The Effect of Spelling and Retrieval System Familiarity on Search Behavior in Online Public Access Catalogs: A Mixed Methods Study

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Although technology can often correct spelling errors, the complex tasks of information searching and retrieval in an online public access catalog (OPAC) are made more difficult by these errors in users' input and bibliographic records. This study examines the search behaviors of 38 university students, divided into groups with either easy-to-spell or difficult-to-spell search terms, who were asked to find items in the OPAC with these search terms. Search behaviors and strategy use in the OPAC and on the World Wide Web (WWW) were examined. In general, students used familiar Web resources to check their spelling or discover more about the assigned topic. Students with difficult-to-spell search terms checked spelling more often, changed search strategies to look for the general topic and had fewer successful searches. Students unable to find the correct spelling of a search term were unable to complete their search. Students tended to search the OPAC as they would search a search engine, with few search terms or complex search strategies. The results of this study have implications for spell checking, user-focused OPAC design, and cataloging. Students' search behaviors are discussed by expanding Thatcher's (2006) Information-Seeking Process and Tactics for the WWW model to include OPACs.

Introduction

Searching for information is a complex task, particularly for novice searchers. There are numerous, interrelated factors that affect the efficacy of online searches. Some of these factors relate to information retrieval (IR) system design (e.g., Borgman, 1996, discusses access points and technical skills); others relate to search query formulation (e.g., Novotny, 2004, notes the use of advanced search features and synonyms; Varnhagen et al. 2009, note the importance of correct spelling). Additional factors, such as user knowledge (Borgman, 1996), searching experience (Kim, 2001; Lau, & Goh, 2006), personality (Heinström, 2005), cognitive style (Kim) and strategy use (Varnhagen et al.) also influence searching success. This article examines the impact of correct spelling on IR in a university's online public access catalog (OPAC), as well as the impact of spelling on users' searching behaviors.

The ability to spell words correctly is a literacy skill that is essential but nearly invisible. Effective communication skills—from writing a memo, to searching for information in a directory, or sending an e-mail message—rely on appropriate spelling skills. Indeed, many guides to professional communication note the importance of editing skills to ensure that documents are error-free and communicate the intended message to the reader (e.g., Ross & Dewdney, 1998). In online environments, misspellings may lead searchers to miss important information or believe that very little information exists on a given topic. Despite the advent of spell checkers, spelling continues to be an important aspect of online searching as spell checkers may not recognize mistakes or may make incorrect spelling suggestions. In searching OPACs, spelling is especially important to consider in assessing users' searching skills, as most systems do not include spell-checking functions, leaving many misspellings to go unnoticed. Unfortunately, spelling is not often studied in examinations of effective IR strategies. In the field of library and information studies (LIS), spelling in OPAC searching has been examined primarily to determine the number of bibliographic records that contain typographical errors (e.g., Beall & Kafadar, 2007; Randall, 1999), or it has been treated mainly as a typographical input error similar to

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improper search syntax, rather than a more substantive user issue (e.g., Yee, 1991). When spelling has been examined in studies of users' searching behaviors, this has typically occurred through transaction log analysis of OPAC searches that examine the frequency of misspellings (e.g., Blecic, Dorsch, Koenig, & Bangalore, 1998; Blecic et al., 1999; Drabenstott, & Weller, 1996a; Drabenstott & Weller, 1996b; Malliari & Kyriaki-Manessi, 2007), rather than studies of the individuals themselves who are making the mistakes.

Examining individuals' experiences, in context, as misspellings occur in search queries can give new insights into user behavior, particularly their compensatory search strategies when faced with spelling difficulties. This study adds to the body of research on information-seeking behavior and IR by focusing on the ways that university students search for information when faced with difficult-to-spell keywords, representing topics about which they may have little or no background information. The study focuses, in particular, on the actions taken by these students when misspellings derail their online searches. The findings of this project provide insight into the ways that misspellings in OPAC searches affect IR, with implications for both OPAC (and other online system) design, for cataloging practices, and for effective reference services to support students' searches.

Background and Rationale

Online Search Behavior of Students

Despite the research that has been done concerning students' search behaviors (e.g., Grimes & Boening, 2001; Metzger, Flanagin, & Zwarun, 2003; Urquhart & Rowley, 2007), and despite advances in IR systems (e.g., Sauperl & Saye, 2009), searching in online systems remains a difficult task for most undergraduate students. Griffiths and Brophy (2005), for example, found that 27% of students were unable to find a Web site in the time allotted and 35% of students noted that they found the task difficult to complete. The Web has a vast amount of information, which can make locating specific information particularly difficult; however, even with a smaller amount of information, such as the information in a particular library's collection, finding desired results can be challenging. Case (2007) used the example of searching in a library to delineate some of the common difficulties in searching, including finding the process intimidating, struggling to decide on the "aboutness" of information, gathering together materials on similar topics, and storing information retrieved in different formats.

The OPAC (i.e., the IR system for a library's books, journals, and other materials) can present many problems to users during the searching process. First, OPACs were originally designed for expert searchers or individuals who knew what information was needed and how to express that need in the system's own language. Today, users bear the burden of translating their information needs into a precisely structured query that suits the OPAC's design. In addition to its required rigid queries, the search process in an OPAC also has knowledge requirements, i.e., conceptual knowledge of the IR process, semantic knowledge of how to implement the search, and technical knowledge about skills and syntax (Borgman, 1996). Examining the ways that users interact with these systems remains an important area for research, as OPACs are now typically integrated with databases, online chat, and other tools and services made available on libraries' Web portals (see Leckie, Given, & Campbell, 2009).

Many researchers have noted the difficulty users have in using OPACs (e.g., Borgman, 1996, 1986; Connaway, 2007; Dervin & Reinhard, 2007; Guha & Saraf, 2005; Griffiths & Brophy, 2005; Markey, 2007a; Mercun & Žumer, 2008). One of the reasons cited commonly in this research is that students often search the OPAC as they would a search engine, i.e., with high use of keywords and low use of subject headings, Boolean operators, and truncation. As Griffiths and Brophy note, when students use commercial search engines (in particular, Google) to help them find information, their experience with these systems also "influences their perception and expectations of other electronic resources" (p. 550). Novotny's (2004) research with university students also found that students' search strategies, and students' confusion about OPAC results, were because of their familiarity with search engines and expectations that OPACs would perform in the same ways. The lack of understanding of the capabilities of an OPAC creates difficulties for students and other users. The lack of understanding, generally, about library resources also creates difficulties. Connaway, using focus groups and interviews with faculty, undergraduate, and graduate students, found that users did not understand that databases were library resources and that their inability to access full-text resources frustrating. Familiarity with resources is a major factor in determining which resources are selected (Dervin & Reinhard; Griffiths & Brophy). And many students prefer to use search engines to conduct their searches (Urquhart et al., 2005), using them frequently—Google in particular (Urquhart & Rowley, 2007). Familiarity, along with experience, in using OPACs is also important for the quality of the searches performed (Malliari & Kyriaki-Manessi, 2007). Not only do students choose familiar resources, but some students have been found to be unwilling to try the unfamiliar unless it is required (Urquhart & Rowley). An unwillingness to try the unfamiliar and frequent use of search engines are possible reasons for students' low usage of OPACs, overall, and the difficulties they experience when using OPACs to look for information.

Search engines and OPACs have certain similarities; however, the system complexity of OPACs is far greater than that of search engines. Malliari and Kyriaki-Manessi (2007), when examining over 17,000 OPAC sessions using transaction logs, found that individuals use very few of the search features provided by the system. This poor use of search features, in combination with poor search strategies, was also noted by Novotny (2004). Individuals typically use very simple keyword searches, often simply adding or subtracting terms to change search results (Novotny). Boolean operators are also rarely used (Lau & Goh, 2006; Novotny) and search

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queries tend to be short. Lau and Goh found that only two terms were most commonly used in OPAC searches, followed by the use of only a single term in the search query.

These findings are also mirrored in studies of online searching in Web environments. Spink, Wolfram, Jansen, and Saracevic (2001) found that about two thirds of modified queries changed the number of search terms, with changes typically involving adding terms rather than subtracting. The authors also noted that 48.4% of the users of Excite submitted single-term queries, while 20.8% submitted two terms, with a mean of 2.4 terms overall. Wang, Berry, and Yang (2003) found an average of two words or 13 characters used in university Web site searches. Boolean operators were rarely used, with less than 5% of queries containing an operator (Spink et al.). These findings have been substantiated by a recent review of online end-user searching by Markey (2007a, 2007b), in which users entered short search statements of two to four words with little use of Boolean operators or advanced system features. After the searches are performed, users scanned only the first two pages of results (Markey, 2007a).

In addition to the influence of an IR system on an individual's search, individuals' personal characteristics also affect searching. Personality can influence the ways in which people search for information (Heinström, 2005). Novotny (2004) found that users who had knowledge in a particular domain are more likely to have a successful search than those who have no background knowledge. Tabatabai and Shore (2005) found that more years of attending a university related to search success. In addition, the role of affect has been shown to be a key factor in influencing students' information-seeking activities (e.g., Parker & Berryman, 2007). Overall, search behavior is affected by a myriad of factors that need to be taken into account in studies of students' strategies.

Search strategy use. Search strategies have been studied in LIS to examine the differences between Web-based and OPAC-based IR systems. Thatcher (2006), for example, used Marchionini's (1995) four levels of description in information seeking in Web environments to categorize areas of search moves identified, organize sequences that constituted tactics, identify cognitive search strategies, and group those strategies into patterns. Participants frequently changed their cognitive search strategy during a search task. The type of search task, whether it was researcher-defined or participant-chosen, and whether it was a known-item search or a general browsing task, changed the types of strategies used by searchers. Participants tended to use cognitive search strategies that were more analytical and safe (i.e., using a familiar search strategy) for the researcher-defined tasks to find the most direct path to the answer.

Novotny (2004), for example, examined strategies used in OPAC searching and found that users were unsophisticated searchers, rarely using Boolean operators or synonyms, and more often "refining" insufficient searches by selecting another search type, adding a search term, or deleting a term. Urquhart et al. (2005) noted that participants in the JUBILEE and JUSTEIS studies tended to keep strategies simple, with many users not altering search strategies at all, which often sufficed. Although the OPAC examined in this study provided more sophisticated search options (with drop-down boxes and multiple search boxes), students rarely made use of its capabilities. In general, students lacked a clear understanding of the OPAC's capabilities and tended to rely on their own personal strategies.

Strategy use has also been studied extensively in psychology. Developmental psychology has taken a particular interest in how strategies used in problem solving develop over time. Siegler (1986, 1999), rather than viewing strategies as stages or steps, with simpler strategies being replaced with more complex strategies as children develop, describes strategy choice as overlapping waves. Here, simpler strategies are not discarded; rather, over time the frequency of strategy use will change with some strategies used more frequently and others less (Siegler, 1999). All strategies remain in an individual's repertoire, and individuals learn to choose more effectively between the available strategies, according to the demands of the situation. Strategies used by children and adults become more complex and are used more effectively with time and experience (Siegler, 1999). Finding information using IR systems remains a problem to which users must apply strategies, so this remains an important area of study.

Looking at strategy choice from the perspective of an information-processing cognitive model, individuals have only so much available cognitive space to process information. Strategy use takes up cognitive space, although familiar strategies and learned patterns will require less processing space. New information will also take up more cognitive space than familiar material. Each new task or piece of information that must be dealt with takes up extra cognitive space and makes leaves less cognitive space for processing than familiar tasks and information, thus making the tasks more difficult and time consuming. What this means from an IR perspective is that research (and system design) must account for the variety of factors that influence students' search strategies.

Information Retrieval

Information retrieval is a vast field of study that looks at IR systems, users, and the interplay between them, and these aspects of the field have been looked at in multiple ways. Markey's (2007b) review of several of the current IR models, including Bates' Berrypicking, Kuhlthau's information search process (ISP), and the multiple information seeking episodes (MISE) models, demonstrates the complex nature of retrieving information. In addition to models of user IR, there are models of OPAC design that address these modes of retrieval. Query models, which require some specific query formulation by the user but allow some search modification, have been used frequently in OPAC design. Borgman (1996), for example, describes query matching as effective only when a searcher knows precisely what is wanted; however, one of

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the challenges of much IR is that it requires a description of information that is not yet obtained.

IR systems are complicated and require a certain level of expertise to use. Information retrieval in an OPAC also requires knowledge in the three following areas: conceptual knowledge of the IR process, semantic knowledge of how to execute a query in a particular system, and technical skills to implement the query (Borgman, 1996). As many searchers are not experts and lack conceptual knowledge, they often have difficulty formulating queries, initially using the first keyword that comes to mind, rather than using the controlled vocabulary required to use the system effectively (Markey, 2007b). Users also lack semantic knowledge, tending to "flip-flop" between broad concepts in their initial queries and words and phrases that are more specific (Markey, 2007b). Some scholars (such as Markey 2007b) have labeled this type of information-seeking behavior as "random," attributing to users a low level of metacognitive knowledge (i.e., the process of reflecting on the effectiveness of behaviors and altering behaviors when necessary). Users may also lack the technical skills required to operate an OPAC, tending not to take advantage of the advanced search tools offered by OPACs (Markey, 2007a).

Spelling

Spelling is often thought of as a secondary literacy skill; however, it is essential for clear and accurate communication. It is the skill of converting phonemes into graphemes (Holmes & Castles, 2001). Spelling mistakes obscure communication and affect others' opinions of the person making the mistake. Poor spellers are stigmatized as careless and having poor language arts skills (Varnhagen, 2000). Poor spellers may find that spelling difficulties negatively affect other language arts skills (Vedora & Stromer, 2007). And poor spellers may be advanced readers who take part in postsecondary education (Holmes & Castles). Indeed, as society becomes more technologically dependent, the use of correct spelling increases in importance, especially for effective online IR (Varnhagen et al., 2009).

Spell checkers. Spell checkers, used by many millions of users every day, compare strings of letters entered with the strings of letters in a dictionary or repository, and may make word suggestions if the string does not exist. However, spell checkers do not always produce the correct spelling of a word. For example, spell checkers may come up with erroneous suggestions when the misspelled words are orthographically or phonologically dissimilar to the target word (Montgomery, Karlan, & Coutinho, 2001) or when the spell checker uses common spellings rather than a true dictionary, as is the case with Google's "Did you mean" spell-checking function (Varnhagen, et al., 2009). True dictionaries, with fixed collections of words can also result in text correction problems, particularly for specialized vocabulary. Using the Web as a text repository can be beneficial for correcting text (Jacquemont, Jacquernet, Sebban, & Curien, 2007) and creating dictionaries (Ringlstetter, Schulz, & Mihov, 2007). These benefits are particularly true when domain-specific Web sites are used and when Web sites with orthographic errors are filtered out (Ringlstetter et al.).

Despite advances in spell checkers, they remain problematic, particularly for those with learning disabilities and for whom English is not their first language. Users with learning difficulties, especially those with dyslexia, often produce incorrectly spelled words that are orthographically dissimilar to the intended word. This means that the first suggested spellings from the spell checker will not be the correct term (Montgomery et al., 2001) and IR systems may retrieve results for unintended queries, as some systems modify queries by replacing unknown (i.e. misspelled) terms with the first word suggested (Sitbon & Bellot, 2008). English language learners (ELLs) encounter a spell-checking program designed for native speakers, which does not address how ELLs use phonetic approximation and other ways to compensate for their lack of language knowledge (L'haire, 2007).

In addition, efforts are being made to improve spell checkers to address the needs of those with learning disabilities (e.g., Sitbon & Bellot, 2008) and English language learners (e.g., L'haire, 2007; Ndiaye & Faltin, 2003); however, spell checkers are far from perfect. For these reasons, it is important to investigate spelling consequences and compensatory behaviors in Internet and OPAC searching in more depth, as well as to what can be done to change spell checkers themselves.

Spelling and online searching. Computer searches require input, letter by letter, just as a telephone requires the input of specific numbers in a certain sequence. Each letter added to the search string increases retrieval precision; however, it also increases the likelihood of an input error, which can have negative effects for retrieving the desired information (Yee, 1991). Retrieval systems that use keywords require accurate spelling (Borgman, Hirsch, Walter, & Gallagher, 1995). As computers lack reasoning capabilities, these machines will search only for the user's input, with individuals bearing the burden of performing accurate and skilled searches. Despite advances in fuzzy term, word stemming, and spell checking features, systems still require a certain degree of accuracy for successful searches.

Many OPAC users are also users of Internet search engines. In fact, search engines are used to a much larger degree than OPACs, as evidenced by weekly search engine statistics that dwarf yearly OPAC statistics (Markey, 2007a). As libraries integrate OPAC interfaces into their Web portals, users' experiences with searching practices across these two platforms also become increasingly blurred. Griffiths and Brophy (2005) cite Google's spell-check function as one of the reasons the search engine is popular with students. Although many users expect a spell checker in an OPAC (Drabenstott & Weller, 1996), OPACs typically do not include this feature (Borgman et al., 1995), leaving users unaware of one of the key reasons they may experience an unsuccessful

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search. Should users want to check their spelling, they must first recognize that they have made an error and then verify it through other means.

Misspelling and online searching. Spelling in online searching, although often not the focus of IR studies, has been discussed in research papers. Misspelling, whether in OPACs or the Web, during online searching has been described as "not serious" because of its infrequency (Drabenstott & Weller, 1996a, p. 131), as well as "probably the most common [mistake] made by users of all ages and levels" (Tenopir, 1997, p. 31). The dearth of research on misspellings may be, in part, responsible for these wildly differing opinions. Although research into the frequency and effect of misspellings in bibliographic records on IR has been done (Beall & Kafadar, 2007; Randall, 1999), little research has been done on the effect of user misspellings in Internet (Proctor, 2002) or OPAC searches.

Another reason for some of the disagreement about misspelling frequency may be because of the definition of misspelling. Before graphical user interfaces, input errors and spelling mistakes in command searchers were often lumped together. In Yee's (1991) review of typographical errors, the percentage ranges from 6–54%, in part, because of this imprecise definition. In addition to input errors, variant spelling may be considered a spelling mistake and have a great impact on users' retrieval. Proctor (2002) addressed the issues of archaic, non-English, alternative, and idiosyncratic spellings on the Internet, discussing the challenges that inconsistent spelling poses for IR. Nelson and Feinstein (2007) highlight the degradation of spelling and grammar that has accompanied the introduction of the Internet and the challenges this poses for clear communication. Ernst-Gerlach and Fuhr (2007) discuss the digitization of older works in English and German, making available texts on the Web with variant spellings. The non-standardized spelling used in these older works makes searching for historical documents challenging. As information is produced globally (i.e., documents written with American and British spellings are equally available on the Web) and as different types of information become more widely available (e.g., historic texts with archaic spellings), problems with spelling retrieval may increase. Whether there are incorrect spellings of a search term or whether there are variations of correct spellings, IR systems that are unable to match queries to stored information will result in IR problems.

Though the prevalence of misspellings in online searching is debated, that misspellings have a serious impact on IR is not. Though Drabenstott and Weller (1996a) assert that spelling errors in OPAC searches are not common and are, therefore, not a serious problem, they acknowledge that a misspelling in a search query can disrupt the entire search. Researchers have found that longer, less familiar, and more difficult to spell words result in less successful online searches (e.g. Borgman et al., 1995; Chen, 2003). Varnhagen et al. (2009) found that university and fourth-grade students who could not obtain the correct spelling of a search term could not retrieve information on the topic.

In addition to reduced IR and failed queries, the way in which users interpret and react to misspellings affect searches. Borgman et al. (1995) found that children often abandoned difficult-to-spell search terms and used easier-to-spell, more general search terms in their place. Varnhagen et al. (2009) also observed this finding, in which children and university students modified unsuccessful search queries in a variety of ways, including changing the entire search expression. Drabenstott and Weller (1996a) found users engaged in a variety of behaviors after receiving a failure message from an OPAC that pointed to possible spelling errors, including entering a query on a different topic, abandoning the search, and correcting the spelling. Part of the problem that many users encounter is that OPACs, unlike most search engines, do not have spell checkers.

Misspellings in a keyword search, even in one of the terms in a query, will cause a search to fail, unlike searching by browsing (Drabenstott & Weller, 1996b). Spell checkers have been called for many times over the years (e.g., Drabenstott & Weller, 1996a, 1996b; Tenopir, 1997). Not only does the lack of a spell checker mean that students are without the spelling suggestions they appreciate so much, they may also be unaware that they have made a spelling mistake at all. Drabenstott and Weller (1996a) watched a student misspell a search term multiple times in an OPAC before walking away from the search.

Current Study

This study[1] is a partial replication and adaptation of Varnhagen et al.'s (2009) study *Spelling and the Web*. This research, in the area of developmental psychology, examined how university students and children adapt their search strategies when they are unable to retrieve desired information using an Internet search engine. In particular, participants' behaviors in response to misspellings were analyzed. Search strategy adaptation was examined by asking university and fourth-grade students to search for a given search topic using Google. With the level of difficulty of spelling as the independent variable, half of the students were asked to search for the life cycle of a lemming, while the other half were asked to search for the life cycle of a ptarmigan. Google states that its "spell checking software automatically checks whether your query uses the most common spelling of a given word" and will suggest an alternative spelling ("Did you mean") if that spelling is more likely to retrieve better results (Google, 2008, ¶ 22). Ptarmigan was chosen as a keyword for the study, because at the time the study was conducted, Google did not suggest the correct spelling of the word for orthographically dissimilar spelling variations.

Varnhagen et al. (2009) found that both children and university students changed their search strategies when unable

[1]This paper extends preliminary findings presented at the 2008 Canadian Association for Information Science (CAIS) Conference.

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to spell the keywords. This ability to change search strategies indicates that both groups have an array of strategies in their searching repertoire. As anticipated, university students showed more adaptive strategy use to retrieve information, more often changing their search expressions, whereas, the children were more likely to attempt spelling variations of the keyword or follow the Google's "Did you mean" spelling suggestion. Participants' ability to correctly spell the keyword positively affected their searches, with those participants engaging in fewer searches, viewing fewer pages, and completing the search in less time. If participants were unable to correctly spell the keywords, then the search was unsuccessful. These results supported Varnhagen et al.'s hypothesis that spelling affects search behavior and reinforces previous calls that recommended spell checking in OPAC search programs, namely, spelling programs that use a source dictionary rather than an algorithm based on spelling frequency.

This study modified and extended Varnhagen et al.'s (2009) study of Google to examine IR using an OPAC and to address the following research questions: What effect do misspellings have on catalog record retrieval when using an OPAC? What strategies do participants employ when misspelled keywords render OPAC searches unsuccessful? Do the search behaviors of participants searching for difficult-to-spell keywords differ from those searching for easy-to-spell keywords?

Methods

Participants

Study participants comprised 38 undergraduate and graduate students at the University of Alberta. Participants were recruited in a variety of different ways, including posters, listservs, classroom announcements, and a student participant pool from introductory psychology courses. (Introductory psychology courses require students to participate in research studies to experience the research process. This study was one of the studies in which these students could participate [Varnhagen et al., 2009].) This participant research population was chosen for this study because of the strenuous secondary research demands placed on university students. Participants were randomly assigned to one of two groups: difficult spelling or easy spelling. Ethics approval for research involving human subjects was obtained from the University of Alberta for this study.

Procedures

The study included a pilot study to trial procedures. The only change to procedures was to eliminate the spelling test given to the pilot study students; therefore, all participants were grouped together. Students participated in one 30–45 minute session that comprised a series of three tasks: a pre-search checklist, a computer-based search task, and a post-search semistructured interview. This article focuses primarily on the results of the pre-search checklist and the computer-based search task. Although some key findings from the interview data are included here, to provide additional insight on specific points raised in the search tasks, the interview data will be explored in a separate publication because of the richness of the data gathered.

Pre-search checklist. The session began by having the students complete the presearch checklist (Kim, 2001; Slone, 2000; Tabatabai & Shore, 2005; Varnhagen et al., 2009). The pre-search checklist was created to gather basic demographic data and to assess students' previous experience with OPACs and other online searching. The pre-search checklist was used to determine the impact of previous experience on search behavior. The pre-search checklist modified existing questionnaires (Slone; Varnhagen et al.). The checklist obtained participants' demographic information and, using Likert scales, participants' comfort using computers, experience in online searching (including the Internet, OPACs, and databases), and confidence in searching abilities.

Search task. The search task comprised four separate OPAC searches for specified search terms. The search terms used in the search task included two terms that represented subjects/topics, one geographic name and one personal name. The types of search terms were determined according to the frequency of keyword access points used in OPAC searches (Drabenstott & Weller, 1996a). The easy spelling and difficult spelling groups were given different search terms, the independent variable being the difficulty level of the search terms. The search terms that were given to the easy spelling group were at approximately a 10th-grade reading level, as determined by the Flesch-Kinkaid reading level. These search terms are as follows: lemming, civilian, Bolivia and Sigmund Freud. The search terms given to the difficult spelling group came from lists of commonly misspelled words (LovetoKnow Corp., 2009; Oxford University Press, 2009) or, as was the case for the geographical and personal names, they are orthographically impossible in English. These search terms are as follows: ptarmigan, millennium, Qatar, and Michel Foucault. Lemming and ptarmigan were chosen, because these were search terms used in Varnhagen et al.'s (2009) study, to provide comparative data. Particularly difficult search terms were given to the difficult spelling group in an attempt to induce misspellings and to then observe students' search strategies in relation to the resulting problems encountered.

Participants were given up to 5 minutes to perform a search for each term in the search task, for a total of 20 minutes. Participants used a laptop to search the University of Alberta's OPAC, which runs SirsiDynix' integrated library system, Unicorn, and contains a union catalog, NEOS (a consortium of central Alberta government, health, college, and university libraries). The NEOS catalog's default is the basic search and the keyword search (called "Any field"). Participants were given the choice of using either Internet Explorer 7.0 or Firefox 2.0 as their Web browser.

To ensure that participants did not see the correct spelling of the search term, the researcher read the first search term

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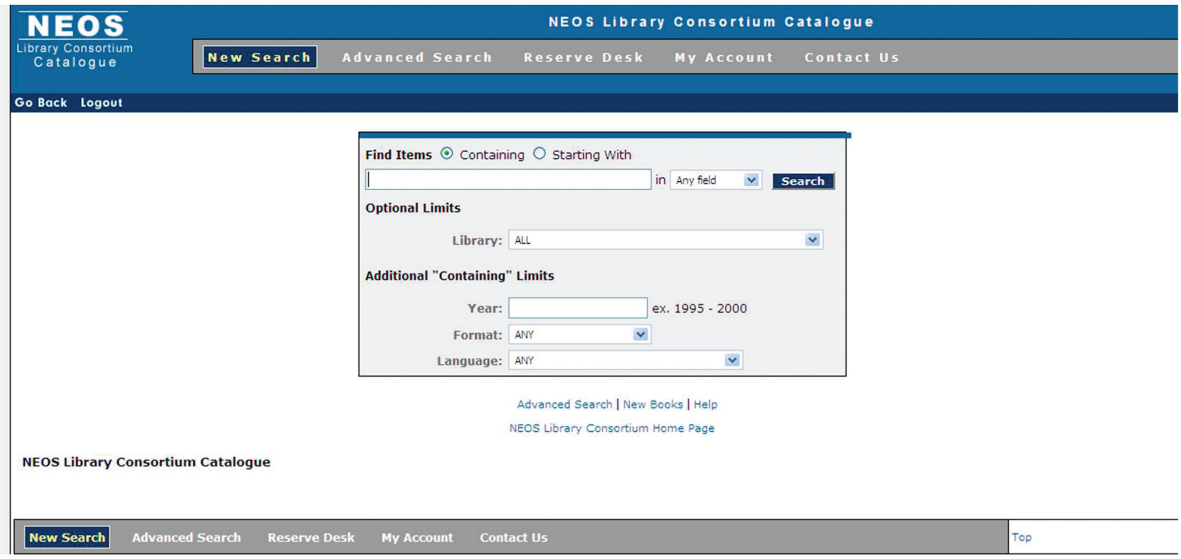

FIG. 1. NEOS OPAC interface. (Used with permission of the NEOS Library Consortium and the University of Alberta.)

aloud to the participant. If participants were unfamiliar with the search term, the researcher provided a brief definition (e.g., "A ptarmigan is an arctic bird"). The researcher then instructed the participants to find as many items on the topic as they were able in the OPAC. Participants made decisions about how to search for the search term and what to include as being "on topic." After 5 minutes had elapsed or the participant had indicated they were finished the search, the research read the next search term. This occurred until all four searches were completed. Although participants were asked to retrieve information from the OPAC, they were instructed that they could use any "other resources" (i.e., computer programs or online resources) to aid them in their search. Participants' searches were recorded using the screen recorder program Camtasia (Novotny, 2004; Varnhagen et al., 2009) to capture students' search behaviors, in particular, problems students encountered while searching and the strategies they employed to solve those problems, and to determine the resources on which the students relied. Camtasia, which records approximately 13 frames per second screen activity and interleafing an audio recording, was used to capture the search activity as well as any comments made by participants. Descriptive statistics and Welch's *t* tests were performed on the search task data.

Semi-structured interview. After the search task was completed, participants were asked to complete a post-search, semi-structured interview. The interview explored participants' reasoning behind their search behaviors, confidence levels when searching, and problems encountered during the search task. In addition to the interview questions, aspects of the participants' searches that were noted during the search task were discussed with participants. The semi-structured interview was created using research tools from the literature (Slone, 2000; Varnhagen et al., 2009) and new questions designed for this study. The interviews were also recorded using Camtasia. The interviews were examined using a grounded theory approach.[2] Students were assigned a pseudonym to keep confidentiality when discussing interview results. A mixed methods approach was used to gain clarity of participants' actions and the reasoning behind those actions.

Findings and Discussion

Participant Backgrounds

Demographic information about the participants was gathered through the pre-search checklist. In total, 38 students participated in the study, 6 in the pilot study and 32 in the principal study, including 24 (63%) females and 14 (37%) males. The median age was 19.5 (range 18–59). There were no significant demographic differences between the groups.

Participants varied in years of experience and faculty background. Of the 38 participants, six were graduate students and 32 were undergraduate students. Participants were divided into junior students (students in their first and second years of university) and senior students (students in their third year of university or higher), of which there were 20 (53%) junior students and 17 (45%) senior students (one student did not provide that information and his data were, therefore, excluded from the *t* tests conducted to examine junior vs. senior breakdowns). The students had a variety of faculty backgrounds, with the majority of students coming from the faculty of science (17), followed by arts (7), engineering (5), education (4), physical education (4), and open studies (1).

Using the pre-search checklist, participants indicated whether they were "comfortable" or "very comfortable" using computers (average of 3.5 on a 4-point Likert scale).

[2]The interviews are discussed below as far as they enlighten participants' searches. Details of the interview results will be discussed in another paper.

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Participants also indicated they most often searched using the Internet (average rating 4.4 on a 5-point Likert scale), less frequently the University of Alberta's OPAC (average rating 2.2), less frequently still the University of Alberta's databases (average rating 2.1), and rarely searched other library OPACs (average rating 2.0). In comparing responses, there were no statistically significant differences between the difficult spelling and easy spelling groups. Comparing responses between junior and senior students, senior students reported higher usage of the University of Alberta OPAC and rated their finding of information in the OPAC higher, $t(34) = 2.48$, $p = 0.018$ and $t(23) = 2.45$, $p = 0.022$, respectively. (Equal variances for the populations could not be assumed, so all comparisons of means were done using Welch's t test.[3]) Overall, participants indicated they were comfortable using computers and had some experience doing online searching.

Spelling

Use of spell checking. Each participant was asked to perform four separate search tasks, totaling 152 searches, to find as many items in the University of Alberta library catalog as they could for given search terms. Participants were informed that they could use other resources to aid them in their OPAC search. Therefore, participants used both the Internet and the OPAC to perform their search tasks. Participants used several different Internet and computer resources to check their spelling, ensure they were using the correct terms (when unfamiliar with the search term), and gather background information about the topics.

Participants did not check the spelling of all search terms, however, they did check spelling for 47% of the searches performed (72 of the 152 searches). There were differences between how the two groups used the Internet. For each search, participants in the difficult spelling group checked spelling more often than participants in the easy spelling group, $t(35) = 6.97$, $p = 0.0001$. Senior students (students in their third year of university or higher) appeared to check their spelling more often than junior students (students in their first and second years of university), however, the difference did not reach statistical significance, $t(34) = 1.98$, $p = 0.056$. This finding should be explored further to determine whether years of schooling increase awareness that correct spelling influences IR. (For the breakdown of each search performed on the Internet to check spelling, please see Table 1.)

Internet strategies to find and check spelling. Participants used a variety of search strategies on the Internet to find the spelling of the search term, including typing in the search term (correctly or phonetically spelled), trying spelling variations of the search term, typing in the search term and the general topic of the search term together, and typing in the general topic of the search term by itself. Participants who had difficulty finding the spelling of the search term initially often changed search strategies and searched for the general subject, rather than the specific noun. For example, "Middle East" was used in Wikipedia to find "Qatar." Spelling variations of the term were also paired with the subject to find the spelling. For example, "tarmagin, bird" was used in Google to find "ptarmigan." (For the breakdown of the Internet search strategies to check spelling, please see Table 2.)

The difficult spelling group was more likely to use the topic as a search strategy to find the spelling than the easy spelling group, $t(19) = 5.92$, $p = 0.0001$. Only one participant in the easy spelling group used the general topic (either by itself or in combination with a variation of the word) to find the spelling of the search term. All other search strategies used by the easy spelling group to check the spelling were typing in the word itself (in some variation). Although participants in the easy spelling group more often simply typed in the word, those in the difficult spelling group used multiple strategies, in particular, including the search topic as part of the search query. Although there appeared to be a difference between participants' years of schooling, with senior students appearing to be more likely to use the topic as a search strategy to find the spelling than junior students, the difference did not reach statistical significance, $t(28) = 1.98$,

TABLE 1. Number of participants searching the Internet to check spelling.

Keyword Easy/difficult	Checked spelling (%) Easy ($n = 19$)	Checked spelling (%) Difficult ($n = 19$)	Checked spelling (%) Junior ($n = 20$)	Checked spelling (%) Senior ($n = 17$)*
1. Lemming/Ptarmigan	4 (21%)	14 (74%)	6 (30%)	12 (71%)
2. Civilian/millennium	1 (5%)	10 (53%)	4 (20%)	7 (41%)
3. Bolivia/Qatar	3 (16%)	18 (95%)	9 (45%)	11 (65%)
4. Sigmund Freud/ Michel Foucault	4 (21%)	18 (95%)	9 (45%)	12 (71%)

Note. *One student did not give his/her year of program.

TABLE 2. Number of times search strategies were used to check spelling.

Group	Type in word only	Type in search topic	Try spelling variations	Type in word and search topic together	Total strategies
Easy ($n = 19$)	11	0	0	1	12
Difficult ($n = 19$)	30	10	12	25	77[a]
Junior ($n = 20$)	15	3	9	6	33[b]
Senior ($n = 17$)[c]	25	7	3	19	54[d]

Note: More than one search strategy can be used by a participant.

[a]Participants in the difficult spelling group used multiple search strategies while completing a search for a single term a total of 15 times.

[b]Junior participants used multiple search strategies while completing a search for a single term a total of seven times.

[c]One student did not give his/her year of program.

[d]Senior participants used multiple search strategies while completing a search for a single term a total of nine times.

[3]The Student's t test was attempted to compare the means of the data, however, Levene's test for equal variance indicated that the equal variance assumption could not be met and Welch's t test was used instead.

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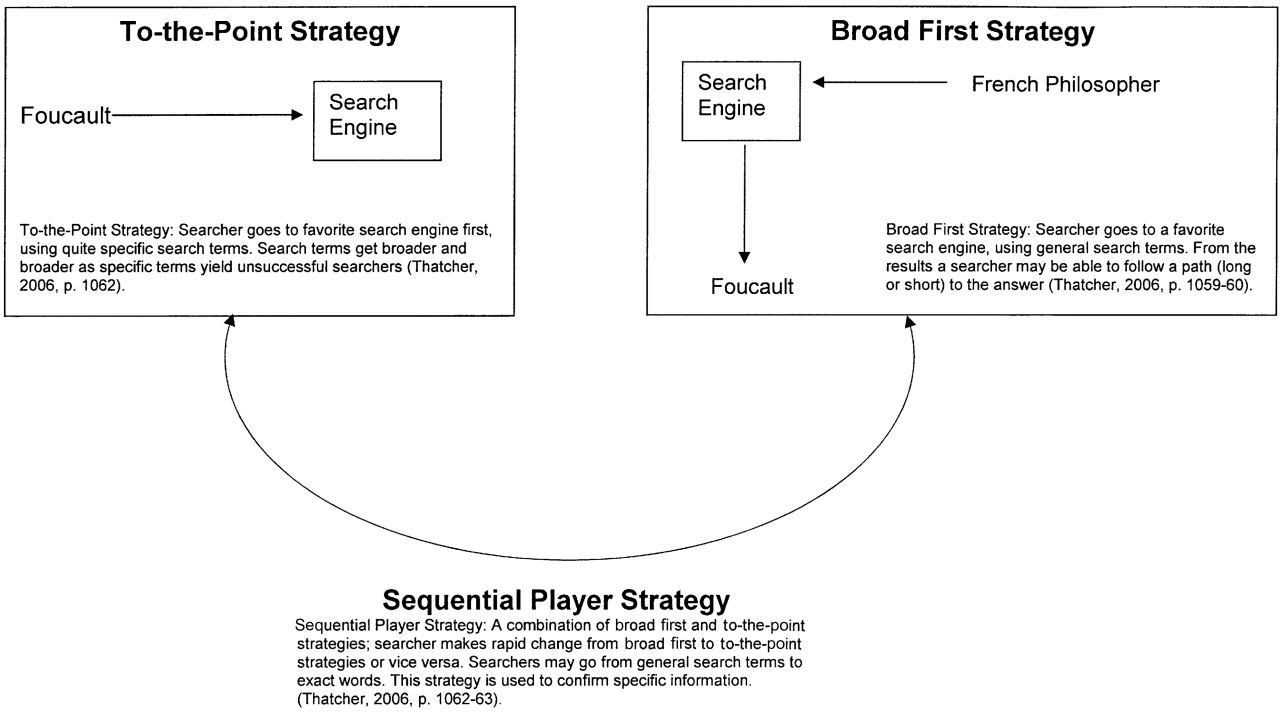

FIG. 2. Example of the difficult spelling group search using Thatcher's cognitive search strategies.

$p = 0.058$. This finding should be further explored to determine whether years of schooling increase the use of topic search strategies for IR. The inclusion of search topics to find difficult-to-spell words has been observed in other research (Varnhagen et al., 2009).

Students who search for a general topic in a search engine to check spelling was similar to the "broad first" cognitive search strategy identified by Thatcher (2006), in which participants went to a known search engine and used "one or more general search terms defined by the search task" (p. 1060). This strategy is one of the "safe player" strategies, as participants used a cognitive strategy flexibly for familiar tasks. Typing in the word only was similar to Thatcher's "to-the-point" strategy, in which participants went to a favorite search engine and used specific search terms to quickly find the exact answer. This strategy was not considered "safe," as there was no narrowing down of the search but was meant to find the most direct path. This strategy was typically used with researcher-defined search tasks. Students also used the "sequential player" strategy, in which participants make rapid changes from "to-the-point" to a "broad first" strategy by alternately using broader and narrower search terms. Participants who wanted to confirm specific information used this cognitive search strategy in Thatcher's study. (For a graphical depiction of the "broad first," "sequential player," and "to-the-point" strategies, please see Figure 2.)

Results of checking spelling. To obtain the correct spelling, participants used a combination of checking the spelling and retrieving the spelling from memory. Of the 152 searches, 123 (81%) were found by either retrieval from memory or looking the search term up on the Internet, indicating that search strategies were effective. Some of the correct spellings of search terms were obtained as a result from correcting initially misspelled search terms. Of the 123 correctly spelled search terms, 19 (15%) were corrections made after attempting to search using misspellings. The majority of the corrections made were as a result of checking spelling (16 corrections or 84%), while the rest (three corrections or 16%) were corrected from memory.

For one of the search terms, millennium, many of the participants misspelled the search term throughout their search ("millenium"). Of the 15 participants whose searches contained the misspelling, nine (60%) did not catch the misspelling because the spelling was not checked. However, checking spelling did not always result in correct spelling, as six participants (40%) checked their spelling but the misspelling was not caught by the resource used. The lack of a true dictionary provided by search engines such as Google, which bases its spelling suggestions on the frequency of use, meant that the correct spelling did not appear in "Did you mean" and the misspelling of the word was even suggested for one search. This type of misinformation is not only misleading but also very confusing for searchers, as it may reinforce their incorrect beliefs in their spelling abilities. Despite the problems with obtaining the correct spelling of millennium, the search strategies of checking spelling or retrieving correct spelling from memory were effective.

Impact of spelling on IR. Each participant had four search tasks to complete, using the University of Alberta's OPAC. In total, 138 (91%) of the 152 searches were completed. Incomplete searches were because of participants being unable to retrieve information in the OPAC on the topic given.

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TABLE 3. Number of participants per spelling group with corrected misspellings, uncorrected misspellings, and unsuccessful searches.

Group	Corrected spelling mistakes	Uncorrected spelling mistakes	Unsuccessful searches	Total mistakes
Easy (number of mistakes)	Lemming (2) Bolivia (2)	N/A	Lemming (1)	
Count	4	0	1	5
% of spelling mistakes, $n = 46$; (% of searches, $n = 152$)	9% (3%)	0% (0%)	2% (0.7%)	11% (3%)
Difficult (number of mistakes)	Ptarmigan (5) Millennium (3) Qatar (3) Foucault (2)	Millennium (15)	Ptarmigan (4) Qatar (6) Foucault (3)	
Difficult totals	13	15	13	41
% of spelling mistakes, $n = 46$; (% of searches, $n = 152$)	28% (9%)	33% (10%)	28% (9%)	89% (27%)
Overall total	17	15	14	46
% of spelling mistakes, $n = 46$; (% of searches, $n = 152$)	37% (11%)	33% (10%)	30% (9%)	100% (30%)

The searches were categorized as (a) containing a corrected spelling mistake, (b) containing an uncorrected spelling mistake, or (c) being unsuccessful (i.e., the search was not completed and information on the topic was not retrieved, bringing up a "[search] found no matches in the library you searched" message). (For the breakdown of each search performed that included a misspelling, please see Table 3.) The difficult spelling group was more likely to have incomplete searches than the easy spelling group, $t(19) = 2.55$, $p = 0.20$. Of those 152 searches, 46 searches (30%) contained a misspelled search term at some point during the OPAC search. Some searches were performed with a correctly spelled search term, but another word in the search was misspelled, affecting IR. Words such "arctic," "and," "rodent," "culture," and "philosopher" were misspelled during the searches. Although some of the misspelled words are commonly misspelled (e.g. "artic"), others were simply typographical errors (e.g., "adn"), which were not caught and corrected by the searcher. Whatever the cause of the mistake, the misspelling resulted in no results retrieved.

The searches that contained misspelled search terms retrieved no records, with the exception of "millennium." The misspelled word "millenium" retrieved results from the University of Alberta OPAC, as some of the OPAC records contain this spelling in fields such as title, notes, and subject heading. (This spelling of millennium is both a misspelling and an archaic nonstandard spelling). Of the 19 searches for millennium, 15 (79%) were misspelled. The incorrect spelling of this term resulted in approximately 6% of the records that contained the term millennium being retrieved, a difference of 2,496 for *millennium* and for 152 *millenium*. Indeed, many students were unaware that their search for *millenium* contained a misspelling, especially because several students checked this spelling in Google but did not receive a suggestion for the correct spelling, as millennium is a very commonly misspelled word. Millennium is misspelled so commonly that it was mentioned in the Wikipedia article on the topic until the article was revised June 30, 2008 (Wikipedia, 2009a) and Wikipedia will automatically redirect misspelled queries to the correctly spelled page (Wikipedia, 2009b).

Although it was not possible to determine how spelling affected overall IR rates (as participants' variety in OPAC search expressions and search fields used, more greatly affected retrieval rates than the spelling difficulty of search terms), it is evident that spelling greatly affected the searches. Misspelled search terms retrieve a fraction of the total number of items on a topic and are successful only in retrieving those few items because of archaic spellings or typographical errors in the catalog (or in the original works). Retrieving records with misspellings often misleads students into believing that they have found all that they can on the topic, which appeared to be the case for 79% of the participants, who misspelled the search term millennium. For misspelled search terms that do not correspond to typographical errors in the OPAC, no results were retrieved. If the correct spelling cannot be obtained in some way, as was the case with 9% of the searches, then the search results in a failure to retrieve any information on the specific topic, confirming the findings of other studies (e.g., Drabenstott & Weller, 1996; Varnhagen et al., 2009). More difficult-to-spell search terms resulted in misspelled search terms and searches that retrieved no results.

Use of resources to check spelling. Participants used a variety of sources to check spelling, tending to use more common Internet resources such as Google, Wikipedia, and Dictionary.com. Some used many different resources to check their spelling. Of the 23 participants who used other resources to check their spelling, 21 (91%) used Google, five (22%) used Wikipedia, four (17%) used Dictionary.com, and one (4%) used Merriam-Webster.com, Yahoo!, Ask.com, and Microsoft Word. (It should be noted that Google was the search tool located on the menu bar of both the Web browsers used for the study). Although resources used by the different groups were similar, it is difficult to compare, as more

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participants in the difficult spelling group performed Internet searches than participants in the easy spelling group.

Participants used the resources in different ways. Wikipedia was used to confirm if an unfamiliar term was the correct search term, as well as to gather background information. Google was used to search for the search term, as well as for spelling suggestions. Participants in this study used resources similar to those in the sense-making studies done through Ohio State University and OCLC. Connaway (2007) found that in addition to participants' heavy use of Google, students and faculty members tended to use Web browsers and Web resources frequently, especially for quick searches and to familiarize themselves with topics. These results echo another finding from the sense-making studies about how users choose to use resources. Dervin and Reinhard (2007) found that users generally made rational decisions about their searches based on their context and chose search strategies and effort levels based on the needs of the situation (quick vs. detailed searches). Although some of the most common Web sites were used, they were used in ways to meet specific needs for the search tasks.

Spelling suggestions were obtained through Google's spell-checking function, "Did you mean," or typing letters into the Google search box on the menu bar (i.e., as you input letters, a list of possible words is given in a drop down menu below). Google automatically "checks to see if you are using the most common version of a word's spelling" (Google, 2008, ¶ 22). The "Did you mean" function appears when Google calculates that a more relevant search would be generated using an alternate spelling. Google's suggestion is based on all the occurrences of the words used on its indexed sites. Similar spell-checking functions with spelling suggestions could be obtained with Dictionary.com and Merriam-Webster.com. Of the 152 searches performed, 36 searches (24%) used spelling suggestions. Of the 36 spelling suggestions, 31 (86%) were from Google (either "Did you mean" or the search box suggestions), four (11%) were from Dictionary.com, and one (3%) was from Merriam-Webster.com. We found it interesting to note that Google did not suggest "millennium" when "millenium" was used as a search term, indicating this is a frequently misspelled word. Participants often used the spelling suggestions generated by Google and Dictionary.com; however, the spelling suggestions were not always correct.

Students used familiar resources to check spelling. The way in which some students used Wikipedia resources was similar to Thatcher's (2006) cognitive search strategy, "known address search domain," in which participants went directly to a Web site, rather than a search engine, and used that site as a portal for the search task. Several students checked spelling or confirmed unfamiliar terms, directly going to Wikipedia. Other students used Google to search for their topics and selected Wikipedia articles from the results, unlike Thatcher's "known address search domain" strategy. It would be useful to ask students in the future whether they type search terms into Google knowing that Wikipedia articles are typically the first results displayed.

TABLE 4. Examples of participants' interview responses about resources used to check spelling.

Resources to check spelling	Participant examples
Resources used	• "No, I don't have a problem because if I do a Google search and I type something wrong, it already gives me a suggestion of the right spelling." Sunil • "Then [to make sure the spelling was correct] I would go onto Roger's Dictionary on here and then find the correct spelling of the word and then I would go back and put it in." Taya • "I go to Dictionary.com or Oxford Dictionary.com or 'define' in Google, Yahoo! or an electronic dictionary I have at home. Or a book, a normal dictionary." Wadiah
Use of spelling suggestions	• "I often use Google as a dictionary. Well, at least for spelling, just because I find if you use an online dictionary you have to type it in correctly spelled, pretty much, before you get it. But Google's really good at picking up on wacky spellings of words so that's nice when you don't know." Stella • "Google's good for that because you can spell it sort of correct and it'll tell you, it'll give you one or two forms and you can read the descriptions – this is completely wrong and this one's right." June

Students typically used Google as their search engine. One of the two students who used a different search engine displayed Thatcher's (2006) cognitive search strategy, "search engine narrowing down," in which a participant selects a search engine to narrow down the search domain and select that engine based on its attributes. The student who used Ask.com stated that he wanted to use a search engine that would give topic suggestions. Because other search engines could have provided more useful search options than Google, it may be wondered if students lack a variety of sources with which they are familiar.

When asked about what resources students use to check spelling, many participants mentioned the same resource used to do their searches. Google was often discussed as a place to check spelling. Students discussed the convenience of having Google automatically spell-check search terms, especially as many students regularly use the search engine for their personal, and sometimes academic, searches. Students also listed electronic dictionaries, more commonly online than computer desktop dictionaries. Dictionary.com was most often cited, however, Merriam-Webster.com was also mentioned. Many students appreciated a spelling suggestion feature. (See Table 4 for examples from participants' interviews about spelling resources and the use of spelling suggestions.)

Dervin et al. (2006) discussed users' views of the helpfulness of a resource. Though some sources, discussed by users, provided information, users judged information as more helpful when they saw that information as moving them forward in their self-defined situation. Whatever the type of information source, the most important aspect of the source is the user-perceived helpfulness in a specific situation. As users strive to make sense of the information universe, what is

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important to the user is its ability to help when needed. Olsson (2009) discusses current models of information seeking as system-focused, based on information professionals' interactions with users—beginning with a defined question, progressing with a search for specified information, and ending when information is supplied. Information-search behavior is one aspect of information behavior as a larger field (Wilson, 2000), yet is the focus of a disproportionate amount of research (Olsson). Information professionals identify and design information retrieval systems for specified tasks. However, there appears to be a discrepancy between what users and information professionals consider important. Users are less concerned about what systems were designed to do and more concerned with whether the system is useful to them in their current situation.

Discussion of spelling as an obstacle. Difficult-to-spell words were used as the independent variable in this study. When asked in the post-search interview about problems encountered during the search task, many participants (particularly those in the difficult spelling group) mentioned spelling as a problem. Although many participants indicated that they rarely search for topics about which they know so little, several participants made mention of the unknown item searches they perform, often from what they hear on television, the radio, or in lectures. Participants discussed these searches as sometimes causing difficulties.

What we also found interesting were the responses of many participants about how spelling affected their searches and what they do to deal with spelling difficulties. Participants reported that the effect spelling had on their searches ranged from almost none (typos) to a quite a lot, with some participants habitually checking their spelling. Participants often identified themselves as either "good" or "poor" spellers. When discussing spelling problems, some participants mentioned specific strategies such as using resources to check spelling, searching for a more general topic, or asking for help, while others were very nonspecific about how they problem-solve. (See Table 5 for examples from participants' interviews about spelling as an obstacle to searching). It is interesting to note some of the students' expectations of what an OPAC should include: a spell checker and one with suggestions.

TABLE 5. Examples of participants' interview responses about spelling as an obstacle to searching.

Spelling as an obstacle	Participant examples
An obstacle	• "Because sometime I type in the wrong spelling and I just, my search goes in the wrong way, that might cause some confusion and these are topics with similar—they must seem similar in spelling but they are different things. So, . . . I check it with Google quickly or I might check a dictionary." Mahdi • "Because with the Web, at least it tells you 'Did you mean this?' and it gives you the best spelling. But with NEOS, just zero searches, or zero results. It doesn't do its job." Mei • "Yeah, I definitely find that that's the case sometimes, I'll be in class and I'll be like, "Oh that's an interesting word I should go look it up." And then I'll go and type it in and then not necessarily know how to spell it and not really be able to find anything and then get frustrated. But then ask somebody else that maybe knows what it means. But no, I do find that sometimes I'll kind of get stuck on a word or just a concept that I hear people talking about or on TV." Amy
Not an obstacle	• "I think if I don't know exactly how to type it, I'll just type in, if I don't know exactly how to spell it I'll just type in different versions of it and the result that comes up in most is probably the one that's how you actually spell it. And sometimes I'll use Wikipedia because it's just easy and it just comes up and you don't need to look through many searches, it'll just bring you the person right at the top." Alana • "No, I don't have a problem because if I do a Google search and I type something wrong, it already gives me a suggestion of the right spelling." Sunil • "Well, in this day and age where no one know how to spell anything, I think because we just type things and who even cares? And my Mac is Mac Leopard, so it does a spell check while you're searching for things or if you're writing an e-mail it spell checks directly on the screen, so, you know, I don't even need to know except when I'm writing exams and stuff." Cory

OPAC Searching

This study was designed to determine the percentage of the total number of records on the given topic that students were able to find using their natural search strategies. In particular, the study intended to compare the percentage of the total number of records found by the easy and difficult spelling groups. However, students' search strategies and what they determined to be "on topic" were so variable that comparisons were of little value. What was interesting was examining their search behaviors.

Participants tended to keep their OPAC searches simple. The majority of participants' completed searches comprised one word (or one full name) in their search. Of the completed 138 searches, 101 searches (73%) comprised one search term. Only 37 searches (27%) combined two or more different terms in the search string. The terms added were either an attribute of the topic (e.g., "bird" added to "ptarmigan") or a specific aspect of the topic (e.g., "civilian military").

Several different search strategies were observed in the OPAC searches, including: spelling variations, Boolean operators, truncation, synonyms, other search fields, additional terms, multiple searches, and the same searches retyped. Although there was some variation, the only statistically significant difference between the groups in strategy use was the difficult spelling group, which used spelling variation more than the easy spelling group, $t(23) = 2.15$, $p = 0.042$. (For the breakdown of the search strategies that were performed using the OPAC to find items on the topic, please see Table 6.)

Although some of these strategies were used initially in the searches with the intent to find the correct spelling, only

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two searches were able to find resources specifically on the topic using searches for the general topic or spelling variations. The majority of strategies employed were used with the correctly spelled search term to find items on the topic. The most common search strategies were adding in search terms and performing multiple searches using the same search term in different search fields. Search strategies were quite similar between the two groups.

Although there was some variety in the search field used, the majority of participants used "Any field" in which to perform their search. (For the breakdown of the search fields used in the OPAC searches to find items on the topic, please see Table 7.) Participants also tended to keep the search field broad, most often choosing "Any field" as the field in which to search. Of the 138 final searches, 79 searches (57%) used "Any field." There was no statistically significant difference between the use of the search fields between groups or for years of experience. Participants who used the Internet tended more to use different search fields than those who searched the Internet less often. Students who searched the Internet every day were more likely to use "Any field," $t(28) = 2.12$, $p = 0.043$. The finding that students who use the Internet use "Any field" more frequently also indicates that students' OPAC searches are influenced by their experience with search engines.

The search strategies used by participants are similar to other research findings. Students used Boolean operators, truncation, and synonyms infrequently (Markey, 2007a; Novotny, 2004; Urquhart et al., 2005), while they changed search fields and added terms frequently (Novotny). As with the users in other studies, this indicates that students may be attempting to search the library's OPAC as they would a search engine. Students' experience is one of the most influential factors to user behavior (Urquhart et al., 2005). An alternate explanation for participants' use of familiar resources and simple search strategies was their evaluation of the amount of effort and complex searching required for the task given, as users make rational decisions based on the need of the situation (Dervin & Reinhard, 2007). Although many factors influence search behaviors and retrieval results, spelling is an important aspect of online searching, whether on the Internet or in an OPAC. With the exception of misspelled search terms that retrieved misspellings included in the catalog records themselves, an uncorrected misspelling led to the retrieval of no information on the topic.

TABLE 6. Number of participants per spelling group using different search strategies to search the OPAC.

	Easy group	Difficult group	Total
Search strategy	Total searches = 76 (% of group's total searches)	Total searches = 76 (% of group's total searches)	Total searches = 152 (% of total searches)
Multiple searches	36 (47%)	47 (62%)	83 (55%)
Additional terms	30 (39%)	39 (51%)	69 (45%)
Change search field	29 (38%)	23 (30%)	52 (34%)
Boolean operators	8 (11%)	9 (12%)	17 (11%)
Searches retyped	9 (12%)	6 (8%)	15 (10%)
Synonyms	3 (4%)	4 (5%)	7 (5%)
Truncation	2 (3%)	0 (0%)	2 (1%)
Spelling variations	1 (1%)*	7 (9%)*	8 (5%)

Note. OPAC = online public access catalog.
*Indicates a significant result at the $p < 0.05$.

Conclusions

In examining the results of this study, some limitations should be noted. Participants were asked to search for unfamiliar search terms in an OPAC, with which few had experience. Although participants were encouraged to perform searches as they normally would and were made to feel as comfortable as possible during the study session, some participants noted that they rarely searched the library catalog, so those participants could not search the catalog in a "normal" way. Similarly, the researcher read the words to the participants to study the effects of (mis)spellings on search behaviors. Although some of the students' instructors will give them topics orally in class, students will encounter most topics in some textual form. Similarly, although university students may often perform searches for topics with which

TABLE 7. Number of participants using different search fields in completed OPAC searches.

	Easy group	Difficult group	Search Internet 2–5 times/week	Search Internet every day	Total
Search field	Total completed searches = 75 (% of group's completed searches)	Total completed searches = 63 (% of group's completed searches)	Total completed searches = 56 (% of group's completed searches)	Total completed searches = 68 (% of group's completed searches)	Total searches completed = 138 (% of total completed searches)
Any	39 (52%)	40 (63%)	21 (38%)*	48 (71%)*	79 (57%)
Subject/LCSH	20 (27%)	9 (14%)	17 (30%)	11 (16%)	29 (21%)
Multiple	8 (11%)	9 (14%)	10 (18%)	5 (7%)	17 (12%)
Title	7 (9%)	5 (8%)	5 (9%)	4 (6%)	12 (9%)
Author	1 (1%)	0 (0%)	1 (2%)	0 (0%)	1 (0.7%)

Note. OPAC = online public access catalog; LCSH = Library of Congress Subject Headings.
Columns do not add to the total as they categorize participants in multiple ways.
*Indicates a significant result at $p < 0.05$.

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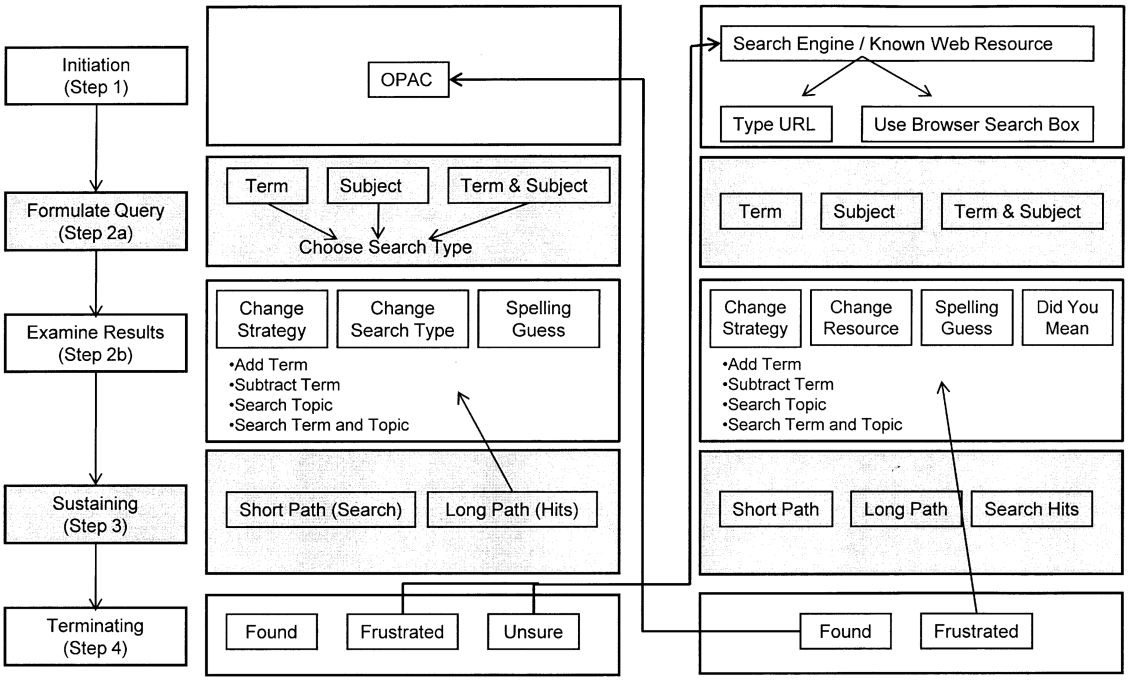

FIG. 3. Student's information-seeking process and tactics in the NEOS OPAC and on the World Wide Web (adapted from Thatcher's, 2006, p. 1061, figure entitled WWW Information-Seeking Process and Tactics).

they have little familiarity, they rarely perform searches with such strict time limits as in this project. The searches were observed, recorded, and timed. The unnatural setting, while allowing participants' searches to be observed and giving an opportunity to start a conversation about their regular searching habits, decreases the validity and, therefore, the generalizability of the study.

The results of this study have many implications, such as using true dictionaries for spell checkers, user-focused OPAC design, and ensuring accurate cataloging. In addition, this study has implications for examining students' OPAC searches. Students' tactics, when searching an OPAC in the context of this study, can be discussed using Thatcher's (2006) Information-Seeking Process and Tactics for the WWW, keeping in mind how students' experience and understanding of the overall information framework contributes to the process.

Thatcher's process has four steps: initiating (Step 1), formulating query (Step 2a), examining results (Step 2b), sustaining (Step 3), and terminating (Step 4). In addition to categorizing students' behavior into steps of the information-seeking process, it is necessary to remember the importance of individuals' experience and its effect on behavior. It is also important to look at the world of information available to students and what aspects they access.

Students use OPACs and other resources on the WWW in similar ways. Relying on familiar resources, they use these search engines and Web sites to aid searches when they are less familiar with the content or the IR system. Students' lack of familiarity with academic resources and their frequent use of other non-academic resources influences student expectations about how academic resources work. There is also a transfer of search strategies from non-academic to academic resources, which often means that students fail to make use of advanced search features available in academic resources. One feature more readily available in non-academic resources is a spelling checker, noted by students as useful. Students appreciate the spelling suggestions offered by search engines such as Google. Spelling remained an important aspect of searching, especially with difficult-to-spell search terms. Most notable, however, was the difficulty in finding items in the OPAC with a variant spelling of millennium, reinforcing the importance of spelling as a literacy skill, spell checkers, and cataloging accuracy.

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