to participants not finding a quick and easy way to answer the question, thus skipping it.

Participant Knowledge about Best Practices for Handling and Storage of Optical Digital Media

The researcher deliberately began the survey with the question that he suspected participants would have the least knowledge about, and he was not disappointed by the results. Q1 asks which side of a CD is most easily damaged by scratches, the top (label side) or the bottom (without label). 83% of all survey respondents believe that the bottom side is more easily damaged, when in fact the opposite is true. The physical composition of all CDs[1], both manufactured and recordable, consists of a thin layer of aluminum substrate on the top side (often covered with a thin layer of lacquer, ink, and/or inkjet-printable surface) and a thicker layer of clear plastic on the bottom (Byers 7-8, Svensson, et al.). It is the aluminum layer on the top side that holds the data, and thus a scratch on the top side that penetrates the aluminum layer causes irreparable damage, whereas a scratch in the clear plastic on the bottom side can often be polished away, filled in, or even left alone due to the efficacy of CD playback devices' oversampling and correction algorithms. To a person without this knowledge, "common sense" suggests that the bottom side, because it is the side read by the laser in the playback device, must be the more fragile of the two sides. The responses to this question strongly suggest that more user education about the physical makeup of CDs is necessary.

Q2 asks the same question about DVDs. The "correct" answer to this question is not as clear-cut as it is for CDs, due to differing physical compositions of different types of DVDs. DVD-Rs and single-layer manufactured DVDs are similar to CDs in that their

[1] DualDisc™ CDs, with their aluminum data layer sandwiched between two layers of clear plastic, are an exception to the rule; however, they respresent a very small segment of the manufactured CD market.

data layer sits relatively unprotected on the top side of the disc. Dual-layer DVDs, on the other hand, consist of a data layer sandwiched between two layers of clear plastic, thus protecting the data from scratch damage on both sides. Regardless of whether the survey participants are aware of these varying physical characteristics, the response was nearly identical to that of Q1: 79% of all respondents believe that the bottom side of a DVD is the most easily damaged by scratches, when in fact this is never the case; either the top side is more fragile, or both sides are equally protected.

Q3 and Q4 both elicit participant knowledge about writing (by hand, with a physical writing implement) on CDs. The former question (Q3) asks which writing utensils are safe to use. Best practices guides such as Byers, NIST, et al. generally agree that a permanent felt-tip pen (such as a Sharpie™) is a safe instrument to use, and here the survey results show that 89% of respondents agree. This is heartening news for librarians and others with conservation and preservation of disks in mind. Slightly less encouraging is the data showing that 40% of respondents believe a non-permanent felt-tip pan (such as a Magic Marker™) is also safe to use to write on a disk. While using such an implement is not certain to damage a disk by corroding its outer coating, it is within the realm of possibility due to the variation and lack of industry standards in the manufacture of non-permanent ink markers. Even if the ink itself does no damage to the disc, the impermanent nature of the ink can lead to smearing and spreading across the surface(s) of the disc, which may then lead to cleaning, which always entails risk of damage. Most frightening of all is the data showing that some respondents consider other implements to be safe for use, namely Grease Pencils (15%), Paint Pens (12%), Ballpoint Pens (8%) and Lead Pencils (5%). The former two are thought to be dangerous because

of the possibility of their chemical components reacting with and corroding the disc surface; the latter two are known to be dangerous due to the ease with which their hard sharp points can scratch the data layer of the disc. It is good to see, however, that these users are definitely in the minority compared to those who know that permanent felt-tip markers are the safest for use. It is interesting to note that 7% of respondents believe it is never safe to write on a disc; while they may be exercising unnecessary caution, it is also possible that time will prove them correct, because of course optical digital media have only existed for three decades and any deleterious long-term (i.e., decades ahead) effects of permanent ink on them is yet unknown.

The second of this pair of questions (Q4) asks participants what locations on discs they believe are safe for writing upon. Here again there is a gray area due to the unknown long-term effects of permanent ink on disc surfaces. While it is generally believed that it is safe to write with permanent ink anywhere on the top surface of a disc, as 82% of respondents agree, experts often say this with fingers crossed. The only area that is *guaranteed*[2] to be safe for writing is the 1.5-inch center ring, which contains no data layer; 14% of respondents concur. However, were this survey a graded quiz, the researcher would give full credit to the 82% who believe it is safe to write anywhere on the top surface of a disc, as this is one of the pieces of advice commonly included in the instructions in the packaging of CDs and DVDs, particularly recordable ones. As discussed in Section C, packaging instructions are the second most popular means of user education about discs, so it is commendable that such instructions are accurate about the use of safe utensils (Q3) and safe locations (Q4) for writing. It might be noted in

[2] To take the true long-term view, even this guarantee is marked with an asterisk; it is not known whether permanent ink on the central hub may lead to accelerated aging of the plastic and eventual cracking, for example.

conclusion that users may arrive at the latter knowledge through common sense or guessing – they may suspect that writing on the bottom surface would interfere with the reading laser, causing faulty playback – whereas the former (knowledge about utensils) probably must be taught, or learned by hard experience ("[m]istakes that ruined CDs").

Q5 and Q6 both ask participants about the use of adhesive labels on optical digital media. In this matter, experts and usage guides are in near-unanimous agreement: it is never safe to place an adhesive label on a disc, and once a label is applied, it is never safe to remove it. Labels on the bottom/reading surfaces of discs would of course block the playback laser entirely, rendering the disc unreadable. Labels on the top, however, can potentially render a disc equally unreadable via various mechanisms of damage. For one, depending on its chemical makeup and the chemical makeup of the particular disc in question, the adhesive on the label may interact with and corrode the outer coating of the disc, eventually eating through to and into the data layer. More frequently, adhesive labels, being paper- or cellulose- based, contract and expand due to variations in ambient temperature and humidity. This can cause the disc to warp in a concave manner (edges pulling up) when the label contracts, or in a convex manner (edges pulling down) when the label expands; in either case, the resulting curvature of the disc makes faulty tracking by the playback laser likely. Expansion and/or contraction of the label can also cause it to warp or "bubble" unpredictably, pulling areas of the top layer away from the rest of the disc if the adhesive is strong enough. Another danger comes from labels that are placed off-center, which can cause the disc to spin off-balance, adversely affecting playback. Finally, as is known to be the case with book bindings, all adhesives eventually fail. This can result in particulates of dried adhesive flaking off the disc into the playback device,

as well as the label itself becoming partially or wholly dislodged from the disc into the playback device.

All in all, it is agreed that adhesive labels are dangerous. The data from the survey, however, show that 69% of respondents believe it is safe to place a label anywhere on the top side of a CD or DVD. The best and hoped-for answer to this question is that it is never safe to place adhesive labels on optical digital media, a fact agreed upon by 20% of respondents. If this survey were a graded quiz, again, partial credit would be given to the 11% who stated that the 1.5-inch center ring of a disc is safe for labeling. This is often how libraries, who must somehow brand their discs to claim ownership and prevent theft, label their CDs and DVDs, and general users cannot be faulted for following this example. If a label *must* be placed on a disc, this is certainly the safest location to do so.

Once a label has been placed on an optical digital disc, it can never be safely removed, as stated before; 27% of the survey participants agree. Unfortunately, 42% believe it is safe to peel off an adhesive label, and 29% believe a label may be safely removed by moistening and gentle wiping. In a worst-case scenario where a label *must* be removed, the latter method (moistening and wiping) may potentially be successfully employed with utmost caution; however, there is still a significant risk of scratching and/or entirely removing areas of the data layer by doing so. Scraping (which 2% of respondents thought safe) is obviously worse as it implies rougher treatment of the disc surface. Peeling, the most popular option according to the survey data, is the very worst method, due to the layered construction of optical digital media. If the adhesive on the label is (or has become with time) stronger than the adhesives binding the disc layers

together (which weaken over time due to stresses from temperature, humidity, bending, and inherent vice), peeling off the adhesive label can pull the data layer right off with it. The use of labels – or rather, the discouragement of their use – is clearly an area where more user education is needed. It is also a topic that is conspicuous by its absence in retail disc packaging instructions, which is perhaps not surprising when one considers that most major disc manufacturers are also sellers of disc labels and labeling kits.

Q8 and Q9 ask survey participants what they know about safe disc cleaning methods. Unlike labeling, but similar to writing guidelines, cleaning guidelines are often included in commercial disc packaging; many disc cleaning apparati and solutions are also available for purchase separately from discs, and come with their own instructions. According to best practices standards, the answers to these questions are fairly clear. Permissible cleaning liquids (Q8) include pure water, mild detergents, and mild solvents – anything but strong solvents such as nail polish remover. Permissible cleaning motions (Q9), on the other hand, are limited to radial wiping from center to edge. This is an area where common sense may fail the older user who is accustomed to cleaning vinyl records in a circular motion so as not to cause scratches across the grooves. On optical digital media, it is in fact less dangerous to cause radial scratches, since the playback laser and playback device oversampling and algorithms can often compensate for such scratches. Circular scratches, on the other hand, are more likely to cause faulty tracking by the playback laser, which is why a circular cleaning motion is inadvisable. Here the survey data show the respondents are split roughly equally in their knowledge, with 58% believing a circular wiping motion to be safest and 47% preferring a radial motion. This is perplexing and counter to the researcher's expectations, because, of all the pieces of

advice disseminated in optical digital media packaging instructions, the only one that has been a part of them from the very first commercially available CD[3] is this: "Always wipe in a straight line from center to edge." One could take this as suggesting that packaging instructions often go unread or unheeded; one should also refer to the finding from Section C that nearly twice as many participants reported learning about optical digital media by word of mouth (Friends/Family) than from printed materials.

Proper storage casing is the subject of Q7, and the survey responses correspond to the advice of experts and best practices guidelines, in that the general consensus is that there is no general consensus. It is agreed by Byers, NIST, et al. that vertical storage in hard plastic cases (called "jewel cases" or "jewel boxes" in the industry) is least likely to cause either scratches or warping, and this option was indeed the one selected by more respondents than any other (74%). Storing discs in jewel cases and stacking them horizontally like books (which 53% of respondents believe is safe) is also thought to cause minimal damage, although over the course of many years (decades), it may lead to gradual warping as gravity pulls the edges of the disc downward. Beyond jewel cases, however, expert opinions vary as to the risk levels of other common types of storage. All of the common storage methods besides jewel cases involve the entire disc surface (not just the 1.5-inch central hub) coming into direct contact with the storage housing, leading to friction and potential abrasion when removing and replacing the disc. The survey results are similarly undecided. (This question had the highest average number of responses per respondent, 2.90 (2470 answers from 850 individuals), of all multiple-answer questions in the survey.) In descending order of popularity, "safe" methods of

[3] Generally agreed to be Bruce Springsteen's "Born In The U.S.A." (Sony, 1984), at least in America (appropriately); depending on which source one believes, there may also be Japanese and German contenders for the honor of first CD to market.

storage indicated were vertical jewel cases (74%), vertical cloth-backed sleeves (58%), wallets with cloth-backed pages (54%), horizontal jewel cases (53%), and horizontal or paper sleeves (34%). The least popular option among survey participants, stacked on a spindle without individual enclosures (17%) also happens to be decidedly the least safe method of storage, as it easily leads to circular scratches from particles caught between discs. According to experts, the truth of the matter is that apart from jewel cases, the storage enclosure one chooses to use is less important to the well-being of the disc than the care with which one removes and replaces the disc, and the ambient temperature and humidity (which will be discussed shortly).

The other storage question, Q10, asks how an optical digital disc may be most safely removed from a jewel case that is stubbornly clinging to it. Here the near-unanimous survey response (90%) – to exert pressure on the "teeth" at the center of the plastic case – is the unmistakably correct answer. Bending a disc even once causes the various physical layers to delaminate slightly and rub against one another; repeated bending will eventually cause total delamination (layers visibly peeling apart), or, more dramatically, cracking of the plastic due to accumulated invisible stress fractures. Recalling the data from Q1-Q6, which suggest that survey participants are largely unknowledgeable about the layered physical composition of optical digital media, one might attribute the overwhelmingly correct response to this question to a combination of common sense (if you bend anything enough, it will break) and hard-won experience (discs cracked to the point of unplayability or even completely snapped in half). On this issue, survey participants agree with the experts that it is better to damage the storage case than to damage the disc it is storing.

As mentioned before, ambient conditions of temperature and humidity are of great consequence to the health and longevity of optical digital media. The survey question that most directly confronts this issue (Q11) is another which the vast majority of respondents answered correctly. As 86% of them attested, discs are safest when stored in a cool and dry climate. 23% also think warm and dry conditions are safe; while not as optimal as cool and dry, warm and dry is indeed safer than cool and humid (4%) or warm and humid (1%). "Store in a cool, dry place" sometimes appears in printed instructions accompanying optical digital media, so participants may have picked up on that. More likely, perhaps, is that this is a facet of storage where common sense indeed prevails, as innumerable other everyday items – buildings, vehicles, books, photographs, clothing, wine, food – have proven to last longest in cool and dry climates, and suffered the most damage in the opposite conditions.

Q12 also touches on climate conditions, in the form of sunlight, but also is the first question to introduce the subject of possible differences between types of optical digital media, namely the two broad categories of discs that have been pre-recorded (by a manufacturer) versus recordable discs (those which the user loads with their own data). The researcher waited until this point to introduce the subject for two reasons: (1) for the purposes of Q1-Q11, recordable discs are not appreciably different than pre-recorded discs; and (2) more participants might have stopped taking the survey sooner if complications such as the (physical and chemical) differences between types of discs were introduced sooner. (Indeed, with a total response *(n)* of 831, this is the very last survey question to receive more than 814 Reponses; on the next question, Q13, *(n)* drops to 804 and hovers around 800 thereafter for the remainder of the survey).

Putting the motives of the researcher aside and focusing on the question at hand, one can observe from the survey data that two-thirds (67%) of respondents believe that both types of disc, pre-recorded and recordable, are easily damaged by exposure to sunlight. This is not the case. While it is not a good idea to leave a pre-recorded disc exposed to direct sunlight repeatedly or for prolonged periods of time (as with so many other common items – books, photographs, clothing, wine, food…), studies do not show conclusive evidence that brief or occasional exposure to sunlight significantly shortens the lifespan of pre-recorded discs. The opposite, however, is true of recordable discs, which are *catastrophically* damaged by exposure to sunlight due to their chemical makeup. Data is recorded onto recordable discs by a laser burning holes in a light-sensitive layer (in the same location that a pre-recorded disc has the data-bearing aluminum substrate); thus, being light-sensitive, a recordable optical digital disc left sitting in the sun suffers the same fate as a recordable magnetic disc or tape left sitting next to a magnet. The survey responses do suggest that (apart from the 13% who know the risk sunlight presents to recordable disks) participants are unaware of this fundamental chemical difference between the two types of discs. However, the researcher feels that he might have worded this question more precisely, or split it into more than one question, in order to learn more specifically what people know about the difference between disc types.

On the other hand, perhaps it is just as well that the survey did not get overly detailed about the physical and chemical composition of various types of optical digital media, since Q13, the second question in a row to ask specifically about recordable disks, represents the point when 20 to 30 people stopped taking the survey. As mentioned

before, from this point onward the response rate rises and falls according to the question but generally hovers around 800, which is the exact number of participants who answered questions to the very end.

Q13 sought to discover if participants were aware that there are significant differences between the various dye colors used in recordable optical digital media. 71% of respondents believe there are no significant differences. In fact, accelerated aging studies by Youket, et al. predict that discs using a phthalocyanide dye layer – those which appear silver, gold, or pale green to the naked eye – will outlast those made with other dyes to a remarkable extent. It is unsurprising that members belonging to a university community, but not bound together by other specific interests, would be unaware of the chemical differences between dye types; the researcher would only have expected to find widespread knowledge of the subject in a specifically focused group (such as photographers, archivists, or recording manufacturers) whose professional or personal interests required such knowledge.

Q14 and Q15 ask participants about their perceptions of the longevity of pre-recorded versus recordable discs. Here, in both questions, the results are inconclusively spread among three possible answers: 1-10 years, 11-50 years, or more than 50 years. It is interesting to note, however, that the results from each question do tend to cluster around what is thought to be the truth. (Since optical digital media have not yet existed for 50 years, all predictions of longevity are necessarily based on accelerated aging studies and predictive models.) 50% of respondents believe the average lifespan of a pre-recorded disc to be between 11-50 years, which most experts would agree is a reasonable estimate (few besides those with business connections to disc manufacturers would

unhesitatingly say these discs will last more than 50 years). The remaining 50% of respondents are split nearly evenly (26/24) as to whether the average pre-recorded disc will last less than 11 years or more than 50 years. (Those who hold the former belief may have come to that conclusion based on the failure of their own discs, perhaps due to mistreatment of the sorts alluded to in earlier questions; those who hope for an average lifespan of 50 years or more may be either overly optimistic or overly susceptible to persuasion by the same recording industry forces that used to promise "a lifetime of listening enjoyment" in the small print in the liner notes of every CD manufactured in the 1980s., as reprinted in Appendix C.) The responses to Q15 are not quite the same, however: 50% believe the lifespan of recordable CDs to be 10 years or less, while 36% believe they will last 11-50 years, and only 14% hope for 50 years or more. These data show that members of the sample base (and thus perhaps users on the whole) are generally more skeptical about the longevity of recordable discs than pre-recorded ones. One might conjecture that this is an attitude that can only come from personal experience with recordable disc failure, since the data from earlier questions suggest that participants are unaware of intrinsic differences between recordable and pre-recorded discs.

Q16 is the final question to gather data about participants' knowledge rather than personal demographic data, but it takes a different tack than previous questions by introducing the subject of libraries for the first time. (Subsequent questions established further information about participants' usage of libraries, as discussed in Sections B and C, but up until this point, the word "libraries" had not been mentioned in the survey nor in the solicitation email[4].) The question supposes that a CD or DVD retails for $15-$20

[4] The solicitation email did identify the researcher and his advisor as members of the School of Information and Library Science, but only in a boilerplate statement of IRB approval, not the main body of the email.

and then asks participants what they believe the cost is for a library to obtain said CD or DVD and make it available for patrons to borrow. The researcher included this question almost as a lark, yet with serious intent: studies have been done about patrons' valuation and subsequent treatment (or mistreatment) of books and other printed materials in libraries, as discussed in Chapter 2, yet the researcher is unaware of similar studies about patrons' valuation of optical digital media.

The results from this one question are interesting indeed to anyone in the library profession. The majority of the 812 respondents (41%) believe that the cost to the library is *less* than the retail price of the CD or DVD in question. Only 20% of the respondents realize that truthfully, the cost of the disc itself compounded with the costs of processing it for patron use (e.g., cataloging, labeling, tattle-taping, repackaging/reformatting, etc., plus the labor hours involved) leads to an overall cost to the library of more than $35 for a disc that retails for $15-20. Some might even estimate the cost to the library to be over $50, depending on whether processes are automated and what kinds of labeling and security measures are used. The remaining 39% of respondents realize the cost to the library is not *less* than retail, but do not believe it to be significantly more than retail either.

Participant Desire for Further Education

The final two questions of the survey (Q23 and Q24) were explicitly presented as optional, since they both required the participant to provide an email address. Q23 asked whether the individual participant would like to learn more about the best practices for handling and storage of optical digital media, upon the completion if the study. If so,

they would be emailed the URL of a page with the “correct” answers to all of the questions asked in the survey (although, as described in Section D, not every question has a singular and/or correct answer), as well as further information and a reading list of resources for further research. Of the ~800 respondents who successfully completed the entire 22-question survey, 55% indicated that they would like to receive this information. This response should be heartening to anyone in the LIS field, and the researcher hopes that those who said “yes” were not merely being polite. They will be directed to a webpage which consists of the information contained here in Chapter 4 (pared down and rewritten for a general audience, of course) as well as a few selected highlights from the bibliography presented in Chapter 8.

Q24 asked whether the individual participant would like to be entered into a random drawing for one of five $20.00 Amazon.com gift certificates. It is no surprise that of the ~800 respondents who successfully completed the entire 22-question survey, 98% said “yes.”

Chapter 5: Study Limitations

As with any survey study, limitations are inherent. The chosen population of the University of North Carolina at Chapel Hill community may be unrepresentative of users of optical digital media on the whole. It is probable, for example, that the overall education level of members of this community, being centered around an esteemed university, is to some degree higher than that of the overall populace; this could have affected the survey results. Members of the UNC-CH community may also be, on average, more frequent library users than the general populace, which could have affected the results of the questions specifically dealing with library usage. On the other hand, UNC-CH library users could very well use optical digital media in libraries *less* frequently than members of the general populace; without a direct study to provide data, this is another unknown.

For the purposes of this study, members of the UNC-CH community were defined as those who are subscribed to the Mass Email System at UNC-CH. While all members of the UNC-CH community are subscribed by default upon entering the community, they may individually choose to opt out for any reason and at any time[5]; these individuals were thus precluded from receiving the invitation to participate in the study. Other factors such as spam blockers, custom email filters, and personal email reading habits may also have caused some members of the UNC-CH community to fail to receive the survey invitation.

[5] The researcher himself, not a fan of unsolicited email, is among those who have opted out.

As with all surveys, the participant base is to some degree composed of people who are generally disposed to taking surveys, more than those who are generally disposed not to. The fact that the survey was online, not on paper or in person, is another potentially influential factor. The two rewards offered in the solicitation email – further education in the survey subject (promised) and a $20.00 gift certificate (possible by luck of the draw) – may also have influenced participants' choosing to complete the survey, for better or for worse.

The survey itself contains questions which the researcher would choose to revise if the survey were administered again, as discussed in Chapter 4. Q7 (proper storage containers), for example, has one answer that is definitely correct (hard plastic cases stored vertically) and others that may or may not be acceptable depending on which standard one follows. While it is appropriate and educational to see an inconclusive response to a question whose answer is itself somewhat vague, better data might have been gathered if this question were reworded, split into more than one question, or changed to allow only one response instead of multiple responses. Another pair of questions (Q12 and Q13) caused a decline in survey participation, which the researcher believes is due to their introducing more technical language and themes than previous survey questions. Again, while it is appropriate and educational to see how respondents reacted to the introduction of recordable optical digital media into the equation, these questions could perhaps have been revised/reworded, placed later in the survey, eliminated altogether, or expanded into greater detail to provide more clarity for the participants (for instance, color illustrations could have enhanced Q13). If the survey were to be repeated, the researcher also suggests including more "write-in" responses,

either standing alone or appended to existing questions, as those that were included provided some very interesting and unexpected insights into participants' treatment of optical digital media and the vectors by which they came to their knowledge.

Finally, it should be reiterated that since digital optical media have only existed since the late 1970s, and only been widely commercially available since the 1980s (with DVDs and recordable discs arriving later in the 1990s), much of what is thought to be "correct" about best practices for handling and storage is fundamentally based on accelerated aging and other predictive experiments, and conjecture. The standards published by NIST, LOC, et al. represent the best of scientific knowledge *as of now*, but they could well be proven to be wrong in certain aspects in the future, as optical digital media continue to naturally age and descriptive (not predictive) studies of them are undertaken. This is *particularly* true of questions about using ink to write on discs (Q3 and Q4), proper storage containers (Q7), and disc longevity (Q14 and Q15), where the long-term effects are not truly known. The best that this current study can hope to do is measure participants' perceptions of proper handling and storage against the (somewhat conjectural) best practices standards that have been published; any conclusion that a segment of the survey sample is "correct" should be construed to mean "agrees with expert conjecture based on the best predictive science available."

Chapter 6: Implications

The first group of questions (Q1-Q16) sought to collect data about participants' knowledge of best practices for handling and storage of optical digital media. The overall data collected from ~800 members of the UNC-CH community suggest that user knowledge of this subject is of very mixed quality.

The participants' answers to survey questions are almost entirely correct about certain aspects, such as the optimal climate conditions for storage (Q11), the best way to remove a disc from a stubbornly-gripping storage case (Q10), and writing implements (Q3) and cleaning fluids (Q8) that are safe for use on discs. Conversely, they are almost entirely incorrect about other aspects, such as which side of a disc is more prone to serious damage by scratches (Q1 and Q2), the use and removal of adhesive labels (Q5 and Q6), and the differences between pre-recorded and recordable discs (Q12) and types of recordable discs (Q13). The responses to a third group of questions show a lack of consensus among respondents; in some cases this may be due to the actual absence of a definitive answer, e.g., safe storage enclosures (Q7) and disc longevity (Q 14 and Q15), while in other cases it suggests a lack of user education in areas where experts generally agree on a correct answer, e.g., safe cleaning motions (Q9), safe locations for writing on disc surfaces (Q4) and cost of library acquisition and processing of discs (Q16).

The mixed results from this first group of questions (Q1-Q16) imply that the study participants do not have solid and consistent knowledge about the best practices for handling and storage of optical digital media.

The second group of questions (Q17-Q19) sought to collect data about participants' usage of optical digital media in libraries and vectors of usage/storage education. The data collected from these questions potentially shed light on the results of the first group of questions. The results from Q18 show that the majority of respondents rarely or never use CDs and DVDs owned by libraries, either by using them in the library or borrowing them for home use. The results from Q19 suggest that these same respondents overwhelmingly use libraries for personal and academic reading/research, with only 8% indicating usage of audio/video materials in libraries. Together, these data imply that participants, since they are not using optical digital media in libraries, are thus not being presented with educational opportunities about best practices by librarians or library materials.

The researcher found the responses to the question about vectors of user education (Q17) to be the most illuminating and unexpected results of the survey. As discussed in Chapter 2, while a considerable body of academic literature about best practices for handling and storage of optical digital media has been published, this is unlikely to have been read by the general populace. Instead, the researcher suspected that articles in popular media such as Svensson, et al., might have been the primary vector of education for the non-academic populace. The results of the survey show that, to the contrary, print media and writings on the Internet are each named by only 17% of respondents as sources of education; far many more respondents have learned what they know from friends/family (72%) and instructions provided in the packaging of CDs and DVDs

(40%). Library staff and/or materials, by comparison, were named by only 10% of respondents at best[6] as instrumental in their education.

Finally, it must be acknowledged that a considerable percentage of participants have explicitly or implicitly received no education whatsoever about best practices for handling and storage of optical digital media. As discussed in Chapter 4, Q17 received the lowest response rate of all survey questions, perhaps because no check-box option for "Don't know" / "Have never received education" was provided. This same question received the largest number of write-in "Other" responses, most of which indicate in one way or another that respondents are "(n)ot sure where [they] heard most of it," "figured it out [them]self," "just assume [they] know how to handle them," or are "(g)uessing on most answers."

The results from Q17-Q19 imply that users of optical digital media are, on the whole, neither using them in libraries nor being educated about them in libraries. The primary vector of user education is word-of-mouth/hearsay and the secondary vector is instructions included in purchased CDs and DVDs. Taken together with the results from Q1-Q16, which show that user knowledge of best practices is varied and inconsistent, the overall implication is that word-of-mouth/hearsay and commercially available instructions are not effective means of educating users in best practices.

Since participants in the survey (and by extension, the overall UNC-CH community) are primarily gaining their knowledge about best practices from friends and family (word-of-mouth/hearsay) and secondarily from printed instructions included in commercially marketed optical digital media, and since libraries are powerless to directly

[6] 4% indicated they have received advice from library staff, 3% from library staff demonstrations, and 3% from printed materials in libraries. Considering the possibility of overlap, the total percentage of library-educated respondents could be as low as 4%.

influence either of these vectors, then the implication for libraries is that they must make a concerted effort to expand outreach in patron education, if they wish to increase user knowledge about optical digital media. Even though the survey shows that participants are not using library discs frequently, it is in libraries' best interest to educate their patrons in the best practices for handling and storage of optical digital media. It can be argued, in fact, that infrequent usage of library discs increases the likelihood of patron mistreatment of these discs, as proper treatment cannot become a habit with infrequent usage.

Furthermore, libraries have an opportunity here to directly benefit their patrons by increasing education in best practices, if not for the libraries' collections, then for the users' own collections. Any knowledge that libraries can impart to their patrons will become part of the word-of-mouth/hearsay network that spreads information to everyone in the UNC-CH community. This would eventually benefit all users of optical digital media by helping to offset popular misinformation, eliminate "guessing," reduce experimentation "w/cleaning using liquid car polish" and the like, and prevent the kinds of "(m)istakes that ruined CDs" in the past.

Chapter 7: Conclusion

In the absence of any known published studies about the general populace's knowledge of best practices for handling and storage of optical digital media, this study sought to collect data from a representative segment of the general populace in order to establish baseline data for further research. In this regard, the study was successful. The chosen survey, although skewing 2/3 female for unknown reasons, represented a broad range of ages and affiliations with the UNC-CH community. The sample size of ~800 was much larger than anticipated, which only strengthens the statistical data collected.

This study also sought to collect data about particpants' usage of libraries in general, and specifically their usage of optical digital media owned by libraries. In this regard, the study was a qualified success. While valuable data was gathered, the researcher feels that this area of inquiry was not sufficiently covered by two questions, and thus respondents' use of optical digital media in libraries is not fully quantified. The results were strong enough, however, to enable implications to be made in combination with the data from questions that preceded and followed them.

Lastly, this study sought to collect data about how the survey participants have learned what they know about the subject at hand, i.e., vectors of education. Despite the fact that only one question addressed this subject, the researcher feels the responses were sufficiently rich to consider the study successful in this regard. The data gathered from this question show that an entire study about vectors of user education may well be merited.

The conclusions that can be drawn from this study are that people's education about optical digital media is inconsistent and incomplete; that most people receive the knowledge they possess from other people and from corporate manufacturers rather than from scholarly/reputable sources; and that libraries are not currently playing a significant role in educating people about the best practices for handling and storage of optical digital media. The strongest implication for the future is that libraries must expand their educational outreach if they wish to cut through the "noise" generated by hearsay and advertising, and make a valuable contribution to increasing user education, for the good of both the libraries themselves and the general populace.

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Appendix A: Survey Instrument With Responses

1. Which side of a CD is most easily damaged by scratches?

The top side (where the label is printed)	60	7%
The bottom side (the side without the label)	723	83%
Both sides are about the same	91	10%
Total (n)	***874***	***100%***

2. Which side of a DVD is most easily damaged by scratches?

The top side (where the label is printed)	48	6%
The bottom side (the side without the label)	671	79%
Both sides are about the same	126	15%
Total (n)	***845***	***100%***

3. What writing utensils are safe to use to write on a CD or DVD? (You may select more than one answer)

Lead pencil	39	5%
Grease pencil	132	15%
Ball-point pen	66	8%
Non-permanent felt-tip pen (for example, a Magic Marker)	344	40%
Permanent felt-tip pen (for example, a Sharpie)	769	89%
Paint pen (for example, a White-Out pen)	102	12%
No writing utensils are safe for use on a CD or DVD	63	7%
Number of responding subjects (n) = 861		

4. Where is it safest to write on a CD or DVD?

Anywhere on the top side (label side)	700	82%
Anywhere on the bottom side	5	1%
Within the 1.5-inch center ring	120	14%
It is never safe to write on a CD or DVD	32	4%
Total (n)	***857***	***100%***

5. Where is it safest to place an adhesive label on a CD or DVD?

Anywhere on the top side (label side)	588	69%
Anywhere on the bottom side	2	0%
Within the 1.5-inch center ring	92	11%
It is never safe to place an adhesive label on a CD or DVD	170	20%
Total (n)	***852***	***100%***

6. What is the safest way to remove an adhesive label from a CD or DVD?

Peel the label off slowly	354	42%
Moisten the label to soften it, then gently scrape it off	21	2%
Moisten the label to soften it, then gently wipe it off	246	29%
It is never safe to remove an adhesive label from a CD or DVD	225	27%
Total (n)	***846***	***100%***

7. How should CDs and DVDs be stored to minimize damage?
(You may select more than one answer)

In a "wallet" with cloth-backed plastic pages	462	54%
In individual cloth-backed plastic sleeves, filed vertically like folders in a drawer or box	497	58%
In a stack on a spindle, without individual enclosures	143	17%
In hard plastic cases, arranged vertically like books	627	74%
In hard plastic cases, stacked horizontally like papers	448	53%
In paper sleeves, filed vertically or horizontally	293	34%
Number of responding subjects (n) = 850		

8. Which of the following liquids are safe to use to clean a CD or DVD? (You may select more than one answer)

Strong solvents (for example, nail polish remover)	5	1%
Mild solvents (for example, rubbing alcohol)	223	27%
Mild detergents (for example, soapy water)	328	39%
Pure water	420	50%
It is never safe to use a liquid to clean a CD or DVD	217	26%
Number of responding subjects (n) = 841		

9. When cleaning a CD or DVD, what wiping methods are safe? (You may select more than one answer)

Wiping from side-to-side or up-and-down (like cleaning a window)	59	7%
Wiping outward from center to edge (like cleaning the spokes of a bicycle wheel)	394	47%
Wiping in a circle around the disc (like cleaning a dinner plate)	486	58%

10. If you are having difficulty removing a CD or DVD from a plastic storage case, you should...

Pull up on one edge of the disc	7	1%
Pull up with even pressure on opposite sides of the disc	66	8%
Push down on the plastic case's "teeth" at the center of the disc	751	90%
Spin the disc to loosen it	13	2%
Total *(n)*	**837**	**100%**

11. Which of these climates are safe for storing CDs and DVDs with minimal damage? (You may select more than one answer)

Cool and humid	31	4%
Cool and dry	716	86%
Warm and humid	9	1%
Warm and dry	189	23%
Climate is unimportant for storing CDs and DVDs	111	13%
Number of responding subjects (n) = 834		

12. Which of these types of CDs and DVDs are easily damaged by exposure to sunlight?

Pre-recorded CDs and DVDs (store-bought music, movies, games, software, etc.)	9	1%
Recordable CD-Rs and DVD-Rs (blank discs you write your own music or data on)	108	13%
Both	560	67%
Neither	154	19%
Total (n)	***831***	***100%***

13. Which type of recordable CD-R or DVD-R (one that you purchase blank and then record music/data onto) is best for long-term storage?

One whose bottom side is silver, gold, or pale green	117	15%
One whose bottom side is medium green or dark green	33	4%
One whose bottom side is dark blue or purple	81	10%
There is no significant difference between types of recordable discs	573	71%
Total (n)	***804***	***100%***

14. Assuming ideal conditions of usage and storage, how long will the average pre-recorded CD or DVD last? (Pre-recorded = a disc you buy with music, movie, game, data, etc. already on it)

1-10 years	214	26%
11-50 years	404	50%
More than 50 years	196	24%
Total (n)	***814***	***100%***

15. Assuming ideal conditions of usage and storage, how long will the average recordable CD-R or DVD-R last? (Recordable = a blank disc on which you write your own music, movie, data, etc.)

1-10 years	399	50%
11-50 years	286	36%
More than 50 years	116	14%
Total (n)	***801***	***100%***

16. Suppose that a CD or DVD costs between $15-$20 to purchase in stores. How much does it cost for a library to obtain this CD or DVD and make it available for patrons to borrow?

Less than $15	333	41%
$15 - $20	205	25%
$21 - $35	115	14%
More than $35	159	20%
Total (n)	***812***	***100%***

17. How have you learned what you know about handling and storing CDs and DVDs? (Please check all that apply)

I have read instructions provided in the packaging of CDs and DVDs	315	40%
I have read about how to treat CDs and DVDs in newspaper/magazine articles	134	17%
I have read articles about the subject on websites	131	17%
I have read discussions about the subject on blogs, online forums, etc.	65	8%
I have done academic research about the subject	5	1%
I have heard advice about the subject from family/friends	563	72%
I have received training about the subject as part of my job	34	4%
I have received advice about handling/storage from library staff	35	4%
I have seen library staff demonstrate handling/storage using actual CDs and DVDs	22	3%
I have read handouts/flyers/signs in libraries	27	3%
I have received advice from salespersons at retail stores	114	15%
I have received advice from electronics/repair technicians	69	9%
Other:	90	12%
Number of responding subjects (n) = 781		

NOTABLE "OTHER" RESPONSES	
Personal Experience	15
Guessed / Made It Up	13
Received no training / Have no real knowledge	12
Common Sense	11
Trial and Error / Experimenting	11
Observing / Mimicking Other's Behavior	9
Hearsay / Word of Mouth	8
IT professionals / faculty / students	6
Commercial CD Cleaning Kit Instructions	3
Unclassifiable	2

18. How often do you use CDs and DVDs owned by libraries, either by using them in the library or borrowing them for home use?

Daily	15	2%
Weekly	26	3%
1-4 times per month	69	9%
5-10 times per year	67	8%
2-4 times per year	120	15%
Once per year or less	233	29%
Never	275	34%
Total (n)	***805***	***100%***

19. What purposes do you most often use libraries for? (Please check all that apply)

Personal reading/research	551	69%
Academic reading/research	508	64%
Internet access	198	25%
Group meetings (business and/or academic)	189	24%
Email access	148	19%
Other computer use	85	11%
Business reading/research	79	10%
Listening to audio / watching video	66	8%
Taking classes	40	5%
Group meetings (personal interests)	36	5%
Socializing	29	4%
Playing video games	4	1%
Other:	39	5%
Number of responding subjects (n) = 796		

NOTABLE "OTHER" RESPONSES	
Rarely or Never Use Libraries	9
Children's Materials, Storytime, Activities, Family Time	7
Work / Employment	5
Teaching / Tutoring	4
Printing	4

Audiobooks / CDs for car trips	3
Borrowing Films	2
Other	2

20. What are your primary affiliations with UNC-Chapel Hill? (Please check up to 3 that apply)

Undergraduate student	158	20%
Graduate student	101	13%
PhD student	58	7%
Faculty	72	9%
Staff / Employee	478	59%
Alumnus / Alumna	106	13%
Chapel Hill / Triangle Area resident	156	19%
Long distance patron of UNC-CH libraries	10	1%
Long distance user of other UNC-CH services	9	1%
Other:	22	3%
Number of responding subjects (n) = 806		

NOTABLE "OTHER" RESPONSES	
Postdoctoral Student	4
Continuing Education Student	3
Spouse/Relative of employee	3
Spouse/Relative of student	2
Spouse/Relative of alumnus	2
Other	5

21. Gender

Male	242	30%
Female	562	70%
Total (n)	***804***	***100%***

22. Age

18 - 22	165	20%
23 - 29	156	19%

30 - 39	197	24%
40 - 49	127	16%
50 - 64	148	18%
65+	12	1%
Total (n)	***805***	***100%***

23. LEARN MORE! ***(optional)***

When this study is completed in December 2009, a web page will be made available which contains answers to the questions you were asked about CDs and DVDs, plus more information and sources for further reading. If you would like to be sent an email notifying you about this web page, please provide a working email address. (Do NOT include your name or any other personal information. Your email address will not be used for any other purpose, and will be discarded immediately after the email is sent to you.)

I would like to learn more about CDs and DVDs. Please email me at:	443	55%
No, thank you.	356	45%
Total (n)	***799***	***100%***

24. ENTER THE PRIZE DRAWING! ***(optional)***

Five lucky participants in this study (drawn at random) will win a $20 Amazon.com gift certificate. If you would like to be entered into the random prize drawing, please provide a working email address. (Do NOT include your name or any other personal information. Your email address will not be used for any other purpose, and will be discarded immediately after the prize drawing.)

I would like to enter the random prize drawing for one of five $20 Amazon.com gift certificates. If I win, please email my gift certificate to:	785	98%
No, thank you.	15	2%
Total (n)	***800***	***100%***

Appendix B: Recruitment Email

From: massmail@unc.edu
To: massmail-students@listserv.unc.edu;
massmail-employees@listserv.unc.edu;
dkoster@email.unc.edu
Subject: INFORMATIONAL: What do you know about your CDs & DVDs? (Survey)

We're looking for volunteers to take a survey about CDs and DVDs, as part of a research study. If you've ever used a CD or DVD, you're qualified!

The survey will take 10 minutes of your time. For participating, you will have the chance to win one of five $20 Amazon.com gift certificates -- enough to add a new disc to your collection.

The survey is online, and you can take it anywhere & anytime you choose, in the next two weeks.

To learn more and to volunteer to take the survey, visit this URL:
http://uncodum.qualtrics.com/SE?SID=SV_0lhuMulhMNywWKo&SVID=Prod

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Choosing or declining to participate in this study will not affect your class standing, grades, or employment at UNC-Chapel Hill. You will not be offered nor receive any special consideration if you take part in this research; it is purely voluntary. Your answers to the survey will remain completely anonymous at all times. This study has been approved by the UNC Behavioral IRB (IRB Study No. 09-1813, approved 10/05/2009). Principal Investigator: Dan Koster, Masters of Library Science Student, School of Information and Library Science, UNC-Chapel Hill. Supervisor: Dr. Diane Kelly, Assistant Professor, School of Information and Library Science, UNC-Chapel Hill.

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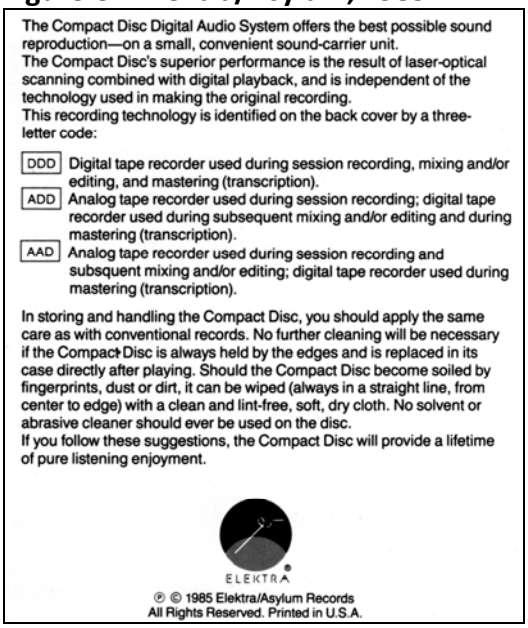
Appendix C: A Brief, Incomplete History of Care Instructions In the Packaging of CDs

Figure C1: Elektra/Asylum, 1985



The Compact Disc Digital Audio System offers the best possible sound reproduction—on a small, convenient sound-carrier unit.
The Compact Disc's superior performance is the result of laser-optical scanning combined with digital playback, and is independent of the technology used in making the original recording.
This recording technology is identified on the back cover by a three-letter code:

DDD Digital tape recorder used during session recording, mixing and/or editing, and mastering (transcription).
ADD Analog tape recorder used during session recording; digital tape recorder used during subsequent mixing and/or editing and during mastering (transcription).
AAD Analog tape recorder used during session recording and subsequent mixing and/or editing; digital tape recorder used during mastering (transcription).

In storing and handling the Compact Disc, you should apply the same care as with conventional records. No further cleaning will be necessary if the Compact Disc is always held by the edges and is replaced in its case directly after playing. Should the Compact Disc become soiled by fingerprints, dust or dirt, it can be wiped (always in a straight line, from center to edge) with a clean and lint-free, soft, dry cloth. No solvent or abrasive cleaner should ever be used on the disc.
If you follow these suggestions, the Compact Disc will provide a lifetime of pure listening enjoyment.

ELEKTRA

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Figure C1 shows the first template that major record labels included in the packaging of all CDs manufactured in 1984-85. At this point in history, consumers were slow to adopt the CD (cassettes were the best-selling format, followed by vinyl LPs), and thus record companies found it necessary to explain the "benefits" of the CD format, and its mysterious 3-letter digital/analog code, in addition to providing basic care and handling instructions. Hence the care instructions are bracketed by miniature sales pitches promising "the best possible sound reproduction – on a small, convenient sound-carrier unit" *(first line)* and "a lifetime of pure listening enjoyment" *(last line)*.

Figure C2: Reprise (E'G), 1985

The Compact Disc Digital Audio System offers the best possible sound reproduction – on a small, convenient disc. Its remarkable performance is the result of a unique combination of digital storage and laser optics.
For best results, you should apply the same care in storing and handling the Compact Disc as you would with conventional records. No cleaning is necessary if the Compact Disc is always held by its edges and is replaced in its case directly after playing. If the Compact Disc becomes soiled by fingerprints, dust or dirt, it can be wiped (always in a straight line, from center to edge) with a clean and lint-free, soft, dry cloth. Never use a solvent or abrasive cleaner to clean the disc. If you follow these suggestions, the Compact Disc will provide a lifetime of listening enjoyment.

E'G

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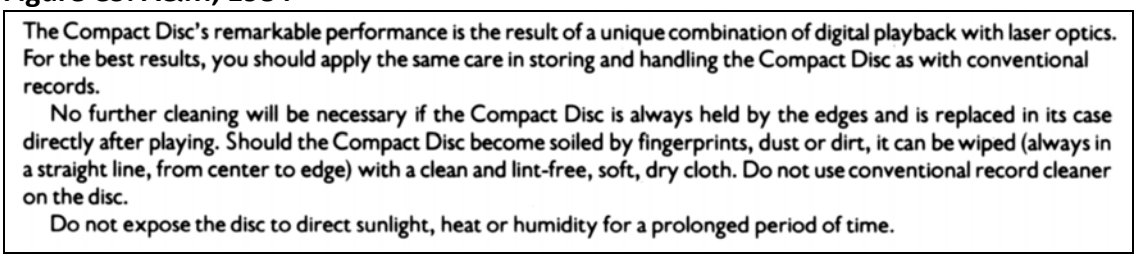
Figure C2 shows the shortened and modified version of the boilerplate sales pitch/care instructions that was quickly adopted in favor of the former model. (The author does not know of any CDs that bear the earliest model, shown in Figure C1, in their packaging after 1985.) Note here that the term "disc" has replaced the unwieldy "sound-carrier unit" *(first line)*; the explanation of the 3-letter digital/analog code has been removed; and the promised "lifetime of listening enjoyment" is no longer "pure" *(last line)*. Overall, the technical jargon has been removed and/or smoothed out, and the sales pitch does not come on quite as strong, nor promise quite as much.

Figure C3: A&M, 1984

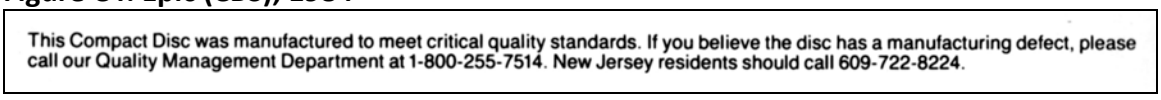

The Compact Disc's remarkable performance is the result of a unique combination of digital playback with laser optics. For the best results, you should apply the same care in storing and handling the Compact Disc as with conventional records.

No further cleaning will be necessary if the Compact Disc is always held by the edges and is replaced in its case directly after playing. Should the Compact Disc become soiled by fingerprints, dust or dirt, it can be wiped (always in a straight line, from center to edge) with a clean and lint-free, soft, dry cloth. Do not use conventional record cleaner on the disc.

Do not expose the disc to direct sunlight, heat or humidity for a prolonged period of time.

Not all major labels used the same template in their packaging. Unlike Warner Bros. and its subsidiaries (including Elektra/Asylum, E'G, Reprise, Geffen, and Virgin America), A&M Records removed most of the sales-pitch aspects of the template in favor of the inclusion of more practical advice about handling and storage. Note here, in Figure C3, the warning about improper climate conditions for disc longevity *(last line)*.

Figure C4: Epic (CBS), 1984


This Compact Disc was manufactured to meet critical quality standards. If you believe the disc has a manufacturing defect, please call our Quality Management Department at 1-800-255-7514. New Jersey residents should call 609-722-8224.

The CDs manufactured in the 1980s by CBS and its affiliates and subsidiaries (including Columbia and Epic) included no care instructions at all in their packaging, instead providing a promise of quality manufacturing and a number to contact should the consumer believe their disc to be faulty through no fault of their own (Figure 4). The author does not know how many (if any) consumers ever called the Quality Management Department at CBS, but he is reminded of the fiasco that later befell the United Kingdom's Phillips Digital Optical (PDO) in the late 1990s and early 2000s. The literal rotting away of PDO discs, caused by a chemical reaction between something in the polymer layer on the label side of the discs and something else in the ink or paper of the printed booklets they abutted in their storage cases, was for many people the first indication that optical digital media can suffer damage due to inherent vice. The PDO incident is also largely responsible for bringing the issue of "CD rot" into the public eye via scientific (and, later, mainstream) media. Happily for purchasers of faulty PDO discs, the company offered a quality hotline similar to CBS's for consumers to contact, and the company made good on its promise to replace faulty discs free of charge.

Figure C5: Denon / Nippon Columbia, 1984

COMPACT disc DIGITAL AUDIO

新しい音のかたちが誕生！

今までのレコードは、その音溝の振動をピックアップの針で受けて音楽等を再生します。この時、レコードや針先、ターンテーブル等の物理的な限界により生ずる雑音、歪、レベル変動、ワウフラッタ等はさけることができません。これらの問題を根本的に解決するためには、音楽信号をデジタル信号に変換してディスクに記録し再生すればよいのですが、同じ音楽内容でも従来のレコードの 100 倍以上の記録帯域が必要となり、従来のままでは実現できません。

これを可能にする為このディスクは、レーザーによりデジタル信号を 0.5 ミクロン位の巾の極微細な凹みの断続信号の形（従来のレコードの溝は巾約70ミクロン）にして、しかも従来の30センチレコードの両面分を直径12センチの片面にぎっしり記録、小型化したもので、これを「コンパクトディスク」と呼びます。

コンパクトディスクの製造には非常にきびしい精度と充分な防塵対策等が必要ですが、その再生は弱いレーザー光により図のように下から（レーベルのない側から）透明プラスチック板本体を透過し、信号記録面で反射して再びプラスチック板を透過したもので得られ、しかも記録面は保護膜でおおってありますので、大切な記録部分はどちらの面にも露出しておらず、皆様のお手もとに渡った後に記録面にキズやゴミがつかない構造になっています。

コンパクトディスクは、音楽信号を再生するにふさわしい充分な性能のデジタル信号で記録されていますので、次のような優れた数多くの特徴を持っています。

(1) ワウフラッタやそれに伴なう変調雑音がほとんどない
(2) 広く平担な周波数特性
(3) ゴーストが発生しない
(4) ダイナミックレンジが広い
(5) 歪がきわめて少ない
(6) クロストークがほとんどない
(7) レコードの材料ノイズがない

また取扱いは、記録面が表面に露出していない為、比較的容易ですが、前述のように大変こまかい記録がされていますので、特にプラスチック面のキズやよごれにはなるべく注意し、べったりした指紋はやわらかい布でふきとるなどして下さい。また、プラスチック製品なので高温多湿の場所での保管はおさけ下さい。そりにもご注意下さい。

コンパクトディスク断面図

6

This page from the booklet accompanying a 1984 Japanese CD is remarkable in that it contains a diagram which clearly shows a cross-section of an optical digital disc (Figure C5). While the author, not versed in Japanese, can only conjecture that the lines numbered 1-7 (right side) are instructions for handling and storage, he has no doubt that the diagram in the lower right-hand corner (which closely resembles illustrations printed in Byers, Svensson, et al. two decades later) is explaining the difference between the top data layer and the clear plastic bottom layer of a CD, complete with digital “grooves” where the pattern of 0s and 1s are etched, and a laser penetrating the clear plastic bottom, bouncing off of the aluminum data layer, and returning to the playback device for processing and translation into sound. The author knows of no such illustrations in English or any other language accompanying commercially sold CDs. However, it is not difficult to imagine that if such diagrams had been a part of CD packaging in the U.S.A. since the advent of CDs in 1984, the findings of the current study (in particular, Q1) would reveal a greater understanding of the physical makeup of optical digital media in the survey responses.

Figure C6: I.R.S. Records, 1986

COMPACT disc DIGITAL AUDIO

The signal read-out surface is the reverse side of the printed label side. While the compact disc is much more resistant to scratches and dirt than a conventional record, it is best to be careful not to scratch the signal surface and to keep it clean — free of dust, dirt and fingerprints.
If the signal surface becomes dirty, clean it in one of the following ways:
1) Fingerprints — Lightly rub the surface with a soft cloth.
2) Dust or Dirt — Blow lightly on the disc and wipe the dirty part with a soft cloth, or clean the dirty part with a damp, soft cloth and then wipe dry.
3) Grease or Oil — Clean with a soft cloth dampened with ethyl alcohol, then wipe dry.
Please note that conventional sprays and liquids used to clean records may damage the surface of the disc. Use of such cleaner is not recommended.
Also, please do not expose the disc to direct sunlight, heat or humidity for a prolonged period of time.

Obwohl die Compact Disc viel widerstandsfähiger gegen Kratzer und Schmutz als eine normale Schallplatte ist, ist zu empfehlen, daß keine Kratzer, Staub, Schmutz oder Fingerabdrücke auf die bespielte Oberfläche kommen.
Falls die bespielte Oberfläche trotzdem schmutzig werden sollte, reinigen Sie sie folgendermaßen:
1) Fingerabdrücke- wischen Sie die Oberfläche vorsichtig mit einem weichen Tuch ab.
2) Staub und Schmutz- blasen Sie leicht über die Platte und wischen Sie die verschmutzte Stelle mit einem weichen Tuch ab oder reinigen Sie die verschmutzte Stelle mit einem feuchten Tuch und reiben Sie sie anschließend trocken.
3) Fett und Öl- reinigen sie die Platte mit einem in Äthylalkohol getränkten weichen Tuch. Anschließend trockenreiben.
Bitte beachten Sie, daß herkömmliche Sprays und flüssigreiniger für normale Schallplatten der Compact Disc schaden können. Der Gebrauch solcher Reinigungsmittel ist nicht zu empfehlen. Setzen Sie die Platte für längere Zeit auch keiner direkten Sonnenbestrahlung, Hitze und Feuchtigkeit aus.

La surface enregistrée se trouve au verso du côté de l'étiquette imprimée. Même si le disque est beaucoup plus résistant aux éraflures et poussières qu'un disque conventionnel, il vaut mieux faire attention à ne pas rayer la surface enregistrée et à la garder propre — libre de poussières, saletés et traces de doigt.
Si la surface enregistrée se salit, nettoyez-la d'une des manières suivantes:
1) Traces de doigt- nettoyez la surface avec un chiffon doux.
2) Poussières ou saletés- soufflez légèrement sur le disque et essuyez la partie sale avec un chiffon doux; ou nettoyez-la avec un chiffon doux et humide, puis essuyez.
3) Graisse et huile- nettoyez avec un chiffon doux humecté avec de l'acool éthylique, puis essuyez.
Veuillez noter que les bombes et liquides utilisés pour nettoyer les disques conventionnels pourraient endommager la surface du disque compact. L'usage de tels produits n'est pas recommandé.
Ne pas exposer le disque à la lumière directe du soleil, à la chaleur ou à l'humidité, pendant une période prolongée.

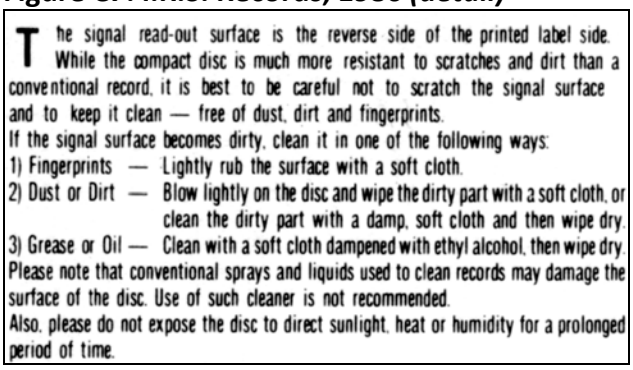
El lado que contiene la señal de lectura es el contrario al que contiene la etiqueta del papel. Mientras que el disco compacto es mucho mas resistente a arañazos y a la suciedad que un disco convencional es mejor tener cuidado para evitar arañazos sobre la superficie que contiene la señal y mantenerla limpia, libre de polvo, suciedad y huellas.
Si la superficie que contiene la señal se ensucia, limpiese de la siguiente forma:
1) Huellas- Frote la superficie ligeramente con un paño suave.
2) Polvo o suciedad- Sople ligeramente sobre el disco y pase un paño suave sobre la parte sucia o bien limpie la parte sucia con un paño suave humedo y despues sequelo.
3) Grasa o aceite- Limpie con un paño humedecido en alcohol etilico y sequelo posteriormente.
Tenga en cuenta que sprays y liquidos convencionales que se utilizan para limpiar discos pueden dañar la superficie del disco. El uso de estos limpiadores no se recomienda.
Tambien tenga en cuenta no exponer el disco a la luz solar directa, al calor o a la humedad durante periodos prolongados de tiempo.

I lato inciso si trova sul retro del lato che porta l'etichetta stampata. Sebbene il Compact Disc (CD) sia molto piu resistente ai graffi ed allo sporco dei comuni dischi LP, è sempre meglio evitare graffi, polvere, sporcizia e ditate.
Per pulire il CD qualora si dovesse sporcare, procedere come segue:
1) Ditate- passare un panno morbido strofinando delicatamente.
2) Polvere o sporco- soffiare lievemente sul disco e poi passare il panno morbido, oppure passare il panno inumidito, indi asciugare.
3) Macchie di grasso- pulire con un panno morbido imbevuto di alcool etilico, indi asciugare.
N.B. Gli sprays ed i liquidi in commercio per la pulizia degli LP tradizionali possono danneggiare il CD e se ne sconsiglia quindi l'uso.
Non esporre il disco alla luce del sole, al calore o all'umidità per un periodo di tempo prolungato.

Spela endast den sida som saknar etikett. Trots att kompaktskivan är mycket mera resistent mot repor och smuts än en konventionell skiva, bor man anda undvika att repa den inspelade sidan. Den bor hallas ren — fri fran damm, smuts och fingeravtryck.
Om den inspelade ytan blir smutsig, kan den rengoras pa nagot av foljande satt:
1) Fingeravtryck — torka ytan forsiktigt med en mjuk trasa.
2) Damm eller smuts — blas latt pa skivan och torka det smutsiga partiet med en mjuk trasa, eller rengör den smutsiga delen med en fuktig, mjuk trasa och torka darefter med en torr trasa.
3) Fett eller olja — rengör med en mjuk trasa fuktad med isopropanol och torka darefter med en torr trasa.
Observera att sprayer och vätskor som anvands till vanliga skivor, kan skada ytan pa kompaktskivan. Anvandning av sadana rengöringsmedel rekommenderas ej.
Skivan bor ej utsättas för direkt solljus, värme eller fukt for en längre tid.

Independent record labels seemingly did not feel the same pressure as the major labels to include handling and storage information about their CDs, as most did not. I.R.S. Records is an exception to this rule, and their own version is reprinted in Figure C6. Even by 1985, one year earlier, when the CD was celebrating its first year in the consumer marketplace, it had become common for manufacturers to print their handling care templates in multiple languages, as did I.R.S. Records (either following suit or by independent decision). Figure C7 shows a detail of the English portion of their boilerplate.

Figure C7: I.R.S. Records, 1986 *(detail)*



The signal read-out surface is the reverse side of the printed label side. While the compact disc is much more resistant to scratches and dirt than a conventional record, it is best to be careful not to scratch the signal surface and to keep it clean — free of dust, dirt and fingerprints.
If the signal surface becomes dirty, clean it in one of the following ways:
1) Fingerprints — Lightly rub the surface with a soft cloth.
2) Dust or Dirt — Blow lightly on the disc and wipe the dirty part with a soft cloth, or clean the dirty part with a damp, soft cloth and then wipe dry.
3) Grease or Oil — Clean with a soft cloth dampened with ethyl alcohol, then wipe dry.
Please note that conventional sprays and liquids used to clean records may damage the surface of the disc. Use of such cleaner is not recommended.
Also, please do not expose the disc to direct sunlight, heat or humidity for a prolonged period of time.

The reader will note that the latter half of the I.R.S. records template is similar to its predecessors. The first portion, however, varies in that it attempts to explain the difference between the top side of the disc ("the printed label side") and the bottom side ("the signal read-out surface"). Unfortunately, the attention paid to the bottom side and the wording employed both give undue emphasis to this more hardy side of the disc, inferring (however unwillingly) that it is the more easily damaged of the two sides. It is probably for the best that this model was not imitated.

The popular use of handling/care instructions in the packaging of CDs appears to have ceased sometime in the late 1980s. It is rare to find an example of the boilerplate text in use in any compact discs from 1990, and virtually unknown afterwards.

Sources of Illustrations for Appendix C

C1: Public Image Ltd. (1985). Booklet. Included with *Compact disc* [CD]. U.S.A.: Elektra/Asylum Records. Also released under alternate titles *Album* or *Cassette* (depending on physical recording format). Catalog # 9 60438-2.

C2: Ferry, Bryan. (1985). Booklet. Included with *Boys and girls* [CD]. U.S.A.: Reprise Records Ltd. Catalog # 9 25082-2.

C3: Summers, Andy, and Robert Fripp. (1984). Booklet. Included with *Bewitched* [CD]. U.S.A.: A&M Records, Inc. Catalog # CD 5011, 75021 5011 2.

C4: Nelson, Bill. (1984). Booklet. Included with *Vistamix* [CD]. Epic / CBS Records Inc. Catalog # EK 39270.

C5: Sakamoto, Ryuichi. (1984). Booklet. Included with *Thousand knives of [Ryuichi Sakamoto]* [CD]. Japan: Denon. Catalog # 35C38-7137.

C6, C7: Ridgway, Stan. (1986). Booklet. Included with *The big heat* [CD]. Europe: I.R.S. Records. Catalog # CDILP 26874.

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