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Evolution and devolution of folkbiological knowledge

Phillip Wolff[a,*], Douglas L. Medin[b], Connie Pankratz[b]

[a]*University of Maryland, College Park, MD, USA*
[b]*Northwestern University, Evanston, IL, USA*

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Abstract

In this paper we present evidence in support of the hypothesis that the average person's knowledge about trees, and about the natural world in general, has declined during the 20th century. Our investigations are based on examination of a large sample of written material from the 16th through 20th centuries contained in the Oxford English Dictionary. In Analysis 1, we show a precipitous decline in the use of tree terms after, but not before, the 19th century. In Analysis 2, we analyze tree terms at different levels of organization and show that the decline observed in Analysis 1 occurs for all levels of organization. This second analysis also reveals that during the 16th to 19th centuries tree terms became progressively more specific, suggesting that during these periods knowledge about trees increased. In Analysis 3, we show similar rates of decline in other folkbiological categories, indicating that the change in tree terms reflects a general decline in knowledge about living kinds. Also in Analysis 3, we show that several non-biological categories have experienced evolution during the 20th century, indicating that the declines in the 20th century for folkbiological categories are not an inevitable outcome of the corpus. Finally, Analysis 4 also shows declines in the frequency of quotations for which the tree term was not the topic of the sentence, and thus incidental to the purposes of the writer. The results from Analysis 4 reassure us that the results from Analyses 1–3 were not solely due to change in the aims and purposes of writers over the centuries. In sum, the analyses indicate that in the domain of trees, there has been a long and sustained period of conceptual evolution followed by a recent pronounced period of devolution.

Keywords: Folkbiology; Conceptual change

* Corresponding author. Department of Psychology, University of Maryland, College Park, Zoology-Psychology Building, College Park, MD 20742, USA.
E-mail address: wolff@psyc.umd.edu (P. Wolff)

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1. Evolution and devolution of folkbiological knowledge

Although science continues to deliver new insights into the basis of life, it is hard to escape the impression that, on an individual and cultural level, knowledge about living kinds is diminishing. Researchers studying traditional societies often note with concern the loss of indigenous languages and a corresponding lessening of knowledge about the natural world (e.g. Atran et al., 1999; Diamond & Bishop, 1999; Nabhan & Antoine, 1993; Wester & Yongvanit, 1995). In technologically oriented cultures, contact with biological kinds may be so minimal that researchers can demonstrate significant differences in children's biological reasoning as a function of whether they do or do not have goldfish as pets (Hatano & Inagaki, 1987; Inagaki, 1990).

A recent survey we conducted at Northwestern University provides some index of what undergraduates know about one domain of biology, namely trees. We provided the names of 80 trees and asked the students to circle the trees that they had *heard of* before, regardless of whether they knew anything about them. More than 90% said they had heard of birch, cedar, chestnut, fig, hickory, maple, oak, pine, and spruce. But fewer than half indicated any familiarity with alder, buckeye, catalpa, hackberry, hawthorn, honeylocust, horsechestnut, larch, linden, mountain ash, sweetgum, and tuliptree, all of which are common to Evanston, IL, where Northwestern University is located. Of course, these observations by themselves do not implicate a loss of knowledge. It may be that Northwestern undergraduates from a hundred years ago would have proved to be equally unfamiliar with biological kinds. Nevertheless, such low levels of knowledge are consistent with the possibility that knowledge about trees is declining.

Factors influencing the level of folkbiological knowledge. Knowledge of living kinds is most likely determined by both direct and indirect exposure to the natural world. Direct exposure would be that afforded by actual physical interaction with the natural world while indirect exposure would be that provided by a culture's research and educational systems. We would expect that decreases in either kind of exposure could lead to decreases in folkbiological knowledge, and visa versa for increases. Based on declines in direct expose, then, we might expect that knowledge of the natural world has declined. With the shift from rural to urban settings, direct exposure to the natural world is no doubt lower now than it ever has been before. However, based on increases in indirect exposure we might expect that knowledge of the natural world has actually increased. Indirect exposure to the natural world through access to the knowledge generated from science is clearly greater now than ever before. Does, then, the average person within our culture know more or less about the biological world than her forebears?

The devolution hypothesis. We hypothesize that despite increases in indirect experience, knowledge about living kinds has decreased during the 20th century, or as we will say, devolved. We will refer to this possibility as *the devolution hypothesis*. While indirect exposure to the natural world may offset the effects of limited direct exposure to an extent, a certain amount of direct exposure may nevertheless be required in order for knowledge about the biological world to take root.

The devolution hypothesis concerns what large groups of people might know about large domains of knowledge across long periods of time. Hypotheses of a similar sort have been made in the philosophy of science literature. According to Kuhn (1970, orig. 1962), for example, domains of knowledge in the sciences undergo a series of peaceful interludes punctuated by violent changes. After a revolutionary episode, the basic tenets and beliefs of a domain are completely replaced. The scale of the devolution hypothesis is similar to that of Kuhn's theory. However, there are several ways in which these hypotheses differ. The kind of conceptual change examined by Kuhn concerns what is known by scientists. The devolution hypothesis, in contrast, concerns what is known by laypersons. According to Kuhn, scientific revolutions involve the replacement of core beliefs with a completely new set of core beliefs. With the devolution hypothesis, the idea is that an entire system of knowledge may simply wither away without replacement. For Kuhn, conceptual change is expected to be turbulent; for the devolution hypothesis, the change is uneventful. The trauma that may often accompany conceptual change in the sciences may also be what makes such change easy to identify and document. For example, the implications of Einstein's theory of relativity or Copernicus' heliocentric theory of the solar system were recognized as significant challenges to their presiding conceptual frameworks even at the time of their introduction. In the case of devolution, the kind of conceptual change involved may be much harder to recognize, which is why a direct investigation may be required in order to establish whether and when such changes have, in fact, occurred.

In this paper, we investigate the devolution hypothesis with respect to the life-form trees. Trees are of special interest because they could represent a particularly strong test of the devolution hypothesis. In terms of contact with the natural world, we may not expect devolution with respect to trees at all. While people in urban environments may have only limited exposure to all but a few mammals (e.g. cats, dogs, squirrels), they are likely to have seen many different kinds of trees. And trees, because of their size, are not likely to be ignored. As argued by Hunn (1999), size is a key factor in determining which natural kinds in a culture attract attention and get named. If the prerequisites for conceptual organization consist solely of an inherent curiosity about living kinds and a perceptual system tuned to discontinuities in nature (Berlin, 1992), then even urbanized cultures should show an appreciation for different kinds of trees. On the other hand, it is possible, despite continued direct exposure, that knowledge about trees has devolved.

Measuring loss of knowledge. In order to test the devolution hypothesis, we are drawn to an assessment of the social–cultural factors that sustain and promote knowledge of a domain, that is, an assessment of the factors that provide ''cultural support'' for a domain of knowledge. Of these factors, the one that probably best reflects a society's cultural support for a particular domain is the content of our communication. What we talk about reflects, in part, what we assume our listeners already know, but also what it is that we want our listeners to know. For example, when walking through a forest, to what extent do adults point out to their children the various kinds of plants and animals and at what level of specificity? Clearly, we are not usually privileged to these sorts of exchanges, and certainly not those occur-

ring during periods much earlier than our own. Fortunately, however, we do have access to another important means of communication in the form of writing. Are people writing about plants and animals as much as they used to? When they do, are they writing at the life-form level (e.g. bird, tree) or at what Berlin (1992) refers to as the folk-generic level (e.g. sparrow, oak)? Not only are written records available, but these records are accessible in on-line databases that permit automated search. By analyzing the contents of what has been written about over the last several centuries, we can provide a preliminary answer to the question of whether or not our knowledge about the natural world is declining.

Oxford English Dictionary (OED). Because our interest is in a longer time span than U.S. written history affords (in terms of databases we might access), we selected a database from England for study: the OED. The OED seeks to capture the evolution of all words in the English language except those that became obsolete before 1150 or are known only to the specialist. The first edition was published in 1933 after nearly seven decades of work. The second edition, the OED2, was published in 1989. It combines the original edition, four supplemental volumes published after 1933, and results from a fourth major reading program.

A partial description of the making of the OED and its most salient characteristics is discussed in a book written by the granddaughter of the original editor, Elisabeth Murray (1977), and in a guide to the OED by Berg (1993). The dictionary contains approximately 616,500 word forms. Definitions for these words are illustrated with quotations from each century with extra quotations provided for significant changes in meaning. The quotations were drawn from a wide range of books, with special emphasis on great literary and scientific works, but also, among other things, books of foreign travel, letters of foreign correspondents, magazines, and diaries. The total number of quotations in the OED2, roughly 2.5 million, was drawn from a sample of between 5 and 6 million quotations. This large sample of quotations was obtained from volunteers known as Readers. According to James Murray, the OED's first editor, Readers were instructed to ''[m]ake a quotation for *every* word that strikes you as rare, obsolete, old-fashioned, new, peculiar, or used in a peculiar way,'' and also ''[m]ake *as many* quotations *as you can* for ordinary words, especially when they are used significantly, and tend by the context to explain or suggest their own meaning.'' It is clear that Murray was interested in obtaining representative samples of quotations: ''The quotations for common words must come from *some* books; they ought to come from all books; and this can be realised only by each Reader sending some'' (Murray, 1989). Overall, we have no reason to expect that the quotations represent a biased sample with respect to the questions we aim to address, but they do not represent anything like a scientific selection of sources. However, the breadth of the inquiry provides some assurance against fairly local sampling biases.

Recently, the entire 12-volume set was retyped into a special computer database format allowing for online searching of all definitions and quotations. The OED on-line corpus may be searched for key words (e.g. *tree*, *maple tree*, *maple*, etc.), and search codes may be written such that the date, source, and full quotation context will be returned.

General predictions. Evidence in support of the devolution hypothesis might be

obtained from two kinds of measures: (1) the number of quotations referring to trees (including kinds of trees) relative to the total number of quotations associated with a given historical period (we used 100-year blocks for our analyses), and (2) the number of sources (kinds of publications from which the quotes are drawn) relative to the total number of sources associated with a given period. Our first analysis examines the general prediction that if knowledge of trees is devolving, it should be reflected in an overall drop in the number of quotes and number of sources across time. A second major analysis examines more specific hypotheses concerning the relative usage of tree terms at different levels of taxonomic organization. Specifically, if knowledge about trees is devolving, declines should occur for all levels of description. A third major analysis investigates the prediction that if devolution is occurring, it should be occurring for folkbiological domains other than trees, but not necessarily in non-biological domains. A fourth and final analysis examines the prediction that if devolution is linked to what the average reader knows, and not to the aims and interests of authors, then it should be reflected in quotations in which tree terms are used incidentally rather than as the main point of the quotation.

Of course, there may be historical periods of time where knowledge about trees was increasing (evolution rather than devolution). The predictions here would be more or less reversed. As we shall see, our analyses suggest periods of both evolution and devolution. Before turning to specific procedures, we first state our assumptions about levels of specificity and identify potential problems that may arise with analyses such as ours.

1.1. Levels of specificity.

In our analysis of taxonomic levels (Analysis 2), we adopt Berlin and his colleagues' (Berlin, Breedlove & Raven, 1972; Berlin, 1973, 1992) approach to taxonomic organization. According to Berlin, categories can be viewed as belonging at one of five levels of organization. At the most inclusive level, there is the unique beginner, typified by categories like *plant* and *animal*. The next level of organization, the life-form level, is commonly referred to by a single word and includes such classes as *tree*, *vine*, *grass*, and *mammal.* At the next level, the generic level, there is an explosion of categories, such as *oak*, *pine*, *catfish*, *perch*, *robin, maple tree* or *box tree*. The generic level, according to Berlin, is the basic building block of all folk taxonomies. Among other things, it is the level most often used in describing an object, the level that is most psychologically salient, and the level that children learn first. The next two levels are the specific and varietal. Linguistically, categories at the specific or varietal level usually require at least two words such as *blue spruce*, *white fir*, or *post oak*.

1.2. Methodological issues

Threats to validity. There are at least five general concerns associated with using text to assess change across time. One problem involves changes in spelling. For example, our search revealed twenty different spellings of *oak* and twenty-five

different spellings of *tree*. Spelling only became fairly uniform in the 19th century. Obviously, one needs to search the corpus for each of the alternative spellings.

A second concern is that the results may be affected by the particular meaning of the term being invoked in a quotation. For example, the term *pine* can be used to refer not only to a particular kind of tree, but also a particular kind of wood (e.g. pine floor) or activity (e.g. pine away); it can also be used as a modifier (e.g. pine grove), or a proper noun (e.g. the cleaning product, ''Pine Sol''). In order to make contrasts between different kinds of categories as comparable as possible, only direct references to trees (the first kind of use) were included in the analyses.

A third concern is that the sources for quotes may change across time in a systematically biased manner. For example, during the age of exploration and colonization, new publications appeared (e.g. *Australian Journal*) devoted not to life in England, but rather to life in the British colonies. These often include descriptions of the (novel) flora and fauna. The rise of science also led to technical publications. We confronted this problem in two ways. First, we decided to omit technical and foreign quotations and focus on what we term folk quotations. Second, we checked to see whether the overall patterns of change held up in a subset of the obtained quotations in which the searched-for term was incidental (non-topical), rather than the main topic of the quotation. The reasoning behind this additional analysis was that non-topical uses, as opposed to topical uses, should be less affected by the publication interests of a particular time period.

A fourth concern is that changes between levels of specificity might be affected by the introduction of new tree terms into the language. Descriptions involving new trees may elicit more attention and favor more specific descriptions. We addressed this and some related problems by selecting a subset of 22 tree generics, all of which have been in use from the 15th century to the present day, as indicated by their dictionary entries. Differences between levels of specificity cannot, then, be attributed to the introduction of novel kinds.

A final concern involves the biases that may be built into the selection of quotations used for a dictionary. In the OED, quotations are included in order to exemplify how certain words were used at particular periods of time. However, the number of quotations used to exemplify a particular term is unrelated to the actual frequency of that term in the language. This means that the number of quotations exemplifying a low-frequency term might be quite similar to the number of quotations exemplifying a high-frequency term. As a consequence, the relative number of quotations for low-frequency terms may be somewhat inflated relative to high-frequency terms. As it turns out, however, the potential problem posed by this bias is not severe. First, in the case of tree terms, the OED contains very few entries for low-frequency terms, that is, entries for terms at the specific or lower level of abstraction (e.g. *pin oak*). Second, the number of quotations of a particular term from other entries is almost always far greater than the number of quotations from the entry of that particular term. Thus, if the full range of quotations is considered, the potential biasing effects due to the quotations found within a term's entry is small. Nevertheless, to eliminate any chance of such biases, quotations used in the entry of any tree term were

eliminated from the analyses. In other words, quotations used in the following analyses came from entries other than the entry of the searched-for term.

Other concerns. The use of the OED constrains our focus to England and its associated history of wars, colonialism and increasing globalization of interests. Our task would have been more straightforward had we been able to pick a more insular culture (though insularity of more traditional cultures may be more a myth than a reality). This factor, however, cuts both ways. It is precisely because of its technological and global orientation that evolution or devolution of folkbiology in England is of interest. Given the importance often attached to science education, it is only reasonable to ask about the cultural supports for learning about the natural world.

2. Analysis 1: Examining the overall use of tree terms over time

The purpose of this first analysis was to test the main prediction of the devolution hypothesis: If knowledge about trees is declining, it should be reflected in an overall drop in the use of tree terms.

2.1. Method

The process of preparing the quotes for analysis had three main phases: (1) abstracting the entries containing quotations, (2) coding the entries, and (3) correcting for uneven sampling in the OED. These three phases are discussed in turn.

Abstracting entries. In the first phase, quotations containing tree terms were drawn from the OED using Open Text Corporation's PAT search engine. In searching for the word *tree* all alternative spellings were considered (including *trau*, *traw*, *tre*, *tren*, *treo*, *treu*, *treuwum*, *triu*, *troue*, *trow*, as well as fifteen other spellings). Alternative spellings were obtained through a word's OED entry. In addition to the word *tree* we also searched for 22 folk-generic level tree terms (including all 138 associated alternative spellings). The folk-generic level tree terms included *alder*, *ash*, *aspen*, *bay*, *beech*, *birch*, *cypress*, *elm*, *fir*, *hawthorn*, *hazel*, *juniper*, *laurel*, *maple*, *mulberry*, *myrtle*, *oak*, *pine*, *poplar*, *sycamore*, *walnut*, and *willow*. All of these folk-generic tree terms have been in use since the 15th century or earlier. The search was limited to singular forms of these terms to avoid the problem of changes in pluralization conventions over time.

Once obtained, the output from these searches was reformatted for easier coding. In the online-version of the OED, the text contains tags that mark the start and end of entries and their associated components (e.g. definitions, quotes, sources and dates). A program was written that removed all extraneous text and formatting markers. The resulting file contained only quotes and their associated dates and sources. Sample quotations are shown in Table 1.

Coding entries. The second phase of preparing quotations for analysis involved coding each entry's source, quotation and time period. The source of the entry was coded as folk or non-folk. An entry was considered folk if its source was neither technical (e.g. *Fruit Trees, Nature, Elementary Botany, Science News, British*

Table 1
Example quotations with their associated dates and sources

Date	Source	Quotation
1593	(2 Hen VI)	Thus droupes this loftie Pyne and hangs his sprayes.
1610	(Tempest)	I will rend an Oake And peg thee in his knotty entrailes
1613	(Hen VIII)	We take From euery tree lop, barke, and part of the timber.
1793	(Lett)	The mountain ash Depends its branches to the stream below.
1851	(Moby Dick)	There she slides now Hurrah for the white ash breeze.
1929	(New Yorker)	The big walnut tree that was an old timer even in her day.

Plants, Dictionary of Gardening), nor concerned with foreign countries (e.g. *Jamaica, New York Times, Barbados, Journal of Upper India, Central America, Pennsylvania Archives, African Hunting)*.

Coding quotations. The quotation part of an entry was coded as either direct or indirect. Only quotes making direct references to trees were included in the analyses, as discussed earlier. There were three primary ways in which a quotation could be coded as indirect. One type of indirectness occurred when tree terms were used as modifiers in a compound noun, as shown in (1).

(1)a. 1865 (Gayworthys) There are wheat cakes and **maple** syrup for your breakfast.
(1)b. 1822 (To Jane the Recollect) We wandered to the **Pine** Forest.

In example (2a), the thing being referred to directly is ''syrup,'' specifically, maple syrup, not a tree. A second way a tree term might be used without referring to a tree directly is as the object of the preposition ''of'' in such phrases as shown in (2).

(2)a. 1860 (Glac) Adjacent to my theodolite was a stump of **pine**.
(2)b. 1728 (46 Spring) The many twinkling leaves of **aspen** tall.

In the noun phrase ''a stump of pine,'' (2a), the prepositional phrase is merely the complement of the head noun ''stump.'' Note that such a noun phrase can usually be paraphrased to form a compound noun: the head noun becomes the head of the compound noun and the object of the prepositional phrase becomes the modifier. For example, the phrase ''stump of pine'' can be rephrased as ''pine stump.'' So in this use, the tree term is not being used to refer to a tree, but to a stump. This is true for other such phrases in which the term occurs as the object of the preposition ''of''. A third way a tree term could be used without directly referring to a tree is as a reference to a substance. If the tree term referred to wood, as shown in (3), it was excluded from the analysis.

Table 2
Frequency counts for quotations and sources by time period.

Time period	Total # of quotes	Est. # of folk quotes	Est. # of folk sources	# Tree quotes	# Tree sources
1525	170358	167000	83200	520	235
1625	424711	413800	202700	1235	594
1725	281342	264300	137900	1010	410
1825	595635	494100	310100	2238	998
1925	716171	513100	350000	1545	642
Totals	2188217	1852300	1083900	6548	2879

(3)a. 1959 (Archit Rev) The wall is pale yellow, the floor **maple**.
(3)b. 1894 (Outing) The **birch** makes a hot snappy cheerful fire.

In addition to eliminating indirect references to trees, we also eliminated quotations that referred to something other than a tree, and quotations that included two tree terms at different levels of specificity. (The purpose of this latter restriction will be discussed in Analysis 2). As for cases of non-tree uses, quotations were excluded if the tree term was used metaphorically (e.g. 4a), as a part of speech other than a noun (e.g. 4b), or as a proper name (e.g. 4c).

(4)a. 1598 (Betr of Christ) Christs night disciple aidfull did agree to take his bodie from that guiltie **tree**.
(4)b. 1774 (Nat Hist) They generally **pine** away and die in a short time.
(4)c. 1838 (Nich Nick) Sir **Mulberry** Hawk leered upon his friends most facetiously.

Coding dates. In the preface of the OED, it is noted that prior to the 1400s, dialectal differences in the English language were quite pronounced. Hence, words and forms that occurred before 1500 and were dialectal were excluded from the dictionary. These factors led us to choose the late 1400s as a cutoff for our analyses. Because the most recent quotations in the OED were entered in 1987, we rounded this date down slightly to look at quotations from 1975 back to 1475 in 100-year intervals: 1475–1574, 1575–1674, 1675–1774, 1775–1874, 1875–1974. In the following analyses, the five resulting time periods are labeled by their median dates of 1525, 1625, 1725, 1825, and 1925.

Correcting for uneven sampling in the OED. As shown in column 2 of Table 2, the total number of quotations in the OED varied widely between time periods. For example, the number of quotations in the 1625 time period was much higher than the number of quotations in the 1725 time period. These differences were most likely due to new words entering into the language and/or changes in the production of written sources, which in turn were probably due to a complex assortment of social, economic, and political factors. Importantly, though, in order to interpret properly the shifts in the number of tree quotations and sources, the total number of quotations and sources in the dictionary must be taken into account. We need to be sure, that is, that differences in tree counts are due to factors relevant to tree terms, not sampling.

To correct for variations between periods, tree counts were analyzed relative to the estimated number of folk quotations and sources in the OED. These estimates were obtained by taking a 1% random sample of quotations in the OED and coding them for source type (i.e. folk versus non-folk) and then multiplying them by 100. The obtained results from this procedure are shown in column 3 of Table 2. In obtaining source counts, an additional procedure was performed. Folk quotations from the 1% sample were grouped by source and then submitted to a program that counted the number of groupings. The estimated number of folk sources in the OED is shown in column 4 of Table 2. This same procedure was used to obtain source counts for all later analyses to follow. Also included in columns 5 and 6 of Table 2 are the raw number of tree quotations and sources prior to their being adjusted for sampling in the OED.

2.2. Results and discussion

Our search for tree terms generated a total of 22 319 quotations. An automatic coding of each quotation's source was performed using a program that checked lists of 134 ''foreign'' and 45 technical sources. The resulting 15 146 quotations with sources not present on these lists were roughly equivalent to 900 pages of text and were further analyzed by hand according to the criteria described in the methods section. Of these, 6548 came from folk sources making either direct or indirect references to trees. Limiting the analyses to only direct references resulted in a total of 3132 quotations, or roughly 14% of the original set of quotations.

The findings provided strong support for the main prediction of the devolution hypothesis: Cultural support for trees, as measured by the relative number of quotations and sources in the OED, has declined during the 20th century. As described above, tree counts were analyzed relative to the estimated number of folk quotations and sources in the OED in order to eliminate differences due to sampling. As Fig. 1 shows, the proportions for quotations and sources was fairly constant through the 16th, 17th, and 18th centuries. In the 19th century, the relative number of quotations and sources increased, suggesting that knowledge of tree terms evolved during this period. However, the gains of the 19th century were completely lost in the 20th century. Starting around the period of the Industrial Revolution and ending about now, writing about trees dropped to a level lower than at any other time in the history of modern English.

The only difference between quotations and sources seems to have occurred between the 16th and 17th centuries: the number of sources increased while the number of quotations did not (as indicated by the confidence intervals). This difference does not change the important conclusion that we can be confident that the observed changes in the number of quotations are not due to an overrepresentation of

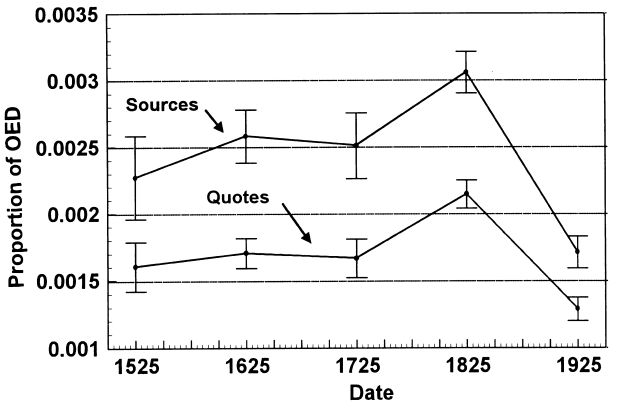

Fig. 1. Proportion of quotations and sources in the OED referring to trees along with associated 95% confidence intervals.

a particular kind or set of sources. Of limited interest, the proportions for sources were slightly higher for each time period than the proportions for quotations. These differences merely indicate that quotations containing tree terms come from a wider range of sources as compared to quotations containing other terms, on average.

A Pearson chi-square test of association confirmed the presence of reliable differences between the time periods for both quotations, $\chi^2(4) = 83$, $P < 0.0001$, and sources, $\chi^2(4) = 176$, $P < 0.0001$. These statistics were derived by converting the proportions shown in Fig. 1 to frequencies, then adjusting these frequencies so that their overall total was equal to their total prior to correcting for sampling differences. Differences between time periods were confirmed using confidence intervals representing ranges having a 95% probability of covering the true population values, assuming a binomial distribution.

In sum, the findings are consistent with the idea that there have been periods of evolution and, more recently, devolution in knowledge about trees. In the next analysis we address an important alternative explanation. Even though the data suggest a loss of knowledge, they are consistent with another possibility. Specifically, the data may indicate a shift from a folkbiological view to a more scientific view of trees. We will refer to this possibility as the *shift-in-knowledge hypothesis*. This hypothesis assumes the presence of two kinds of underlying changes. First, the drop might reflect a tendency to use terms not covered in our searches. For example, people might talk less about particular kinds of trees and more about DNA, evolution, and the biochemical reactions associated with photosynthesis. Indeed, the concept, TREE, has no status in scientific taxonomy. Short of an exhaustive analysis of all of the scientific talk in the OED, this possibility cannot be explored. Alternatively, the drop could be due to a shift towards the use of more specific terms that refer to trees. An overall drop in tree terms might be due to a drop in terms at the life-form level alone, masking increases at more specific levels of organization. This second possibility can, in fact, be tested.

The shift-in-knowledge view makes a set of predictions concerning the relative use of different levels of organization. The simplest prediction is that if knowledge is increasing, generic- and specific-level terms should be increasing. The opposite pattern would count as evidence for the devolution. A subtler prediction made by the shift-in-knowledge hypothesis is in terms of linguistic form. As discussed above, life-form level categories are usually referred to with single words while specific-level categories are usually referred to with two words. Generic level tree terms fall somewhere in between. For example, a particular tree at the generic level might be described as either an *oak* or an *oak tree*. If greater familiarity leads to the shortening of linguistic form (Ziff, 1960), then the two-word forms may precede the one-word forms historically. We expect, then, that if knowledge is devolving, use of two-word forms should rise relative to one-word forms. If knowledge is evolving, the opposite pattern can be expected. In sum, two general sets of predictions can be brought to bear on the question of whether the observed decline in the 20th century actually represents devolution or a kind of evolution in which terms at lower levels of organization are increasing, and which is being masked by a decline in the number of terms at the life-form level.

3. Analysis 2: Examining tree terms at different levels of specificity

The same set of quotations used in Analysis 1 was used in this analysis. In the current analysis, however, the quotations were coded according to level of organization. One of the main goals of this analysis was to better understand the observed decline in tree terms in the 20th century. A closer examination of the quotations could also be used to provide further insight into the apparent lack of change between the 16th and 18th centuries and the observed evolution of tree terms in the 19th century.

3.1. Method

Three levels of organization were coded. The life-form level was indicated by use of the word ''tree,'' or one of its 22 other spellings. An example of this kind of quotation is shown in (5).

(5) Life-form: 1667 (Diary) The cold so intense that there was hardly a leaf on a **tree**.

The generic level was indicated by quotations containing one of the pre-chosen 22 tree-terms listed in Analysis 1. Two kinds of descriptions were coded for at this level: one-word generics (6a) and two-word generics (6b).

(6)a. Generic (one-word): 1611 (Iliad) Down he bustled like an **oak** Hewn down for shipwood.
(6)b. Generic (two-word): 1897 (Westm Gaz) Rolling a large **oak tree** with a timber whin.

Quotations demonstrating the specific level contained a sub-kind of one of the 22 pre-chosen generic tree terms. An example of this kind of quotation is shown in (7).

(7) Specific: 1848 (Poems) The **red oak** softer grained yields all for lost.

As discussed earlier, if a quotation included two tree terms at different levels of specificity, it was excluded from Analysis 1. The purpose of this restriction was to eliminate the coding conflict these quotations raise for an analysis of levels of organization. For example, if sentences like the ones in (8) are used in such an analysis, it is unclear whether they should be coded at the life-form or generic level.

(8) 1832 (Veg Subst Food) The **oak** is a handsome **tree**.
1806 (Balance) It is to be regretted that a shade **tree** useful and ornamental as the **poplar** should be in danger.

3.2. Results and discussion

The findings from this second analysis provide further support for the devolution

hypothesis: Cultural support for trees, as measured by the relative number of quotations in the OED, declined during the 20th century for all levels of organization.

As in Analysis 1, tree counts were analyzed relative to the estimated number of folk quotations and sources in the OED. Fig. 2 shows the resulting proportions for each level of specificity in each period of time along with 95% confidence intervals. The pattern for quotations and sources did not differ appreciably. In order to make the graphs easier to read, only the proportions for quotations are displayed. The patterns of change shown in Fig. 2 indicate periods both of evolution and devolution. Periods of evolution are indicated by the steady rise in frequency counts between the 16th and 19th centuries for both the generic (one-word) and specific levels and a rise in frequency counts between the 18th and 19th centuries for the life-form level. Another way in which evolution is indicated is in the ratios between levels of organization. As frequency counts for generics (one-word) and specifics rose, the frequency counts for the less specific level, the life-form level, declined. This suggests a trade-off between levels: terms from less specific levels of organization were replaced with terms from more specific levels of organization. Consistent with this trend, two-word generics steadily decreased as one-word generics steadily increased. As noted in reference to Fig. 1, the period between the 16th and 18th centuries seemed to show no change. In fact, this apparent absence belied significant shifts in the use of tree terms at different levels of organization (see Fig. 2). The 19th century seems to represent the evolutionary climax for trees. Talk about trees was both more frequent and more precise than in any other time in the history of English. All this changed in the 20th century.

The pattern of frequency counts during the 20th century is most consistent with devolution. Crucially, the 20th century is the only century where frequency counts for all levels of organization declined. Thus, in contrast to the shift-in-knowledge

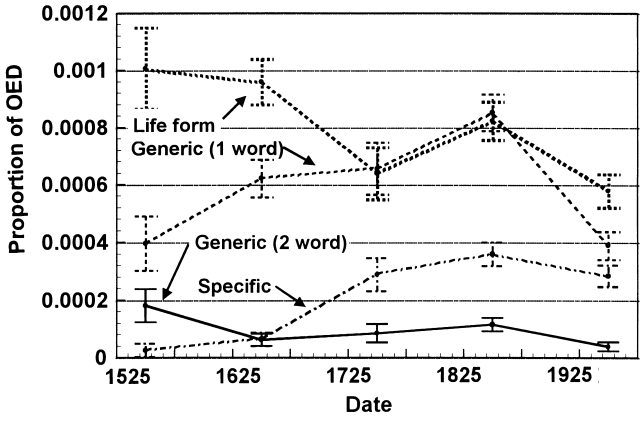

Fig. 2. Proportion of quotations in the OED for different levels of specificity along with associated 95% confidence intervals.

hypothesis, an overall drop in tree terms cannot be explained as a drop in the life-form level alone masking increases at more specific levels of organization. Another source of support for the devolution hypothesis is indicated by the two kinds of generics. In contrast to the shift-in-knowledge hypothesis, one-word generics decline more than two-word generics. However, it must be acknowledged that two-word generics were so infrequent, even in the 19th century, that there was very little room for their decline. This positive finding may represent a floor effect. Finally, the fact that one-word generics decline more rapidly than life-form terms (*tree*) provides strong support for the devolution hypothesis.

The above conclusions are supported by hierarchical log-linear modeling. In order to perform this analysis, the frequency counts were adjusted to correct for the sampling differences as described in Analysis 1. The design of the analysis involved two variables, time period (5) and category type (4). Like ANOVA, log-linear modeling can be used to test for main effects and interactions between those main effects. Using this method, reliable differences were found for level of organization across both quotations, $\chi^2(3) = 1558$, $P < 0.0001$, and sources, $\chi^2(3) = 2424$, $P < 0.0001$. In addition, differences between level of organization changed over time, as indicated by a significant interaction between level of organization and time period, across both quotations, $\chi^2(12) = 302$, $P < 0.0001$, and sources, $\chi^2(12) = 428$, $P < 0.0001$. The tests for time period are the same as those in Analysis 1 because the underlying data set is the same. As in Analysis 1, then, there were reliable differences between time periods across quotations, $\chi^2(4) = 83$, $P < 0.0001$, and sources, $\chi^2(4) = 176$, $P < 0.0001$.

Resilience of the specific level. Although the overall pattern of results is consistent with devolution, there is a modicum of support for the shift-in-knowledge hypothesis. An examination of Fig. 2 shows that the specific level declined the least among the levels of organization during the 20th century. That is, the specific level appears to be relatively immune to devolutionary forces. We believe that this counter-trend is most consistent with a mixture of general devolution and a specialization of knowledge, the latter representing something of a ''cognitive division of labor''.

The specific level may have been more immune to devolution than the other levels for several reasons. First, because our search was limited to 22 kinds of trees at the generic level, changes in frequency counts at this level are primarily in terms of changes in tokens. However, because the specific level is not limited to 22 categories of trees, changes in frequency counts at this level reflect changes in both tokens and types, which may have inflated the proportion of specific-level categories relative to the other category levels. The ideal analysis would hold specific-level categories constant throughout time. The primary reason why this analysis cannot be done is that there are very few terms at this level of organization that have survived across even two time periods, let alone five. Note also that it was probably not until the 17th century that the specific level (in the case of trees) even emerged (Atran, 1990).

A second and potentially more interesting rationale for expecting specific level terms to be relatively immune from devolution is based on the idea that cultures are

composed of both a general population and a small subset of specialists who act as keepers of technical knowledge. This subset may be motivated or required by the nature of their activities to operate at ranks below the generic. If the general population's knowledge is undergoing devolution in terms of how much it talks about trees, then discourse from the subset of experts or specialists will gradually come to comprise a greater proportion of the total amount of discussion of trees. In the limiting case, only specialists will talk about trees and name them at the specific or varietal level. In that case, the number of specific and varietal terms would *increase* relative to the use of generic terms (though the absolute numbers of all three might decline).

Devolution in other folkbiological domains. In the previous analysis, support for the devolution hypothesis was based on within-category (tree) comparisons. While the results were consistent with the devolution hypothesis, at least two major concerns could be raised. The first major concern involves the scope of the findings. According to the devolution hypothesis, it is expected that the decline in knowledge about trees is symptomatic of a more general decline in knowledge of natural kinds. To provide evidence for this generality, we need to consider the evolutionary trends of other natural kind terms. If similar declines are found for such categories as *bird*, *grass*, *fish* and *flower*, we can be more confident that the declines in *tree* are, in fact, due to more general factors. This prediction is tested in the next analysis.

A second major concern is that the declines in the 20th century might merely be statistical artifacts of the OED. Assuming the 20th century has experienced an enormous explosion in new categories, it is certainly possible that talk about any one category could become diluted. Thus, declines in the 20th century may not reflect devolution, but rather decreased talk about any one thing because there are more things to talk about. This dilution hypothesis is relatively easy to test. If the 20th century decline is due to dilution, then similar rates of decline should be observed in categories for which we might expect evolution, in particular, certain non-biological categories. If declines are not observed in non-biological categories, such as *book*, *boat*, *clothes*, *furniture* and *weapon*, we can be more confident that the declines in folkbiological categories reflect declines in knowledge. This prediction is also tested in Analysis 3.

4. Analysis 3: Comparison of biological and non-biological domains

In this analysis we examined whether or not the decline in the tree category represented a general decline in knowledge of natural kinds as the devolution hypothesis predicts. We also tested whether the decline in the tree category was due merely to an inflation of other topics rather than a decline in folkbiological knowledge. To investigate these two issues, we considered categories other than tree, namely folkbiological categories, in which we expected devolution and certain non-biological categories, in which we expected the possibility of evolution. Cate-

gories in this analysis were restricted to the life-form level of organization to make the analyses between folkbiological and non-biological categories as comparable as possible. At lower levels of organization, the analyses would be far more vulnerable to the kinds of idiosyncratic differences that can exist between categories from completely different domains.

4.1. Method

Nine categories, in addition to the category *tree*, were drawn from Battig and Montague's category norms (1969). Half of categories chosen were folkbiological categories, namely, *tree*, *bird*, *fish*, *flower* and *grass*. The rest were non-biological categories, namely, *clothes*, *furniture*, *weapon*, *book* and *boat*. Eight out of the ten categories were at the life-form level or its equivalent in the case of the non-biological categories. However, several categories in Battig and Montague's norms could not be used because they did not include enough observations in the OED to provide sample sizes of at least 500 observations (e.g. *tool*, *toy*) and/or were not in use by the 15th century (e.g. *mammal*). In order to have at least five non-biological categories, two of the categories were again drawn from Battig and Montague, but this time from what in the biological domain would be the generic level, namely, *book* and *boat.*

The data for *tree* was the same as that in Analysis 2. The data for the other categories was obtained in much the same way as for the tree terms. First, quotations containing the words ''bird'', ''fish'', ''flower'', ''grass'', ''clothes'', ''furniture'', ''weapon'', ''book'' and ''boat'' were extracted from the OED. Alternative spellings were also included. For example, *bird* had 10 alternative spellings (e.g. berd, bred, brid, byrd, etc.), *fish* 8 alternative spellings (e.g. fich, fishe, fysch, fysh, etc.) and *weapon* 20 alternative spellings (e.g. waipone, wappin, weppon, wopen, etc.). As before, the searches were limited to singular forms of these terms.

As in Analyses 1 and 2, the results from these searches were coded for source, nature of the quotation and time period. Quotations with non-folk sources were eliminated from the analysis. Also as in the previous analyses, the quotations needed to meet several other criteria in order to be used. Cases in which the term was the object of an ''of'' phrase (9a), the modifier of a compound noun (9b), used non-literally (9c), used to refer to a category at another level of organization (9d), or used to refer to a substance (9e; except for the mass noun terms *grass*, *furniture* and *clothes*) were excluded from the analysis.

(9)a. 1818 (Art of Bookbinding) Put the past boards on each side of the **book**.
(9)b. 1680 (New Castle) Wee have sent away a **boat** load.
(9)c. 1580 (Alv) To chat like a pie or lyke a **birde** in a cage.
(9)d. 1955 (Hansard) This unique difference between the hydrogen and the atomic **weapon**.
(9)e. 1818 (Tales amp Sk Adv Allan Gordon) A good whang of solid **fish**.

In contrast with the previous analyses, most of the data in this analysis was based on samples rather than from all available quotations present in the OED. However,

in the case of *tree*, we already had an exhaustive coding of all of its quotations. Since we knew the actual frequencies in the case of *tree*, we could determine the sample size that would give a good approximation to the actual frequencies for the other categories. It was found that, on average, sample sets of 500 quotations provided a very good fit to the actual frequencies in the OED. As a rule of thumb, then, it may be that stable results can be had with sample sizes equal to the product of the number of time periods (i.e. 5) multiplied by 100.

Sample sizes of 500 quotations were obtained for *fish* after coding 1647 out of 6622 quotations, for *bird* after coding 2291 out of 3925 quotations, for *flower* after coding 2471 out of 6622 quotations, for *grass* after coding 1599 out of 4111 quotations, for *clothes* after coding 897 out of 2142 quotations, for *boat* after coding 1234 out of 3147 quotations, for *book* after coding 1124 out of 5810 quotations, and for *furniture* after coding 1323 out of 1971 quotations. On the basis of these numbers, we estimated the actual number of quotations in the OED for each category in every time period. The only categories exempted from this strategy were *tree* and *weapon*. With these categories, no estimates were needed because our coding of these categories was exhaustive. Note, however, that in the case of *weapon*, the total number of quotations in the OED, 709, resulted in only 319 quotations that passed our various criteria for acceptance. This category was retained, nevertheless, because of its inherent interestingness, the fact that the number of quotations was still relatively high, and because the data was not used to estimate a larger set.

4.2. Results and discussion

The findings provide further support for the devolution hypothesis. As noted above, most of the data in this analysis was based on samples rather than from all available quotations present in the OED. As a consequence, analyses were based only on quotations rather than also sources since estimating source counts would have involved making estimates upon estimates. As in previous analyses, frequency counts were analyzed relative to the predicted number of folk quotations in the OED. Fig. 3 shows the resulting proportions for folkbiological (top panel) and non-biological (bottom panel) categories for each time period along with 95% confidence intervals.

According to the devolution hypothesis, the decline in tree terms during the 20th century reflects a general decline in knowledge about biological kinds. Thus, similar rates of a decline should be observed for other folkbiological categories. An examination of the trends in the top panel of Fig. 3 indicates that this was indeed the case. As with *tree*, the categories *grass*, *bird* and *flower*, after climaxing in the 19th century, declined dramatically during the 20th century. The only exception to this pattern was the category *fish,* which evolved dramatically in the 16th century and then changed little in the following 300 years. The pattern of development exhibited by the category *fish* may be due to the fact that fish is often the focus of food contexts and the subject of a popular sport. Nevertheless, the precise reasons why the category *fish* patterned differently form the other folkbiological categories remains

unclear. Importantly, however, there is no evidence that knowledge about fish has evolved during the 20th century.

While the findings so far are consistent with the predictions of the devolution hypothesis, they are also consistent with a much less interesting possibility. Declines during the 20th century might have occurred not from loss of knowledge but rather from the fact that the range of things that can be talked about in the 20th century has increased so much that discussion about any one thing has decreased. This dilution hypothesis predicts that similar rates of declines should occur for categories that are non-biological. However, the patterns of development displayed in the bottom panel of Fig. 3 indicate that declines during the 20th century are not inevitable. With the non-biological categories of *furniture*, *clothes* and *book*, the pattern of development during the 20th century is one of evolution, not devolution. In the cases of *boat* and *weapon*, the pattern of development during the 20th century is one of maintenance. The fact that decline during the 20th century is not inevitable suggests that the decline found in tree terms, as well as in other folkbiological categories, is due to devolution and is not simply due to a statistical artifact of the corpus[1].

These conclusions are supported by hierarchical log-linear modeling. To correct for sampling, the frequency counts for each of the categories were adjusted in the same way as in the previous analyses. The design of the analysis involved three variables, domain type (2: folkbiological vs. artifact), category type (4: lifeform-specific), and time period (5: 1525–1925). Hierarchical modeling indicated significant main effects of time period, $\chi^2(4) = 423$, $P < 0.0001$, and category type, $\chi^2(4) = 1574$, $P < 0.0001$, but not domain type, $\chi^2(1) = 0.76$, ns. Significant interactions were also obtained between domain type and category type, $\chi^2(4) = 1357$, $P < 0.0001$, domain type and time period, $\chi^2(4) = 294$, $P < 0.0001$, as well as category type and time period, $\chi^2(16) = 308$, $P < 0.0001$. Most importantly, there was a significant 3-way interaction between domain type, category type and time period, $\chi^2(16) = 428$, $P < 0.0001$. This last interaction confirms that folkbiological categories developed differently than non-biological categories across time.

Assumptions about the dependent measure. In the preceding analyses, we assumed that trends in what people write about reflect trends in what people know. It might be, however, that the changes observed in previous analyses were not reflections of what readers might know per se, but rather reflections of what authors wanted to write about. Perhaps trees were considered an important topic of discussion in the past, but became less interesting with time. Changes in the aims of authors could certainly lead to changes in knowledge, but not necessarily. A critical question, then, concerns whether or not changes in the purposes and interests of

[1] Caution should be observed in generalizing the individual trends shown in Fig. 3 to their respective domains. As pointed out previously, a full interpretation of the developmental course of a domain cannot be assessed without also knowing the developmental courses of other terms at different levels of organization within that domain. For example, the developmental course of *tree* as shown in Fig. 3 would seem to indicate constant devolution, except for in the 19th century. However, we know from Analysis 2 that while *tree* declined during the 16th to 18th centuries, more specific terms increased, indicating that, for this domain as a whole, there was evolution during this period.

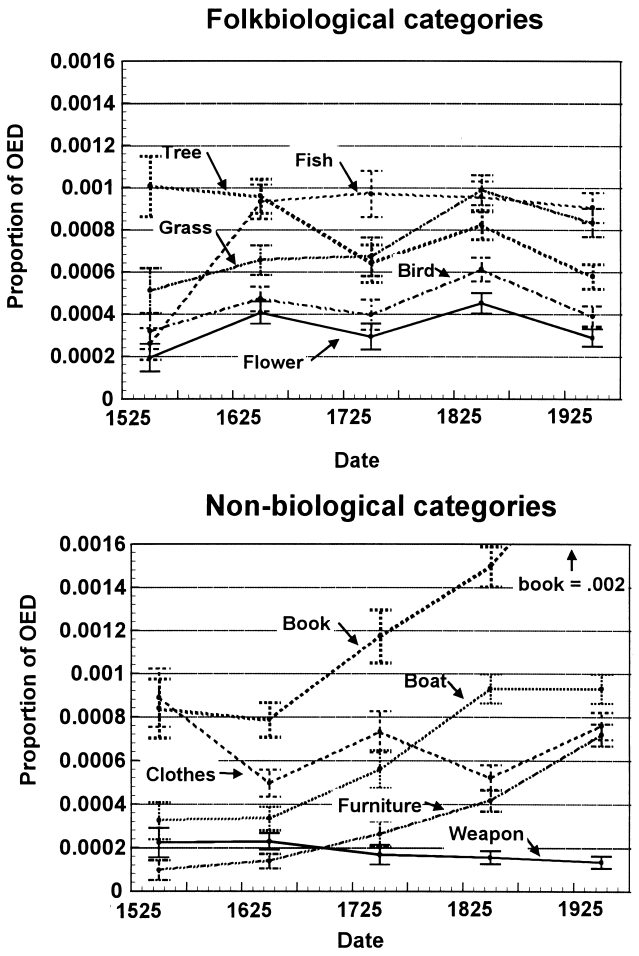

Fig. 3. Proportion of quotations in the OED for folkbiological categories (top panel) and non-biological categories (bottom panel) along with associated 95% confidence intervals.

writers have been the main driving force behind the changes in writing, or whether it has been changes in what writers have assumed the average reader knows.

One way we may be able to address this question is by examining how tree terminology is used within quotations. In some quotations, a particular term might be the main topic of the sentence. For example, the tree referred to in 10a, the *snake skin willow*, is the main topic of that quotation. In contrast, the tree referred to in 10b, the *oak*, is not the topic of the sentence; the topic of this sentence is the *old man*.

(10)a. 1880 (Gt Estate) The snake skin willow so called because it sheds its bark
(10)b. 1904 (Apprentice) The old man began to chip at the toes of the monster oak.

Whether or not a term is the topic of a quotation says much about the aims of the writer. The topic of a sentence (usually the grammatical subject) indicates what the writer intends to be the main focus of proposition. The non-topical part of the sentence (usually the predicate) represents some comment, or offers some information, about the topic (Huddleston, 1984; Gleitman, Fridlund & Reisberg, 1999). In many cases, then, the non-topical part of the sentence explains something about the topic. As a consequence, the non-topical part most likely contains concepts that the writer assumes the reader already understands.

The topicality distinction may allow us to see whether the changes observed in previous analyses were due to changes in what average readers knew (as assumed by the writer) or due to changes in the purposes and interests of writers. If the observed changes were driven by changes in reader knowledge, then an analysis based only on quotations in which the relevant term is non-topical should result in a set of trends that resemble those found in previous analyses. For topical uses only, the pattern may or may not reflect that found in previous analyses. Crucially, however, it should not be the case that the various changes in frequency occur only in topical uses but not in non-topical uses. Such a pattern would suggest that the observed changes in the previous analyses had more to do with changes in the purposes and interests of writers than in the average person's folkbiological knowledge. These predictions are tested in the following analysis through a re-analysis of the data from Analysis 1.

5. Analysis 4: Comparison of topical and non-topical uses of tree terms

A critical assumption in the previous three analyses was that changes in frequency were not solely due to changes in aims and purposes of various writers, but rather to changes in writers' beliefs about what the average reader knew. To provide a rough measurement of the distinction between what writers do and do not assume is known by the average reader, we analyzed the entire set of quotations in Analysis 1 with respect to whether the tree term was used topically or non-topically. We assumed that the non-topical uses would reflect what writers assumed was already known by readers, while topical uses would be more indicative of the purposes and interests of the writer. We predicted that if the overall decrease in use of tree terms is linked to what the average reader knows, and not solely to the purposes and interests of authors, then it should be clearly reflected in quotations in which tree terms are used non-topically.

Quotations were classified as topical if the contained tree term was the grammatical subject of the sentence. It needs to be acknowledged that the relationship between grammatical subjects and the topic of the sentence is not perfectly correlated (Huddleston, 1984). Many ordinary sentences have subjects that cannot be said to identify with the topic of the sentence (e.g. *Nobody likes John*), and identification of the topic is sometimes determined from the surrounding discourse context. Nevertheless, for most English sentences, the grammatical subject of the sentence is the topic (Phythian, 1980). Since the identification of the grammatical subject of a

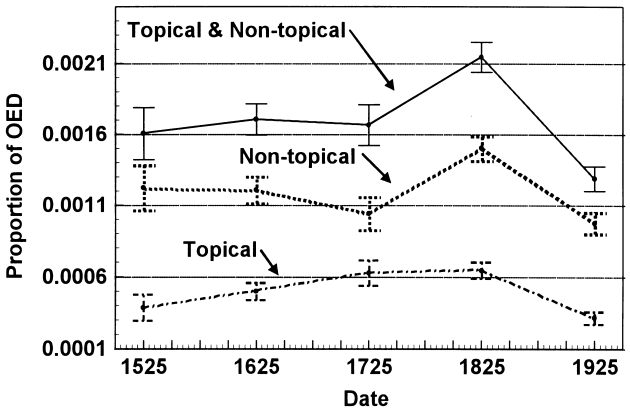

Fig. 4. Proportion of quotations in the OED referring to tree terms broken down by whether the tree term is used either topically or non-topically along with associated 95% confidence intervals.

sentence is a relatively straightforward matter, we decided to use this distinction as a means for determining topicality.

5.1. Method

The materials were the same as those used in Analysis 2. Each quotation was classified as either topical or non-topical. Quotations were classified as topical if the search-for term was the grammatical subject of the sentence, as with those in 11, but not those in 12, which would be classified as non-topical.

(11)a. 1787 (Selborne) The tree sprouted for a time then withered and died.
(11)b. 1830 (Sylva Brit) The Poplar exudes the moisture which it imbibes.

(12)a. 1851 (Child's Burial in Spring) The birds sang forth from many a leafing tree.
(12)b. 1824 (Autumn) The purple finch pecks by the witch hazel.

5.2. Results and discussion

Reassuringly, the results suggest that the trends observed in previous analyses were largely due to changes in writers' assumptions about the average reader's knowledge and not solely due to changes in writers' purposes and interests. Fig. 4 shows the results of Analysis 1 broken down by whether the tree term was used topically or non-topically along with 95% confidence internals.

Fig. 4 shows that non-topical uses evolved during the 19th century, then dramatically devolved during the 20th century. We can be confident, then, that the overall trends observed in Analysis 1 were not simply due to changes in what writers wanted to write about. Moreover, a similar pattern of development occurred in the case of topical uses, with the gains achieved in the 19th century completely lost in the 20th

century. The trends here suggest that there may indeed have been changes in what writers chose to make the focus of their writing. While not strictly predicted by the devolution hypothesis, the fact that writers chose to write less about trees during the 20th century is consistent with the idea that knowledge about trees has declined during this period.

These conclusions are supported by hierarchical log-linear analysis. The variable of topicality was significant across both quotations, $\chi^2(1) = 553$, $P < 0.0001$, and sources, $\chi^2(1) = 1182$, $P < 0.0001$. In addition, the effect of topicality changed over time as indicated by a significant interaction between topicality and time period across both quotations, $\chi^2(4) = 34$, $P < 0.0001$, and sources, $\chi^2(4) = 86$, $P < 0.0001$. The tests for time period are the same as those in Analysis 1 because the underlying data set is the same. As in Analysis 1, then, there were reliable differences between time periods across quotations, $\chi^2(4) = 84$, $P < 0.0001$, and sources, $\chi^2(4) = 176$, $P < 0.0001$.

Further implications. Again, the results make clear that trends in writing cannot be simply explained as due to changes in the purposes and aims of writers. Moreover, the results may be used to counter another argument against the assumption that writing measures what people know. According to this argument, devolution during the 20th century might not be due to loss of knowledge, but rather due to a shift in how such knowledge is communicated. During the last century, for example, transmission of knowledge about trees may have shifted from writing per se, to the schools or other kinds of media (e.g. radio or TV). However, if the means for talking about trees has changed, this should affect only quotations in which trees were the topic (reflecting authors' purposes). Such a shift should not affect non-topical uses since the term, in these cases, is being used for the purpose of describing something other than itself. However, as discussed above, the overall pattern of results for tree terms was reflected in non-topical uses alone. Hence, the overall pattern of results cannot be explained away as merely due to shifts in the means of communicating knowledge about trees or other natural kinds.

6. General discussion

The results from this research support the claim that knowledge about trees evolved slowly during the 16th to 19th centuries and devolved sharply during the 20th century. In Analysis 1, we showed that overall discussion about trees increased from the 16th to 19th centuries, then abruptly decreased in the 20th century. This same pattern was found whether we counted the number of quotations or the number of sources (publications). In Analysis 2, we coded the quotations from Analysis 1 for level of organization. One main finding from this analysis was the emergence of the specific level of organization in the 17th century such that by the 19th century talk about trees was not only more frequent, but also more precise, than in any other time period in the history of modern English. Another major finding was in terms of linguistic form. Consistent with the view that verbal simplicity implies greater familiarity, declines in two-word generics were matched by increases in one-word

generics. However, in the 20th century, the work of four centuries was lost in just one. The 20th century has been marked not only by a major decline in frequency, but also declines in precision. The devolution hypothesis predicts that the shifts in the use of tree terms reflect changes in overall knowledge about the living world. In Analysis 3, this assumption was supported: similar rates of decline were observed for life-form level categories taken from other folkbiological domains, including *bird*, *grass* and *flower*. Importantly, these 20th century declines cannot be explained as simply due to an explosion of categories diluting talk about any particular kind of category. The dilution hypothesis predicts that declines should be observed for all categories. In contrast, the results from Analysis 3 show that several non-biological categories have experienced evolution during the 20th century (e.g. *book, clothes, furniture*) while others have stabilized (e.g. *weapon, boat*). We can be confident, then, that the declines observed in *tree* and other folkbiological categories are not statistical artifacts of the corpus. Finally, the results from Analysis 4 reassure us that the changes in frequencies observed in the preceding analyses were not solely due to changes in the purposes and interests of writers. Had this been the case, the trends would have been most clearly seen in cases where tree terms were the topic of the quotations. In fact, periods of evolution and devolution were observed for non-topical uses, i.e. for uses incidental to the purposes of the writer.

Generalizability of the findings. The generalizability of the results in the preceding analyses depends, in part, on the kind of audience authors assumed. The audience, in turn, depended on the proportion of the population that could read at different periods of time. Examination of the history of education in England suggests that this proportion increased progressively over the centuries covered in the preceding analyses (see Clarke, 1959; Bowen, 1981). Beginning in the 16th century, the literacy rate was no doubt less than 45% (Bowen, 1981). People had access to a relatively wide range of written materials including play-books, ballads and pamphlets as well as erotic literature, implying the existence of a sizeable reading public, and the children of even ordinary parents often learned how to read. But the kind of schooling that would have admitted people to higher culture and vocational advancement was available to perhaps less than 1% of the population (Bowen, 1981). During the 17th century, parish schools continued to serve children of parents of more modest means and grammar schools were firmly in place in every sizeable market town for the sons of the wealthy. In addition, dame schools were established for the children of poor parents. While children typically studied only until the age of 7, they were taught to read. According to Bowen, literacy rates for the urban bourgeoisie were close to universal, at least 90%, compared to approximately 65% for urban artisans and little more than 10% for rural peasants. Overall literacy rates were probably between 20% and 45%. The first part of the 18th century saw few changes in schooling. By the end of the 18th century, however, Sunday schools were instituted for the children of the very poorest in society, representing the beginning of mass education. In one study associated with the Marriage Act of 1753, it was found that 51% of persons could sign their names. Because writing is a productive rather than receptive form of literacy, it is likely that an even greater percentage of these people could read (Bowen, 1981). During the 19th century,

many children between the ages of 6 and 11 were receiving schooling, which supported increases in literacy. By 1844, 67% of the males and 51% of the females could sign the marriage register. In the last two decades of the century, education for all societal classes became compulsory, raising the literacy rate still higher.

In sum, it appears that literacy rates grew steadily over the centuries with literacy rates during the 18th, 19th and 20th centuries at or above 50%. Thus, the whole of our results would probably generalize to a large portion, if not most, of the population for every time period. It should also be remembered that reading was only one of several kinds of cultural support. For those that could not read, there was, for example, the theater. Plays were attended by low- to middle-class citizenry and could have provided exposure to folkbiological categories, as demonstrated by the first three quotations in Table 1, all of which come from Shakespearean plays. We can be relatively confident, then, that the average person had either direct or indirect access to the cultural support communicated through writing for most, if not all, of the centuries covered in the proceeding analyses.

6.1. Psychological implications.

The results from the previous analyses describe conceptual change at the cultural level. However, there are several ways in which the historical examination of words may say something about the nature of conceptual representation and change at the individual level.

Representational states. Analysis 2 showed that the relative relationships between different levels of specificity could differ. In the 17th century, for example, the ratio of specific terms to the life-form term ''tree'' was roughly twice that of what it was in the 16th century. In the 20th century, the ratio of generic terms to the life-form term ''tree'' was roughly half that of what it was in the 19th century. Relationships between different levels of specificity at particular points in time at the cultural level may correspond to how this domain of knowledge could be represented in individuals. Historical analyses suggest, then, that the representational state of knowledge held by individuals may vary greatly with respect to the relative proportion of categories at different levels of specificity.

Acquisition of knowledge. Historical analyses of words may also tell us something about the sequence in which knowledge is acquired by individuals. As shown in Analysis 2, between the 16th and 17th centuries there was a strong increase in the use of generic-level terms, but not of specific-level terms. Between the 17th and 18th centuries, however, there was a strong increase in specific-level, but not generic-level, terms. It may also be the case that the life-form level term, ''tree'', preceded the acquisition of many generic-level terms, but the results from Analysis 2 do not go back far enough to allow us to make this claim too strongly. The historical record suggests, then, that more general categories may emerge before more specific categories. A similar pattern has been observed in children's acquisition of words with basic-level terms usually learned before subordinate level terms (Markman, 1989).

Representation of domains that are in decline. In addition to revealing something about the sequence in which knowledge is acquired, historical analyses may also tell

us something about the way in which a domain of knowledge may die. When a domain devolves, does it reverse the order of its evolution? The answer to this question appears to be a cautious ''no''. When a domain evolves, knowledge of the domain motivates the creation of increasingly more precise categories. When a domain devolves, it may not be the case that the labels for these more precise categories are the first to go. As shown in Analysis 2, during the 20th century specific level categories declined less than predicted compared to the declines at other levels. As mentioned earlier, the resilience of the specific level might have been due to a relatively small group of experts, but it is also possible that something else may be occurring.

It is commonly assumed that when people use a term, they are fully aware of its meaning. However, during the decline of a domain, this tight coupling between a term and its meaning might begin to break down. As mentioned in the introduction, people may know the names of a number of tree terms, e.g. birch, cedar, chestnut, fig, hickory, maple, oak, pine, or spruce, but they may not be able to pair these terms with actual referents in the world. When a domain dies, knowledge of the underlying concepts may decline faster than knowledge of their labels. Thus, certain distinctions may be preserved in the lexicon beyond the time these distinctions are still understood. It is as if knowledge builds up a terminological structure in the language, but that when knowledge declines, the structure, like an abandoned building, remains for a while, giving rise to *vacant categories*, that is, categories that are known in name only. What makes this hypothesis particularly interesting is that it seems to be supported by recent findings assessing people's patterns of induction.

A set of studies by Coley, Medin and Atran, (1997) (see also Atran, Estin, Coley & Medin, 1997), examined the question of how knowledge of a domain might affect categorical induction. The authors investigated the induction patterns of urban Americans and Itzaj Maya for several folkbiological taxonomies including bird, fish and tree. Coley et al., predicted that the Maya would treat the generic level as privileged by questioning the validity of inferences from generic to life-form categories, but not from varietal to specific or from specific to generic. In contrast, Americans were expected to treat the life-form level as privileged, by questioning the validity of inferences from the life-form to the kingdom levels (e.g. animal, plant), but, importantly, not from the generic to life-form like the Itzaj. These predictions were based on studies showing that the Itzaj possess a great deal more knowledge about living things than do American college students (López, Atran, Coley, Medin & Smith, 1997) and on the assumption that the privileged level should depend on expertise. However, despite these differences in knowledge, both Itzaj and Americans treated the generic level as privileged with respect to category induction. What makes this result surprising is that Americans have been found to treat the life-form, not the generic level, as privileged on other tasks (Rosch, Mervis, Gray, Johnson & Byes-Braem, 1976; Tversky & Hemenway, 1984). As in this paper, Coley et al. (1997) found a disparity between category use and knowledge. Their solution is similar to ours. When it comes to category induction, people may rely heavily on the their knowledge of labels, especially when their knowledge for the domain is weak.

Multiple basic levels? One question not fully resolved by Coley et al., concerns the question of why Americans have more than one privileged (basic) level. One possibility mentioned by these authors is that the privileged level may change depending on the task. For Americans, the privileged level may be the life-form level when the task involves explicit knowledge or perceptual distinctions and the generic level when the task involves category induction. What might have led to this dissociation? One possibility is suggested by the analyses in this paper, namely the emergence of another basic level. During the 19th century, the basic level for both induction and perception tasks may have been the generic level. But as folkbiological knowledge devolved, the basic level for perceptual distinctions may have reverted to the life-form level while the basic level for inductions remained at the generic level.

These mismatches in degree of structure and amount of knowledge may have other psychological implications as well. For instance, it may explain why we have the intuition that knowledge about trees is dying. It may be that people sense a disparity between what they know and the terminological sophistication of their language. To end on a more positive note, it may be that while knowledge about trees has devolved, not all has been lost. Much of what has been know about trees might still be preserved in the language, albeit indirectly, and its presence there could facilitate the process of its re-acquisition.

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References

Atran, S., Estin, P., Coley, J. D., & Medin, D. L. (1997). Generic species and basic levels: Essence and appearance in folkbiology. *Journal of Ethnobiology*, *17*, 17–43.

Atran, S., Medin, D., Ross, N., Lynch, E., Coley, J., Ucan Ek', E., & Vapnarsky, V. (1999). Folkecology and commons management in the Maya Lowlands. *Proceedings of the National Academy of Sciences USA*, *96*, 7598–7603.

Atran, S. (1990). *Cognitive Foundations of Natural History: Towards an Anthropology of Science*, Cambridge: Cambridge University Press.

Battig, W. F., & Montague, W. E. (1969). Category norms for verbal items in 56 categories: A replication and extension of the Connecticut category norms. *Journal of Experimental Psychology Monograph*, *80*, 1–45.

Berg, D. L. (1993). *A Guide to the Oxford English Dictionary*, Oxford: Oxford University Press.

Berlin, B., Breedlove, D. E., & Raven, P. H. (1973). General principles of classification and nomenclature in folk biology. *American Anthropologist*, *75*, 214–242.

Berlin, B. (1992). Ethnobiological classification. In E. Rosch, & B. Lloyd, *Cognition and Categorization*, (pp. 9–26). Hillsdale, NJ: Erlbaum.

Berlin, B. (1972). Speculations on the growth of ethnobotanical nomenclature. *Journal of Language and Society*, *1*, 63–98.

Bowen, J. (1981). *A History of Western Education, vol. 3, The Modern West, Europe and the New World*, London: Methuen.

Clarke, M. L. (1959). *Classical Education in Britain 1500–1900*, London: Cambridge University Press.

Coley, J. D., Medin, D. L., & Atran, S. (1997). Does rank have its privilege? Inductive inferences within folkbiological taxonomies. *Cognition*, *64*, 73–112.

Diamond, J., & Bishop, D. (1999). Ethno-ornithology of the Ketengban People, Indonesian New Guinea. In D. L. Medin, & S. Atran, *Folkbiology*, (pp. 17–45). Cambridge, MA: Bradford.

Gleitman, H., Fridlund, A. J., & Reisberg, D. (1999). *Psychology* (5th ed.), New York: W.W. Norton.

Hatano, G., & Inagaki, K. (1987). Everyday biology and school biology: How do they interact?. *The Quarterly Newsletter of the Laboratory of Comparative Human Cognition*, *9*, 120–128.

Huddleston, R. (1984). *Introduction to the Grammar of English*, Cambridge: Cambridge University Press.

Hunn, E. (1999). Size as limiting the recognition of biodiversity in folk biological classifications; one of four factors governing the cultural recognition of biological taxa. In D. L. Medin, & S. Atran, *Folkbiology*, (pp. 47–69). Cambridge, MA: Bradford.

Inagaki, K. (1990). The effects of raising animals on children's biological knowledge. *British Journal of Developmental Psychology*, *8*, 119–129.

Kuhn, T. S. (1970). *Structure of scientific revolutions* (2nd ed.), Chicago, IL: University of Chicago Press Originally published 1962.

López, A., Atran, S., Coley, J. D., Medin, D. L., & Smith, E. E. (1997). The tree of life: Universals of folkbiological taxonomies and inductions. *Cognitive Psychology*, *32*, 251–295.

Markman, E. M. (1989). *Categorization and Naming in Children: Problems in Induction*, Cambridge, MA: MIT Press.

Murray, K. M. E. (1977). *Caught in the Web of Words: James A. H. Murray and the Oxford English Dictionary*, New Haven: Yale University Press.

Murray, J. A. H. (1989). *The Oxford English Dictionary* (2nd ed.), New York: Oxford University Press O.E.D. preface and general explanations.

Nabhan, G. P., & St. Antoine, S. (1993). The loss of floral and faunal story: The extinction of experience. In S. R. Kellert, & E. O. Wilson, *The Biophilia Hypothesis*, Washington, DC: Island Press.

Phythian, B. A. (1980). *English Grammar*, London: Hodder and Stoughton.

Rosch, E., Mervis, C. B., Gray, W. D., Johnson, D. M., & Byes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology*, *8*, 382–439.

Tversky, B., & Hemenway, K. (1984). Objects, parts, and categories. *Journal of Experimental Psychology: General*, *113*, 169–193.

Wester, L., & Yongvanit, S. (1995). Biological diversity and community love in Northwestern Thailand. *Journal of Ethnobiology*, *15*, 71–87.

Ziff, P. (1960). *Semantic Analysis*, Ithaca, NY: Cornell University Press.