AN ANTHROPOLOGY OF READING SCIENCE TEXTS IN ONLINE MEDIA

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ABSTRACT

Reading multimodal (popularized) scientific texts predominantly is studied in terms of technical decoding skills said to be required. In this chapter I suggest that there are other interesting approaches to the study of reading multimodal (popularized) scientific texts grounded in anthropological concerns and the notion of reading as social praxis. These concerns include questions of what people read, how much they read, and the purposes and effects of reading. Here, I focus on reading practices and the kind of semiotic (meaning-making) resources (popularized) scientific texts in online media make available for the *practices* of reading, including the way in which membership categories are used to link different aspects of a text. An anthropology of reading (online science) ought to be of interest to (science) educators and educational psychologists, because, as part of development, members of society encounter reading first in their transactions with others, as a social phenomenon, before reading becomes an individual phenomenon. Important aspects of reading multimodal (popularized) scientific texts therefore can be found by studying sociocultural and cultural-historical practices and resources. Because "mind" is found in society, the development of higher-order psychological processes including reading can be studied using methods more typically found in disciplines concerned with culture. In this chapter, I take inspirations from anthropological and ethnomethodological approaches to reading generally that are consistent with a cultural-historical approach and develop them for my study of the reading of online (popularized) scientific texts. My database includes all science texts that BBC published online between February 16 and March 31, 2007. I develop a framework for reading these texts from a cultural-historical practice perspective and provide exemplary analyses of reading such multimodal texts from an anthropological and ethnomethodological perspective.

INTRODUCTION

Reading science textbooks and science-related materials is pervasive in praxis but it is not a major item in the thinking of science teachers or a major research focus on the part of science educators (Norris & Phillips, 2008). When it is a focus of research, then of interest often are vocabulary, meanings of texts and images independent of the lived work of reading, or science and reading as separate entities that need to be brought together or integrated. A second major dimension common to much of published research on reading in science is the focus on what students *cannot* do—e.g., the misconceptions they have while reading (Anderson, West, Beck, MacDonell, & Frisbie, 1997), the absence of reading comprehension and metacognitive skills (Craig & Yore, 1995), or an over-confidence readers have in their own understanding (Norris, Phillips, & Korpan, 2003)—which generally occurs against an unstated background of the normative performances and questions of why the population under study *ought to know* science in the way laboratory scientists do (Roth, in press). The fact is that even experienced PhD scientists themselves do not provide readings of graphs from introductory college textbooks in their own discipline that the instructors of introductory courses would accept as correct from their students (e.g., Roth & Bowen, 2003).

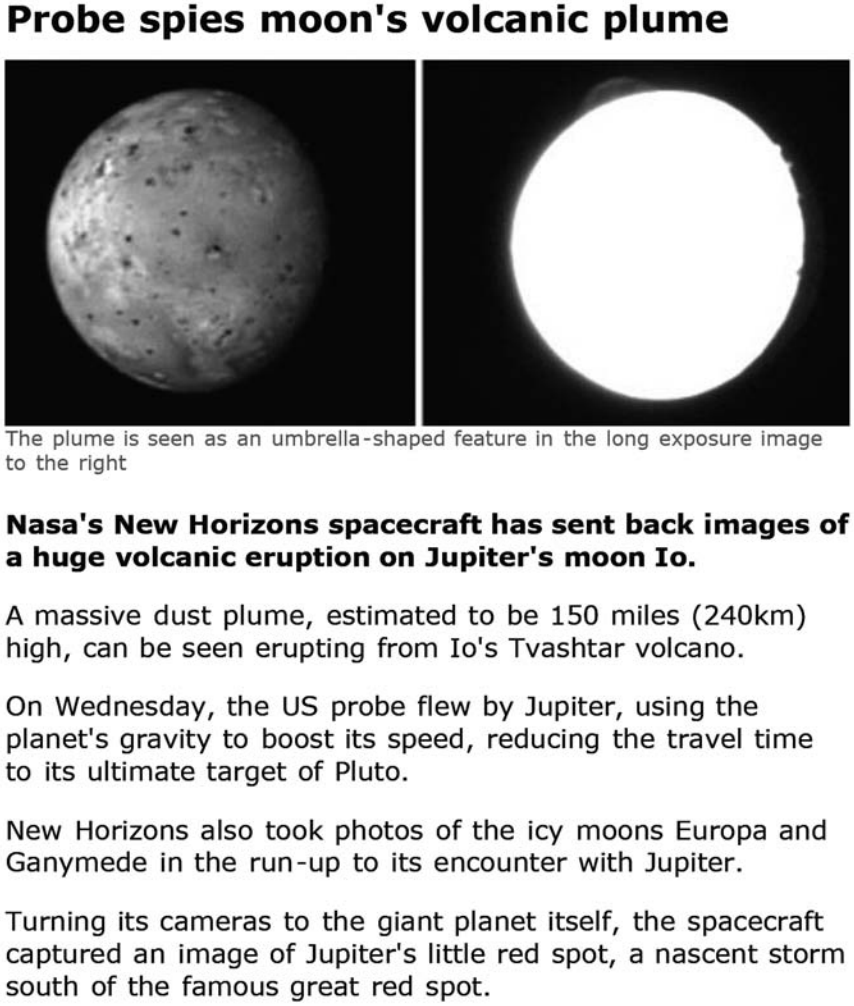
Against the background of such deficit views of students in science specifically and of the public understanding of science more generally, my research agenda has been concerned with the tremendous skills exhibited in everyday praxis that allow individuals to become scientists, doctors, engineers, and so on although at some point in their life they "had misconceptions" and viewed the world much in the way those deficit-oriented studies depict. Concerning scientists and technicians, this has led me to begin anthropological studies concerned with graphs and the way in which these are used—read, produced, and made sense of—in the course of practical, everyday, ongoing work in scientific laboratories, scientific field research, and a variety of workplaces (Roth, 2003a).

Concerning lay science reading in the general public, as a high school teacher I have experienced time and again that students may become interested in science after picking up and discussing such works as Stephen Hawking's (1988) *A Brief History of Time* or Bruce Gregory's (1990) *Inventing Reality: Physics as Language* despite the fact that such works may not constitute easy readings. We know from the literature that everyday people generally may pick up science-related books and become interested in the subject more generally (Schummer, 2005). The following questions of interest to those working in the field of the public understanding of science and scientific literacy then poses themselves: What is it that allows *just plain folks* (an expression I borrow from Jean Lave) never interested in science before—and, in fact, turned away from science in and through their negative school experiences—to pick up a book on nanotechnology, read it, and become interested in science and regular consumers of texts on the topic? What is it that allows just plain folks to pick up a book or open a webpage and read science and science-related text although they do not have what science educators would consider the requisite "prior knowledge"? Proper answers to these questions have to begin with people actually bring to such first encounters, because only knowledge of what just plain folks actually do and think allows us to understand why some, upon encountering a science-related hyperlink, makes them read science and then become deeper entrained into the relevant scientific field.

The purpose of this chapter is to provide an answer to these and similar questions by engaging in an anthropology of reading that focuses, consistent with theories in cultural sociology (e.g., Sewell, 1992), on the *agency*|*structure* dialectic that exists in the reading|text pair. Here, text constitutes a *resource*, one form of structure, whereas the cultural *schema* a person may be said to bring to a situation constitute another form of structure. In ongoing praxis, structure cannot be understood independent of the forms of *agency* that mobilizes it, here *reading*; or, in other words, it is only within agency that we know what the relevant and currently mobilized structures are. On the other hand, without structure we do not know why agency takes the particular forms it exhibits in ongoing praxis. My investigation shows that science texts, as other texts generally, provide resources for reading to organize itself and accomplish a coherence with existing understanding that often is referred to as meaning. Here I take it with the philosopher of everyday cognition Martin Heidegger (1996) that words and sentences *do not have meaning* but that words and new texts *accrue to* always and already existing meaning that constitutes our everyday lifeworlds—where the term lifeworld is understood to denote all those things that are salient and relevant to, and taken for granted by, us in everyday coping with the world that surrounds us and concerns that are pertinent within it. To enter the problematic of reading science online texts, I enact in this chapter an anthropology of reading, which begins with a consideration of reading *practices* available in and through my own reading of online science texts. Here, I am not interested in individual and singular senses or meanings that I—or any other reader for that matter—might evolve in the process of reading. Rather, I am interested in the more general patterns that allow reading—qua social practice that is learned in transmitted in social situations—to organize itself given the cultural resources provided in science and science-related texts that are published, among others, by the British Broadcasting Cooperation (BBC). In the course of one such reading (the website is made available in Figures 1, 4, and 5) selected from more than 6 weeks worth of materials analyzed, I exemplify what an anthropological study of reading might look like and articulate some of the specific resources and skills that characterize the reading|text pair. (The page, which I randomly selected from my database for the present purposes, is available at http://news.bbc.co.uk/2/hi/science/nature/6406721.stm.) I begin with an account of the first time that I encountered this online science text.

It is March 1, 2007, very early in the morning. I begin my workday with a quick look at the BBC news website, scan the "headlines," and follow some but not other links. Among those that I follow ranks "Probe spies moon's volcanic plume" not just because it appears to promise something I am interested in, but also because I am in the middle of a study of reading online science materials that had begun two weeks earlier (February13, 2007) and was to continue for another month (March 31, 2007) as part of which I save copies of (links to) every science-related article that BBC publishes during this period. One of the very first questions that emerges into my conscious mind concerns the reason why we, readers of online materials, follow some links but not others. What is it in the text "Probe spies moon's volcanic plume" (Figure 1) that incites a reader to follow the hyperlink and read the related article? What does such a hyperlink—which turns out to be the headline of the article as well—make available that promises and reveals news, which readers then look for in greater detail by reading the article at hand? An anthropology of reading online science materials begins with an investigation of the hyperlink (headline), for an understanding of scientific literacy must begin with trying to understand what makes just plain folks—heretofore and all too often disinterested in science—take up reading science after seeing link, headline, or book

title that constitutes a starting point for a story that a person subsequently might comment upon with the well-worn "and the rest is history." Reading the hyperlink provides me with a context to introduce several concepts central to an anthropology of reading. The concepts are discussed and further elaborated in the subsequent section before I turn to an exemplary study concerned with understanding the praxis of reading online science materials generally. That is, I am not interested in my or any one else's reading as product (e.g., my interpretation), but in the structures that support the reading processes from which issue this, that, or another reading (product).



Probe spies moon's volcanic plume

The plume is seen as an umbrella-shaped feature in the long exposure image to the right

Nasa's New Horizons spacecraft has sent back images of a huge volcanic eruption on Jupiter's moon Io.

A massive dust plume, estimated to be 150 miles (240km) high, can be seen erupting from Io's Tvashtar volcano.

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Turning its cameras to the giant planet itself, the spacecraft captured an image of Jupiter's little red spot, a nascent storm south of the famous great red spot.

Figure 1. Top third of a BBC online article from March 1, 2007, focusing on a NASA mission to Jupiter and its moons. (Permission to reprint granted by the BBC on November 7, 2007)

I began the work on this chapter because, as part of my research agenda on scientific literacy in everyday practice, I wanted to find out more about what it takes to read online science texts even in the absence of specific preparation in the science covered. It turns out, as shown here, much of what it takes to read online science material are more general cultural practices. It has to be that way, as there are a substantial number of individuals who come to

science through materials posted on the web; more so, individuals who had been turned off from science while attending school, largely at the secondary level, find science very interesting and engaging. One aspect that is particular to online texts is the hyperlink that leads potential readers to another page on which the text appears in its entirety, at least on the BBC site. (On other sites, such as the German *Die Zeit*, articles spread over multiple pages so that the reader has to navigate additional hyperlinks.) I therefore spent a considerable part of this analysis on reading hyperlinks for the newsworthy item. Further aspects that are particular to online science materials are the frequency of images, which, more like in high school science texts, constitute a particular pedagogy in their interaction with the various forms of text present (caption, main text, title). But the online science texts also differ considerably from high school texts in that they are not intended to "teach" a particular content and the concept words associated with it (Pozzer & Roth, 2003); these words frequently are highlighted in boldface type, asking reading to configure itself in a particular way to extract what it is expected to learn. There are other differences with book texts as well: generally no turning of pages, the possibility to highlight text with the cursor, the possibility to change the text size and frequently the images. These, however, are not the focus of the present inquiry, concerned as it is with the issue of how we make sense of text and images.

READING HYPERLINKS FOR A NEWSWORTHY STORY

On this day, the main hyperlink under the *category* "Science" reads, "Probe spies moon's volcanic plume." In fact, "Science" is not just a category but in fact a *category collection*, for there are very different articles on very different topics and from very different disciplines that I have collected over the six weeks of the data collection under this category name. (It turns out that the statement making the hyperlink also will function as the title of the text; or conversely, the title also doubles as the hyperlink.) "Probe spies moon's volcanic plume." This, as my further investigation below shows, also is the headline of the article itself (Figure 1). For a reader to become interested in following the link, it has to have something in it that promises and foreshadows a newsworthy item—after all, the link is provided on the main website of a media outlet featuring "news." What is it that is newsworthy, and what of this newsworthy event or fact is revealed in the hyperlink (headline), the purpose of which is to invite readers to follow and read the associated article? Let us begin with the reading.

"Probe spies moon's volcanic plume." Probe. The term "probe" is used literally to denote an act of examining or probing something and figuratively to denote a penetrating investigation. Figuratively, it is also used to refer to an entity that penetrates some domain "as if to explore or investigate; a thing used to obtain information about something or someone" (OED, 2008). It denotes covert police operations, whereby an undercover officer infiltrates an organization to find out about its activities and intentions, the agents/perpetrators of which might not otherwise be known. In the current situation, "probe" is in what commonly is the subject position of the sentence, though the revelation of the precise nature of the word may have to await further reading. That is, probe belongs to a category of agents or recipients of agency when it is acted upon.

"Spies." The next word is an action verb in the third-person singular. Having read "probe" as the subject now becomes plausible, because subjects generally are agents of

action. The verb "to spy" exists both in transitive and intransitive form. In the latter form, it is used in the sense of making (stealthy, covert) observations. A probe, as "a drone," acts in place of human beings, when it is impossible or too dangerous for human beings to go to the place of interest. (For example, the *Washington Post* featured a headline "U.S. Uses *Drones* to *Probe* Iran for Arms.") "Spies" not only is a verb but also the first part of what is known to grammarians as *predicate*, here "spies moon's volcanic plume." The word appears in the third-person singular form of the verb "to spy." It is generally used to denote watching and making observations in a stealthily manner, though, more uncommonly, it also denotes looking at, examining, observing closely, catching sight of, discovering, or noticing (OED, 2008). As a transitive verb, "spies" demands an object to be spied on or upon or the something that has been spied (seen, discovered). Here, such a reading is confirmed or enabled after the fact as soon as reading arrives at the second part of the predicate, "moon's volcanic plume." A moon, whether it is the one accompanying the planet Earth or the moon of any other planet, is not easily accessible. Few people have been to the one accompanying the Earth, and no human being has been there lately. It now becomes possible to understand why it is a probe that is doing the spying rather than a human being. It has also become possible for the spying to be read as observing, discovering: there is little that requires stealth when one or more moons are concerned.

"Moon's volcanic plume." The second part of the predicate consists of a noun in its genitive form, an adjective, and a regular noun. Plume. The primary sense of "plume" is feather or feathers taken collectively (as in plumage). In metaphoric extension, it also has the sense of adornment, ostentatious display, or mark of honor. In extended usage, the term "plume" refers to anything resembling a feather or feathers; the extension carries both form and lightness of the primary phenomenon. Even prior to arriving at the word, reading has appropriated the adjective "volcanic," which organizes reading to find something pertaining to a volcano. These do not generally have plumes in their primary sense, but the clouds of smoke and materials associated with eruptions. As such, plume takes one of its other senses, a trail of cloud, smoke, or vapor that emerges from some localized source and spreads out (OED, 2008). There therefore is not even an issue of interpretation, because while reading crosses the adjective "volcanic," it configures itself to discover and disclose phenomena related to volcanoes. The newsworthy item thereby becomes the discovery of volcanic plume that—because of the observation as a discovery—has not been observed before at all or not to the extent to be described.

"Probe spies moon's volcanic plume." In engaging with this text that constitutes the hyperlink, therefore, reading has organized itself to find the newsworthy item: the discovery of a volcanic plume on some moon. Reading does so both forwardly, coming to expect particular resources as materials for further reading, and retrospectively, in reading what has been read differently or specifically (when and where alternative readings are possible). As it begins to follow the unfolding text from left to right, both the subject "probe" and verb "spies" open up the cultural (and therefore general) possibility that the hyperlink takes readers to a spy story. But the second part of the predicate makes such a reading unlikely, though not impossible. This is so because activities and action-words are often bound to specific categories, and using a *category-bound activity* implies the category associated with it. Spying is bound to spies and other secretive agents, and probes are consistent with the category collection of secretive agents. Reading thereby retroactively structures itself to alter or make definitive its prior reading achievements; and in this structuring and restructuring,

reading finds the newsworthy item: The discovery of a volcanic plume, sign of an eruption, that has not been seen before.

CULTURAL RESOURCES OF/FOR READING

Everyday reading draws on resources for the production of probable readings, such as finding in the link (title) the newsworthy item that its author has intended to be found. These resources are cultural, available to anyone engaged in competent reading; as cultural resources, which constitute cultural (collective) possibilities for acting, these can be studied anthropologically. Among the resources are, as seen in the previous section, member categories, category collections (devices), and category-bound activities; but there are also maxims (heuristics) and rules. Together they constitute a set of resources for speaking/writing and hearing/reading in culturally specific ways (Sacks, 1974); as cultural resources, they are available to every member. In fact, not using these resources or using other resources would be regarded as foreign, strange, and abnormal, and therefore would ask for an explanation, as was shown in the infamous breaching experiments that Harold Garfinkel (1967) conducted. Thus, it would be curious indeed if, after telling someone that I have been reading an online article about Jupiter's moons, the person were to ask me, "What do you mean by 'reading'?" We would expect the person to provide an explanation for why he or she asked the obvious, because the person has breached what is taken to be plain, ordinary, and everyday sense of the words and phrases we use. Here, I elaborate each of these cultural resources that members of society draw upon in reading and that subsequently figure and are highlighted in the exemplary reading of the selected science online text.

A *category* collects entities that are recognized to be of the same kind: Io, Ganymede, and Europa, which appear in the different parts of the text (see Figures 1, 4, and 5), all are members of the category moons; Jupiter and Pluto used to be members of the same category, planet before the latter was demoted less than a year earlier to be a member of the dwarf planet category. Some planets have moons associated with them, including the three named ones in this article that belong to Jupiter and the three noted but unnamed ones that accompany Pluto (paragraph 5, Figure 5). Together, planets and their associated moons form *standardized relational category pairs*: The pair planet–moon is of the same kind as the husband–wife, teacher–student, or brother–sister pairs. Employing one member of a pair constitutes an opportunity to introduce the other member without additional preparatory work. Thus, the statement "Jupiter's moon Io" affords reading "Jupiter" as the name of a planet even without having to state explicitly that "Jupiter" in fact *is* a planet. This is an important way for extending what a person already knows, that is, allowing reading to extend existing categories by adding further members. This might be evident for planets, assuming every culturally competent person knows all the planets of the solar system and their names. But in less everyday topics that regularly feature on science-related websites such as BBC this becomes an important resource for a novice on the topic.

Categories are combined to form *category collections*—they also can be situationally combined in the case of not "naturally" or previously existing collections. "Solar system" (first paragraph, Figure 5) is one such device, collecting planets, moons, sun(s), and other categories not mentioned in this article (e.g., dwarf planets, comets, asteroids, meteoroids,

interplanetary dust, clouds, planetary discs). A category collection taken together with a given or open set of rules of application constitutes a *categorization device*. Rules of application articulate how and why specific members belong to a category. As the recent history of the member planets in our solar system shows, rules may change thereby refining categories to allow inclusions and exclusions not existing before—Pluto, which used to be a planet no longer falls into this category. Thus, Pluto is a member of the dwarf planet category because of the rule "has not cleared the neighborhood around its orbit, and is not a satellite."

Adequate reference (sometimes *economy*) and *consistency* name two rules that mediate categorization. The first rule allows the use of a single category reference to characterize an entity. Thus, the specification of Io as a moon of Jupiter (Figure 1, first paragraph) is a sufficient resource for reading to find it as a member of the solar system collection. Because of the noted standardized nature of category pairings, therefore, establishing Io as a moon also establishes Jupiter as a planet because of the adequate reference (economy) rule. The second rule states that if some population is categorized and if some category from a collection is used to characterize a member of the population, then that same collection may also be used to categorize further members of the population. Thus, upon encountering the category "moon" in the title, and given that the moon is a celestial body of the solar system, other categories from the solar system collection may be employed for categorization purposes, including "dwarf planet" or named members thereof (i.e., Pluto) and, not applicable in the present article, "small solar system bodies."

Two *maxims* or heuristics constitute further resources for the lived work of reading to accomplish the intended reading of a given text. The first heuristic specifies that if two entities are collected into two different categories that can be hear/seen as being part of the same collection, then they should be seen as such. Io is a member of the category moon; Jupiter is a member of the category planet. Both *can be* read (heard, seen) as categories of the solar system collection and therefore, thus goes the heuristics, *should be* read (heard, seen) that way. The second heuristic allows reading to recognize categories when it comes across action terms that tend to be bound to categories. The actions of seeing and spying are bound to the category of images, so that even without further specification, the category of images (photos, drawings, mental images) not only *is* implied but also *should be* implied.

GEOGRAPHY OF ONLINE TEXTS

A generally unnoticed aspect of reading is the fact that reading organizes itself so that whatever the text, we come to read a science text *as* science text, a poem *as* poem, a commentary *as* commentary rather than as news item, and so on. That is, reading can engage with *any* text even without knowing beforehand what type of text it is; and then as reading unfolds, the process organizes and configures itself to become a form of reading appropriate for a science text, poem, commentary, news item, and so on. Reading, therefore, is a self-organizing process that contingently configures itself to be appropriate to the task. Reading not only produces "a reading," that is, an outcome, but, in configuring itself, produces itself as a process—much like a university committee that not only makes decisions but also configures itself to evolve a process by means of which the decisions are to be made. More so, when reading encounters "Probe spies," it is yet unclear whether there is a spy story to

come or some element of spying or a text that makes tongue-in-cheek reference to spying, and so on. It is the text itself that makes available specifications of how it is to be read. Reading encounters these specifications as resources and uses them to configure itself. In part, the text itself is organized physically, that is, it provides physical resources for reading to organize itself and read a poem, science text, opinion editorial for what they are. The layout of the text is one resource, which generally works well to distinguish poems from other forms of text, though there is prose poetry, which looks more like a literary text than a poem. There are other more detailed structural resources as well, as I show below.

If it appears strange why I focus on the physical features, then consider cryptanalysis or the decipherment of ancient inscriptions in forgotten languages and ciphers. To decipher what the text says, the analyst has to identify recurrent structures and physical organizations that provide clues to "words," "sentences," "paragraphs," "beginnings," "endings," and so on and therefore provide clues to the (spoken) languages that they represent. The physical context and its structure provide resources for the reading of the texts themselves. For example, "'hieroglyphic' script," one of three different forms of writing found during excavations at Knossos (Crete), is found only on seal stones, thereby providing special clues to its decipherment. Another form of writing, denoted by the term "linear B," includes short lines taken to be dividers of words, and "pictograms," which were thought to denote whole words. That is, the decipherment of a text requires reading to use physical clues to organize itself and find what the text is intended to communicate. I use the term "geography," for the physical display provides a heterogeneous terrain of physical resources (structures) that allows reading to take its course.

Topology and Features

On first opening the webpage after following the hyperlink "Probe spies moon's volcanic plume," it becomes immediately apparent that there is not a homogenous but a textured surface that is receiving (on which falls) the reader's gaze. It is not just that the gaze is falling on this surface, but the textured surface of the page has awaited the reader, as anyone following the link, to receive the gaze that is falling upon it. In fact, its author has designed the page such as to invite reading, which therefore configures the author and the reader as a "standardized relational pair of categories" (Hester & Eglin, 1997, p. 36). In this situation, the texture constitutes a particular topology, a surface with different regions, consisting of different physical features. These together make for an entity that can be studied by a science concerned with the way in which physical surfaces that surround us in our everyday world present themselves to us.

From afar, literally, where the details of the webpage remain unclear, a first structure emerges in the relation of different fields, of which we find three in the case of this article (Figure 2). The figure clearly shows the physical similarities that are constitutive of the existence of the three parts of the article. Upon approaching, it can be noted that each field consists of short dark text ("title and subtitles") and lighter printing ("text") and images, the latter associated with even lighter, grey text ("caption"). In the present instance, there are what reading comes to recognize as five "paragraphs" following the "title" and one image associated with a subtext.

The first identifiable part of the display repeats the hyperlink, "Probe spies moon's volcanic plume." It is identifiable as something separate because of its larger size and boldface printing. Here, we do not see the text as a hyperlink but as a title, because reading draws on the structure of the context (background) to establish "Probe spies moon's volcanic plume" as a different kind of figure. That is, the same piece of text, differently located and structured—no longer is there an underline and color feature that marks it as a link to another page—changes the nature of reading from a reading|hyperlink to reading|title pair; and this change is the result of the process of reading.

Etymologically, *title* derives from the Latin word *titulus*, superscription. A title is a form of text inscribed before or above some other text, announcing the latter, announcing its content. What is the work that allows us to (a) see the title as title and (b) find in the text what the title announces? In the Western tradition, reading progresses from left to right and from top to bottom. It is in this that the praxis of (Western) reading comes to realize itself, finding the "superscript," and finding in it something announced, the discovery of a volcanic plume on a moon, which it then finds elaborated in the text that follows.

Probe spies moon's volcanic plume

The plume is seen as an umbrella-shaped feature in the long exposure image to the right

Nasa's New Horizons spacecraft has sent back images of a huge volcanic eruption on Jupiter's moon Io.

A massive dust plume, estimated to be 150 miles (240km) high, can be seen erupting from Io's Tvashtar volcano.

On Wednesday, the US probe flew by Jupiter, using the planet's gravity to boost its speed, reducing the travel time to its ultimate target of Pluto.

New Horizons also took photos of the icy moons Europa and Ganymede in the run-up to its encounter with Jupiter.

Turning its cameras to the giant planet itself, the spacecraft captured an image of Jupiter's little red spot, a nascent storm south of the famous great red spot.

Volcanic fallout

New Horizons made its closest approach to Jupiter at 0543 GMT (1243 EST) on Wednesday, passing within 2.3 million km (1.4 million miles) of the planet.

The gravity "kick" will accelerate the probe's speed by 14,000kmph (9,000mph).

The probe will carry out more than 700 observations of the Jupiter system by June, in a dry run for its planned rendezvous with Pluto and its moons in 2015.

Red Jr is a swirling storm in Jupiter's atmosphere

The pictures of Io provide the best glimpse yet of Tvashtar, one of the most active volcanoes on Io. The volcano can be seen in the "11 o'clock" position in the images. It is surrounded by a dark patch the size of Texas consisting of the fallout from the eruption.

The probe's observations of icy moons like Europa and Ganymede will allow scientists to map their surface features and composition.

Subsurface ocean

Europa is an attractive target; planetary scientists consider it one of the best places in the Solar System to find extraterrestrial life forms.

Beneath its outer shell of ice, the moon is thought to host an ocean of water warmed by heat from the interior.

The little red spot, or Red Jr, is a swirling storm that formed from three smaller features between 1998 and 2000.

Its larger counterpart, the great red spot, is Jupiter's most famous feature. It has been in existence for at least 130 years.

Europa is a promising target in the search for extraterrestrial life

After an eight year cruise across, New Horizons will conduct a five-month study of Pluto and its three moons in 2015, characterising their geology, structure and composition.

Figure 2. This "view from afar" clearly exhibits the physical similarities in structure, a structure that is—in a reflexive way—constitutive of the three-part nature of the article. (Permission to reprint granted by the BBC on November 7, 2007)

Among the features we immediately note in the display (Figure 2) are the different types of "text": There are "letters" of different size in the proportion of 13 (title) : 10 (subtitle) : 9 (text) : 8 (caption), different color (grey, black), and different print intensities. There are empty spaces that separate texts both vertically and horizontally. There are "capital letters." All of this micro-texture provides resources that allow reading to concretize and specify itself in the way it concretely does during this reading, without an awareness that these resources are constitutive elements in its work. The work involved in reading disappears and becomes unremarkable precisely because it has become invisible: identifying periods, capitalization, paragraphs, titles, and subtitles for what they are is so much common sense that we no longer are aware that their identification requires and does work. This work becomes visible when there is some form of breakdown, such as when archeologists encounter tablets with unknown scripts or when children learn to read.

Texts do not just appear at random on the page but, as shown in Figure 2, are organized in very structured ways. The text is not the same throughout but physically differs in different regions of the display. Grey text only appears beneath images, never exceeds the column width that the image occupies. When the image spreads across two columns, as it does in Figure 1, then the grey text spans two columns (Figure 1), whereas when the figure spans one column, the grey text only spans one column (Figure 4, 5). Such differences constitute resources that allow reading to separate out and relate different parts of text. Generally the main text (majority of the display) is black, but below the image it is grey.

Letter sizes also differ, being largest in the first line (which we recognize as title both in its position—English, as other European languages is written from top left toward bottom right, left column before right column). A second type of text is smaller ("Nasa's New Horizons spacecraft . . ."), that is, slightly larger than the majority of text (10:9 ratio), but differs from the latter in that it is printed in boldface type similar to the text (title) immediately preceding it. This text therefore constitutes something like a transition, sharing physical characteristics with the text preceding and the text succeeding it. This "first" paragraph is not really a paragraph, because it also has the characteristics of a subtitle—being printed in boldface type and appearing before the text in regular Roman printing. It is placed after the title of the article as a whole, and, in the same way, is printed in boldface type; but it also has the same size and length as a "regular" paragraph. As such, therefore, it allows a specific type of reading work to occur. Such text is read as a subtitle, as *pretext,* in two distinctly different senses of the word, for the text that follows. Other parts of the texts use the same font, size, and boldface type, but distinguish themselves in their brevity, generally consisting of a noun phrase, a noun modified by an adjective or other noun, and lacking a predicate. Here, these other texts include "Volcanic fallout" and "Subsurface ocean."

Grey text and smaller font size distinguishes another form of text associated with images, which competent members (of Anglo-Saxon culture) recognize as *caption*. That we see captions and the remainder of the text as different may be unremarkable and overstating some point. Yet we may gain a new appreciation of this relation in light of the fact that copy functions in computing environments—e.g., in (scanned) PDF materials—where the different columns remain unrecognized by optical character recognition software. Again, the attribution of the grey text to the image—that is, the relation between the two—is a result of the work of the reading|text pair, which configures reading such that it reads the grey text as caption of the image rather than as main text.

There are smaller regions of text separated from other regions of texts of about the same size—culturally competent readers recognize these as "paragraphs." These are separated from other regions by an area of white larger than the area of white between two lines. There are additional markers of recurrent features. At the "bottom right end" of each paragraph there is a "." a textual feature that members recognize as the grammatical feature "period." It is recurrent, and because of its recurrence it is remarkable and therefore remarked in actual praxis of reading. Periods have a function, or rather, we may ask, "What is the function of periods?" Another recurrent feature is the specific location where we find "capital letters." There always is one following (if the top left-bottom right of Western culture is assumed) a period, clearly marking end and beginning of structures that we recognize as sentences and paragraphs. There is only one exception: texts that do not include a period at their end are in boldface type, generally not exceeding the width of the text that follows. This, therefore, constitutes an additional resource for reading some text as (sub-) title, and allowing reading to approach the first full paragraph more like a regular text than as a subtitle, the physical characteristics of which it has (font size, boldface type).

These physical signs other than letters, though rarely if ever addressed and studied in the research literature on science reading, allow reading to organize itself, to read the text as intended and as read by competent members. This little-attended-to fact in the reading literature generally and in the literature on reading in science more specifically has been problematized and highlighted by James Joyce in chapter 18 of his *Ulysses*, where reading finds no commas, periods, quotation marks, apostrophes, or other punctuation marks as resources to structure itself:

> I wonder is he too young hes about wait 88 I was married 88 Milly is 15 yesterday 89 what age was he then at Dillons 5 or 6 about 88 I suppose hes 20 or more Im not too old for him if hes 23 or 24 I hope hes not that stuck up university student sort no otherwise he wouldnt go sitting down in the old kitchen with him taking Eppss cocoa and talking of course he pretended to understand it all (Joyce, 1986, p. 637)

Here, in the absence of punctuation, reading has to find resources other that punctuation to structure and organize itself. Reading such texts, therefore, constitutes a breach of normal reading and allows the normally hidden (aspects of the) work of reading to exhibit itself (themselves). For example, the unfamiliarity of the word "hes" may provide reading with a resource for turning upon itself and venture a possible alternative, "he's," which does include a structuring device that it normally uses. The verb "wait" can be used to "wait," read what follows as belonging to some other topic. 88. In and by itself it appears to fall out of context until reading encounters "I was married 88," which allows reading to understand the previous as an announcement of a year (1888). As it proceeds reading may arrive at the conclusion (reading as product) that Milly was born in 1889 and on the previous day turned 15, making 1904 the year of the present event. (*Ulysses* recounts the hour-by-hour events of one day in Dublin, June 16, 1904, also known as "Bloomsday.) The protagonist remembers the wedding date, making it plausible that Milly might be her daughter because this would realize the category collection of *family*. Reading can then specify the protagonist's age, as probably somewhat older than 30, making her older than but not yet too old for the male person ("he") she is considering ("he"). In fact, in the interest shown for "him," the probable sex of the "I" is female. Readers note that Joyce has retained other physical features that allow reading to

organize itself, including the capitalization of what culturally competent members recognize as names ("Milly," "Dillon[']s[']," and the English personal pronoun "I." This capitalization provides, among others, clues about how to read "Im," not as another name but as "I'm," the short form of "I am."

There are other physical structures as well, which provide additional resources for reading to structure itself. Among these, there are what is known as commas, periods, inverted commas (title), quotation marks (third paragraph from the bottom, and inverted commas. Reading makes these operate together with the text, such as when what we see as an apostrophe modifies the structure of "moons" so that we read it as a genitive form of a single "moon" rather than the plural form "moons" or the plural genitive "moons'." In constituting "moon's" as a singular genitive form, reading organizes itself and now anticipates some entity that belongs to the moon in question, which here is a "volcanic plume." Furthermore, the letters are of different types: what we recognize as "capital" letters in contradistinction to small letters. Etymologically, capital means "standing at the head," and letters at the beginning of a paragraph or chapter in certain literary books are not only of capital type but also decorated, many times the size of the remaining print. Capital letters stand at the head of words (names) and sentences in much the same way that subtitles and titles stand at the head of text sections and entire texts. In constituting a letter as a capital letter, reading organizes itself to read words that are not at the beginning of sentences as names, such as "Jupiter" or "New Horizons." Thus, the very fact that the two words in "New Horizons" (or "Solar System" [Figure 6]) are capitalized allows reading to recognize these as names rather than as concept words. The capital "S" constitutes a resource for reading to find *our* solar system rather than some other solar system within or outside of our galaxy. Even though a reader may see the words "Io" and "Tvashtar" for a first time, capitalization allows her to recognize it as the names of a moon ("Jupiter's moon Io") and a volcano ("Io's Tvashtar volcano"), respectively, rather than as regular but unknown nouns.

Recurrences and Linkages

Until now, I have noted features as if it were possible to identify something *as a* feature upon seeing a singular instance of it upon the first time. In fact, it is recurrence that allows us to see *features* as what they are, subtitles, regular text, titles, captions, and so forth. Recurrent features also provide reading with resources for structuring itself and get at the informational content of the text. Links and linkages do not appear physically in the text: they are the *product* of the work of reading. The different characteristics therefore mark out physical terrain; but they also mark out conceptual terrain. In the course of its unfolding history, reading organizes itself to establish ephemeral and situated relations between the different parts so that from the organized whole emerges the sense of *one* narrative. The most basic technique for establishing a relation between multiple pieces of the same type (within main text, titles, captions) and different type of text (across title, caption, main text) is the preservation of a word, a category, or a category device across the spatial and temporal gap in the reading|text pair (Figure 3). The definite article "the," personal pronouns ("it"), and possessive pronouns ("its"), are other means that preserve the presence of a previously introduced entity.

Examples of the way in which recurrence is used to provide resources for linking different parts of the text abound in this article, which a closer inspection of the first few lines and images of the article shows (Figure 3). The term "plume" first appears in the title and then is repeated in the caption; the adjective "volcanic" is repeated from title to first paragraph, and so is the category term "moon." The "probe" in the title and the "spacecraft" are not the same terms but they can be read to belong to the same category, and, following the above-noted cultural heuristics, should be read that way. The category-bound nature of the verbs spying and seeing allows us to read the images to be the result of this spying. The definite article "the," which appears twice in the caption, provides a resource for reading to seek the first appearance of the two items thus identified. Some linkages become possible when a term is associated with another term (or a name), so that the second term (name) in fact constitutes a resource for repeating the first. Thus, the moon category appears in the title, then is repeated in the first (boldface typed) paragraph where it appears together with the name "Io." In the second paragraph, Tvashtar is identified as "Io's" volcano rather than as some unspecified moon's volcano, the way in which it appears in the title. But because of the association deriving from collocation in the first full paragraph, reading knows Io to be the moon it first encountered in the title.

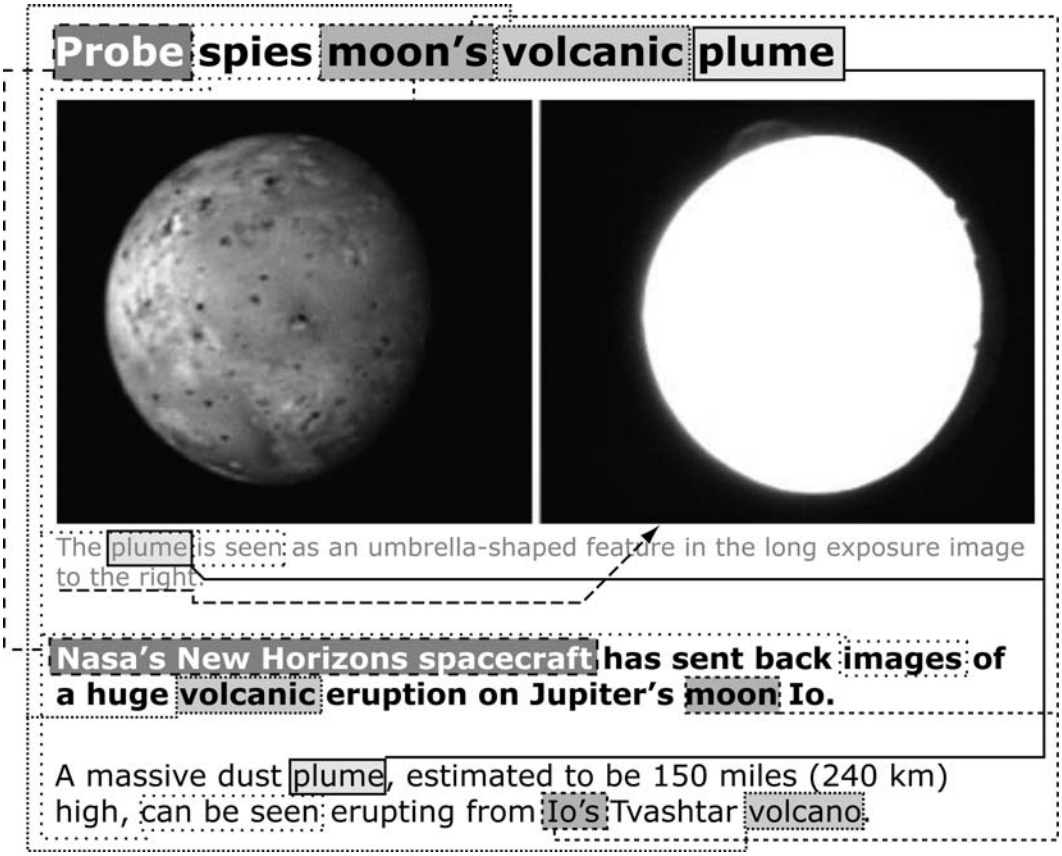


Figure 3. Physical geography of an online article and the resources (categories, category complexes, predicates) it makes available for building a coherent sense.

The relation between text and image, because there is a translation between domains involved, is more complex. However, even the replacement of a word by a synonym constitutes a translation, which, as all translation, relates two things that are non-identical and therefore not replicas of one another. To produce a sense of oneness, the reading|text pair has to provide resources (text) and possibilities for linkages (reading) that relate different parts of the multimodal display (Figure 3). These links, as stated above, are not themselves present in the display: they would not have to be *made* otherwise. But they are not in the making (reading) alone, because then the reason for making them could be found in the reading practice itself and it would not require a text or the text. It is in the dialectic of the reading|text pair that the links come to emerge as the contingent, ephemeral products of *this reading* of *this text*.

Until this point in my analyses (which assumes reading is following the most common, linear trajectory through this text), I have treated recurrence and repetition as an unproblematic phenomenon, though there is evidence available in the figure discussed that requires us to take a closer look. When reading encounters the term "moon" again, it no longer is the same moon that it was in the title. Initially, especially while reading "Probe spies moon's volcanic plume," the moon was an unspecified moon, in an unspecified solar system and accompanying an unspecified planet. Now it is one of Jupiter's moons, named Io, which has been photographed by what we later come to know as cameras (Figure 1, paragraph 5) of NASA's spacecraft New Horizons. Recurrence is a curious phenomenon, which is easily seen in the apparently paradoxical phenomenon of festivals: "they repeat an 'unrepeatable'. They do not add a second and a third time to the first but carry the first time to the 'nth' power" (Deleuze, 1968/1994, p. 1). Thus, the word "probe" is both the same (structurally composed of structurally same letters) and not the same (physically different paper, ink, conceptually richer meaning) as we read from title downward through the paragraphs until we get to the (literal and metaphorical) bottom of the text. Each recurrence transforms the term, taking it to the second, third . . . and n^{th} power.

To sum up: There is work that the repetition allows us to do, such as linking ideas between paragraphs and finding continuation when the topics in different paragraphs are different. Reading recognizes the recurrence of "New Horizons [spacecraft], and in the reading|text pair, there are particular outcomes that result. In reading, "links" between different parts of the text are the result of work, in which we observe a coming together of agency (reading) and structure (text). The links are the ("invisible") results of this reading|text dialectic, contingent outcomes of an emergent and self-organizing process of reading.

READING ONLINE SCIENCE NEWS: A PRACTICAL DEMONSTRATION

There is insufficient space in a single chapter to produce a description of all the resources and forms of agency (reading) that are mobilized and enacted in the reading of an online text, even though these are generally rather short compared to, for example, articles that appear in magazines, scientific journal articles, or books and book chapters. I provide but an outline of a reading, and, with it, provide only a partial account of reading online science materials.

Subtitles

In the BBC online (science) texts, two forms of titles below the main title can be found. Textually appearing second, the "true" subtitles—recognizable in their separation and distinction from the remainder of the text—appear in boldface type, are short and grammatically incomplete statements (i.e., there are only subjects without predicates), and figure on a line of their own. Textually appearing before these is another form of subtitle (recognizable by its font size and boldface type) that also functions as the first paragraph (recognizable by the period that completes it). This paragraph literally is both *sub*title, appearing below (Lat. *sub*) the title, constituting the title as title, and elaborating the main title preceding it. It is also *sub*text: literally, appearing below the text of the title, and metaphorically, elaborating the theme that is sketchily announced in the title. Let us begin a reading of this first, strange subtitle "Nasa's New Horizons spacecraft has sent back images of a huge volcanic eruption on Jupiter's moon Io."

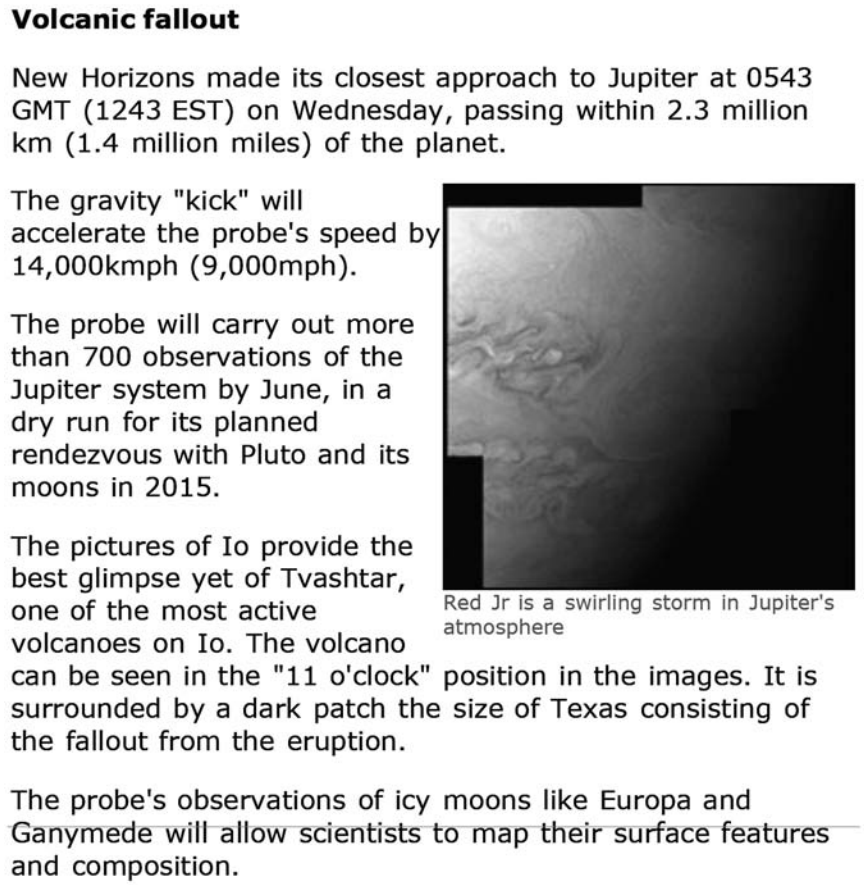
As reading begins, it discovers first a genitive form ("Nasa's"), followed by a capitalized compound noun ("New Horizons"), succeeded by a regular noun before finding the auxiliary verb "has" that announces the beginning of the predicate. Here, the term "spacecraft" is part of a category collection of entities that are launched from Earth into space and may be manned or unmanned. When unmanned, a spacecraft may be a probe to explore either the planet Earth itself or the space beyond. "Probe" and "spacecraft" here are part of the same category collection, following the earlier stated *economy* and *consistency* rules, respectively, (a) that a single category suffices to categorize an entity and (b) that once a first category from a category devices has been used (here "probe"), other categories from the same collection may be used to classify category members (here "spacecraft").

The first part of the predicate reads "has sent back images." The spacecraft, operating as a probe in space where human beings cannot (at the moment) venture themselves, communicates with human beings by "sending back" information, which, in the present case, is specified to take the form of images. In the title, the probe is said to be "spying," which has as one of its senses the mode of making observations. Observations belong to the same category collection as images, which are the results of making observations. The specific content of the images is specified as being (a) "huge volcanic eruptions" that (b) take place on "Jupiter's moon Io." Reading therefore reveals the same structure in the subtitle as it has discovered in the title: A probe observes volcano-related entities or processes on some moon. The extended subtitle elaborates the title preceding it in that it further specifies individual categories that first appear and are announced in unelaborated form. This specification arises from, depends on, and is constitutive of a parallel structure in title and subtitle/subtext. The "probe" turns out to be a spacecraft named "New Horizons" and is owned by NASA (rather than by some other organization or nation). The moon is specified as a moon of the planet Jupiter and as bearing the name "Io." The plume is associated with a volcanic eruption (rather than being volcanic smoke or steam).

In this single sentence, we find two different grammatical forms in which an entity is characterized as both category and as specific entity. In the construction of the subject, the proper noun "New Horizons" *precedes* the category "spacecraft," whereas in the predicate, the proper noun "Io" *follows* its categorical status as a moon. Here, the capitalization constitutes an essential resource for reading to organize itself and achieve the proper

grammatical form to disclose the sense to be communicated in the two different grammatical forms.

The titles in the text—titles below the title and therefore appropriately *sub*titles—are physically smaller than the main title, but are recognizable as titles in that their boldfaced type and brevity makes them stand out from and against the remaining text and background of the page (see Figure 2). At a coarse level they constitute part of the recurrent features that contribute to the overall structure that becomes apparent when the reader stands sufficiently far back so that the recognition of individual words becomes impossible. How do we know that it is a title, text in advance of a text, a "pretext," that is standing before other text rather than belonging to the paragraphs that precede it? In contrast to the first subtitle/paragraph that immediately follows the main title, subsequent titles consist of noun sentences, category words associated with a modifying adjective, which in the present article include "Volcanic fallout" (Figure 4) and "subsurface ocean" (Figure 5).



Volcanic fallout

New Horizons made its closest approach to Jupiter at 0543 GMT (1243 EST) on Wednesday, passing within 2.3 million km (1.4 million miles) of the planet.

The gravity "kick" will accelerate the probe's speed by 14,000kmph (9,000mph).

The probe will carry out more than 700 observations of the Jupiter system by June, in a dry run for its planned rendezvous with Pluto and its moons in 2015.

Red Jr is a swirling storm in Jupiter's atmosphere

The pictures of Io provide the best glimpse yet of Tvashtar, one of the most active volcanoes on Io. The volcano can be seen in the "11 o'clock" position in the images. It is surrounded by a dark patch the size of Texas consisting of the fallout from the eruption.

The probe's observations of icy moons like Europa and Ganymede will allow scientists to map their surface features and composition.

Figure 4. The second third of the BBC online article share structural features with the first, such as a bold-faced title, image, and caption. (Permission to reprint granted by the BBC on November 7, 2007)

"Volcanic fallout." Volcanic is an adjective modifying, in English, the noun that follows. This is a cultural historical and contingent fact; it therefore could be otherwise. In French, for example, adjectives generally follow the noun. However, some adjectives may precede the noun modified, but, in the different position, produce a different reading—"un homme grand"

is a tall man but "un grand homme" is a great man, where Napoleon falls into the latter but not the former category. Fallout. The primary sense of the term volcanic is "radioactive refuse of a nuclear bomb explosion" (OED, 2008). Figuratively, the term can be read as referring to the side effects and aftermath of some event; and, as a combination of the adverb "out" and the verb "fall," it may be read both as leaving a formation or quarrel and as falling out of something. Volcanic fallout. Is it refuse of a volcanic eruption, in an extension of the primary sense of fallout? Is it the process of something "falling out" of the volcano, an extension of the category collection to which also belongs "plume"? Or does fallout denote some possible side effect associated with the volcanic eruption? Without a predicate, the eventual outcome of reading remains indeterminate, several senses co-existing until something that encourages one of these possible reading (outcomes) to become more plausible than others. This something is to come: The title announces something to come. In naming and announcing what is to come, the title as pre-text also names the subtext, the underlying theme in a piece of writing, here a paragraph.

Continuing on below the title to find the subtext, reading searches the text for something motivating the title, and the title motivates reading to find what it announces. If this is not apparent, consider the reflexive and mutually constitutive relation between a pointing finger and the thing pointed to: for various reasons, the relevance of the possible targets of the pointing allow us to identify what is being pointed to, for only relevant things are pointed to, and pointing points to relevant things. Texts and their (sub-) titles stand in a similar constitutive reflexive relationship; and in this constitutive relation, reading finds materials to organize itself.

In continuing, reading finds a first (one-sentence) paragraph about the voyage of New Horizons past Jupiter. The second (one-sentence) paragraph makes a statement about how some "gravity 'kick'" will accelerate the probe. The third (one-sentence) paragraph tells the reader about observations made as the probe passes Jupiter on its way to a "rendezvous with Pluto and its moons." In the next (three-sentence) paragraph, reading encounters materials related to what the main title introduces as the (main) topic, the volcanic eruptions on Jupiter's moon Io. In the third sentence, reading encounters the fallout announced in the title: "It," the volcano, "is surrounded by a dark patch the size of Texas consisting of the fallout from the eruption." The final (one-sentence) paragraph is about observations of the icy moons Europa and Ganymede, which we know from the fourth (second-to-last) paragraph in the first section to be Jupiter moons.

Volcanic fallout. The title orients and positions reading, much as an athlete orients and positions himself for the competition to come. This positioning is indeterminate, it does not determine which actions are taken and when. But it sets up what is to come by specifying sets of possibilities. The title offers reading with the possibility not only to orient and position itself but actively invites reading to search for that content that motivates the title. In the present case, this content does not extend over the entire section that follows the title; in fact only part of the physical subtext is subtext in the metaphorical sense. The title orients reading to find in the section that text that further deals with the announced topic and, as shown in the section below, provides further instructions and pedagogy for reading the top-most images.

Upon proceeding, reading notices the same structure in the final and third section of the news feature, where, directed by the subtitle "subsurface ocean," reading is provided with a resource for finding the information that beneath the ice that makes Europa an "icy moon" there is thought to be "an ocean of water warmed by heat from the interior" of the moon

(Figure 5). There is nothing about these oceans in the three paragraphs that follow. The title therefore constitutes something like a sign post for part of the content that follows.

Image/Caption Ensembles

The figures (images) in the online science websites always are associated with text. This text, the subtext or caption of the figure, clearly is set apart from the remaining text in its smaller font and different color (grey). It is physically separate from other text, always spans the image width, and is printed immediately (empty space is ¼th the size of a capital letter in the caption) below. A figure caption is texts associated with a figure and has dual function: as title and description of the figure content and as instruction for finding what it describes (Roth, Bowen, & McGinn, 1999). The caption therefore constitutes a form of pedagogy specifying the content of the image and the instructions for how to find this content. "Captions" in fact constitute resources for reading to configure itself to be able to find the intended features in the image; and anything found can be tested against the text to see whether it is the thing intended to be found. Let us do an exemplary reading of the first caption, that is, let us concretely realize possibilities that exist for reading at a cultural level.

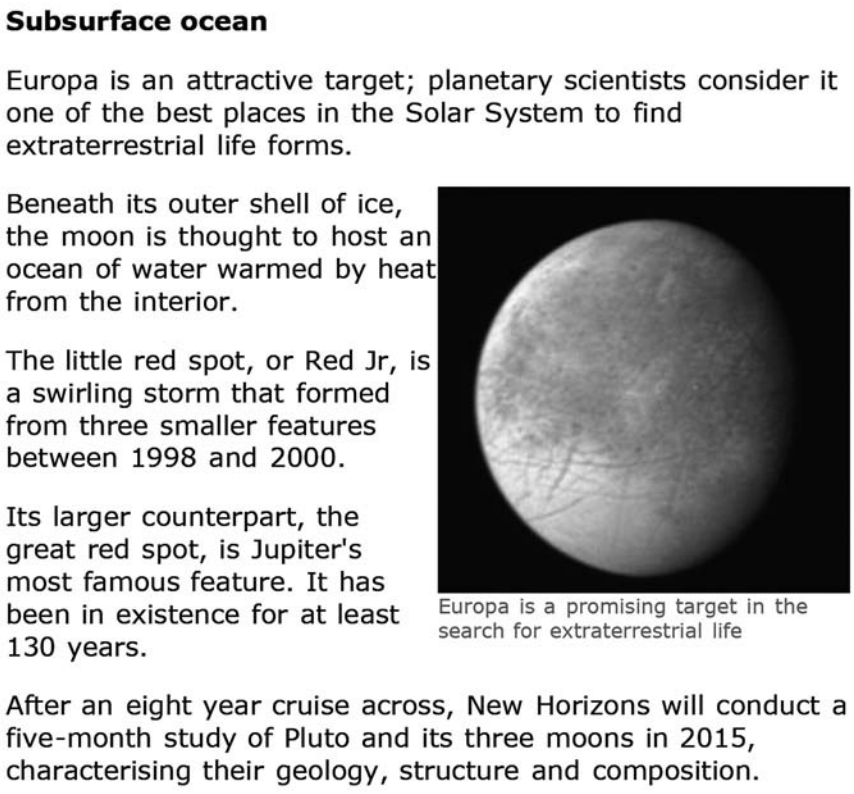


Figure 5. The last one-third of the BBC online article is structurally (lay-out) identical to the second part with its subtitle, five-paragraph text, and photo/caption in the right-hand column beginning with the second paragraph. (Permission to reprint granted by the BBC on November 7, 2007)

The first caption reads, "The plume is seen as an umbrella-shaped feature in the long exposure image to the right." "The plume." The definite pronoun "the" provides reading with a resource for understanding the plume that is the subject of this sentence as a plume that it has encountered before. In the unusual and infrequent configuration of this website, the only text preceding the caption and image is the title, which announces the spying of some (undefined) moon's volcanic plume as the news to be looked out for and found in this BBC science feature. The predicate begins with the passive formulation "is seen." The definite article has announced an explicit subject of the sentence, which now is specified as something to be seen. "The plume is seen" therefore constitutes a statement that the image allows a plume to be seen. It is a description not merely of what *can be* seen but especially of what *is to be* seen. The purpose of the image is to display the plume that is (part of) the newsworthy content of the article. More so, "the plume is seen" directs reading to the image to search for *the* (specific) rather than *a* (possibly one of many) plume. At this point, reading might take the image preceding the text as its object, which in fact consists of two images. Where is the plume? In which of the two parts is the announced to be seen? Where is it to be looked for and found?

In this paragraph, as elsewhere in this article, I use the term "therefore" (beginning of line 9). As innocuous as it appears, this term, as all its other appearances and those of all the "'thus's,' 'hence's,' 'since's' . . . point to orderlinesses of work practice" (Livingston, 1987, p. 103). Here, this is the work of reading concretely realized for the purpose of this chapter with the text at hand. Such organizational remarks tell us what the reader does with the text to produce the reading it prefigures.

As reading continues in the caption, the predicate specifies the plume to be seen "as an umbrella-shaped feature." Reading now has a more specific description of what it is to be on the lookout for. In fact, the term "umbrella-shaped feature" constitutes a resource for reading to configure itself in such a way that it can find not just any feature that can be subsumed into the category collection comprising volcanic plumes—there are different phases, each associated with a different shape, such as vertical column—but directs it to look for features that resemble in some way an umbrella. Reading is directed in this way because there is something in the image that occasions the description, which now, reflexively, becomes an instruction to search for the feature that occasions it. There are many circular features spread all over the left of the two images, whereas there are at least two small "bumps" attached to the white surface in the 1:30 position of the right image, and another, faint and grey, above the white surface in approximately the 11:30 position.

As reading continues on its trajectory in and through the caption, it finds further directions and specifications for accomplishing its work. It is to seek for the announced umbrella-shaped feature "in the long exposure image." At this point, experience with photography and the development of pictures from negatives is required to select *the* (specific) image that resulted from a long exposure rather than a regular or short exposure. In the presence of such past experiences, reading is directed to the right. In the absence, it may go on to find more specification in the remainder of the caption. If reading goes on, it finds out that the long exposure image is found "to the right," just where photographically experienced reading would have already directed its gaze. It is now evident that the plume—announced in the title and the subject of the caption as the subject of the image—is not to be found among the many dark spots in the left image. It is to the right that reading is directed. But the caption leaves out further specification that delimits the reading to one of the different

features that it might have discovered. In fact, research on graphing shows that the uninstructed and inexperienced reading of graphs does not attend to the minute features that subsequently may be the real subject of a display (Roth, 2003b). It is only with time and experience that minor variations become marked, remarkable, and therefore re-marked.

The foregoing analysis shows that reading does not have to move through the text but may stop and scan the image prior to coming to the end of the text. Research on graphing shows that scientific readers often read images (figures) before attending to the captions and main texts, or move back and forth between the two forms of inscription before completing the reading of any one of them (Roth, 2003a). Multiple readings are possible for the same agent and a more definitive reading has to remain open, unless further specification is found elsewhere in the text.

The final part of the caption teaches something else: how to distinguish long exposure photographs from other (regular?) photographs. Whereas the entity emerging from the dark in the left image shows many features, the one to the right is almost entirely white. If the two images are of the same object, "long exposure" apparently effaces the textures and textured surface that other forms of exposure present in detail. Conversely, the image to the right exhibits features not seen in its partner to the left: these are features that are beyond the nearly circular boundary between the surrounding black and the object itself.

Captions and the photographs they accompany do not stand on their own but also in relation to the text (Pozzer & Roth, 2003). Further instructions for reading the first image can be encountered in the fifth paragraph of the second section (Figure 4), where a repetition of the structure in the caption provides a resource to return to the image: "The volcano can be seen in the '11 o'clock' position." Instead of having as subject the plume, the sentence instructs us to seek the volcano, which clearly is not available in the "long exposure image." But as even a quick glance to the right image shows, the plume is approximately in the "'11 o'clock' position." In the corresponding position of the left photograph, reading may detect a white circular feature surrounding a black circular center and being surrounded by another dark grey circle. In the next sentence, we find the statement that "a dark patch the size of Texas" surrounds the volcano, inviting reading to return to the image and find the dark patch. Here, then, reading is directed to organize itself and discover a dark patch, which, if not showing the volcano itself, nevertheless is indicative of the source of the plume and fallout.

In this instance, the text provides a description that reading can test in the appropriate part of the image. The term "'11 o'clock' position" derives from another domain, analog watches and clocks, and the family resemblance of their circular characteristics. This, too, is a culturally and historically contingent resource. It could and possibly will be otherwise. In an age when only watches with digital displays were to exist, the instruction to look for the volcano in the "'11 o'clock' position" would no longer make sense, unless the denotation somehow survived as a dead metaphor in the living languages at the time. That is, the denotation would have lost the figurative relation to the photograph in the same way that the Greek word "cylinder," literally translated as "roller," denoted rolling objects has lost its figurative relation in the languages that make use of the term today (Roth & Thom, in press). In other instances, the captions do not constitute instructions for reading to engage with the image to find the instructed entity. Thus, for example, the third caption in this text, "Europa is a promising target in the sear for extraterrestrial life," has the planet Europa as its subject, possibly and perhaps likely the moon visible in the image (unverifiable in the present instance). But neither the object ("promising target" nor its complement ("in the search for

extraterrestrial life") can be found in the image, though it bears close categorical relationship with the contents of the first paragraph in the same section (Figure 5).

Photos and captions are not related to the main text by the same means as they are to one another, that is, by proximity. As noted, reading discovers further descriptions and instructions for reading the first figure in the fourth paragraph of the second section and in physical proximity of another caption/image pair featuring a feature ("Red Jr") of the planet Jupiter itself (Figure 4). In the same way, top-left to bottom-right reading first encounters text about a red spot in the last paragraph of the first section. In the second section, the "little red spot" is featured somewhere in the image and in the associated caption, which specifies it in the predicate to be a "swirling" storm to be found in Jupiter's "atmosphere." (No further resources than stating its presence are provided to find Red Jr among the many features possibly constituting the dialectical partner to the proper noun.) Because the surrounding text is about the voyage of the New Horizons spacecraft generally, its mission, and some of its other objects, the image|caption pair may appear "out of place." Here, image and caption constitute a pair of resources that are related dialectically because of the mutual constitution of the contents the image is to convey and its title/description found in the text directly associated with it. In the third and final section, reading discovers two further paragraphs in which Jupiter's ("little," "great") red spots are the subjects.

Body of the Text

Reading the article for the newsworthy item, literally and metaphorically is the pretext for following the hyperlink and for reading the associated article. This newsworthy item has already been (partially) found and prefigured in the hyperlink (title), so that reading now finds itself reading for disclosing the subtext that provoked, and is constitutive of, the title (pretext). Reading, which proceeds from top left to bottom right already has covered the body of the text in the first subtitle, which, as noted, takes a position between, literally and figuratively, (sub-) titles and (sub-) text. As reading engages with the first parts of what from afar has been recognized as the body (based on color of text, size, relative amount [see Figure 2]), it finds the subject to be "A massive dust plume." The indefinite article "a" generally is used to introduce a novel aspect, a "massive dust plume." But how does it relate to what reading has encountered before, which might motivate the introduction of the plume as topic? First, reading already has encountered a dust plume in the title and disclosed it as the newsworthy item. In the first paragraph of the first section, reading encounters the text that announces images of a "huge volcanic eruption." Already in the title, reading has discovered the category device that collects volcanic activities and plumes. The same collection now works here, and in drawing on the collection again, reading produces the coherence—via repetition—between the title, the first paragraph, and the subject of this second paragraph.

Following the subject, reading finds a "," (comma), a physical feature that does not denote some thing or action, which reading expects following the subject and as first part of the predicate. The comma is a resource for reading to configure itself: what comes is a clause that modifies the noun (subject) that has preceded it. It is reading that configures itself, because in the reading|text pair, the second part does not change. But because the outcome of the process of reading is different, having given rise to *a different reading*, it is the other partner of the pair in which the change has occurred. Here, the "massive dust plume" is

"estimated to be 150 miles (240 km) high." The clause provides reading with a statement about the size of the plume, which allows reading to elaborate what it already has encountered twice: The enormity of the phenomenon is articulated first as a "*huge* volcanic eruption," which, then, is associated with a "*massive* dust plume." The comma that follows next allows reading to reconfigure itself and now again look for the predicate that tells something about the subject introduced and modified.

The passive tense of the predicate-opening "can be seen" announces that the subject is not in the role of the agent but the receiver of an action, which here is one of seeing. This form of action always is related to images in some form, including photographs and their contents. In its binding to the visual category complex, the verb therefore reproduces the device that also includes the images that reading has encountered in the caption and first paragraph. It also reproduces an action from the repertoire that already contains the verb "to spy" earlier found in the announcement of the newsworthy item in the title. As it continues, reading discovers that the plume is more than simply seen: it is seen "erupting from Io's Tvashtar volcano." The verb "to erupt" exists in transitive and intransitive form, so that it, in its –ing form, could have completed the sentence, "A massive dust plume can be seen erupting." Reading would have stopped or changed itself had it found a comma or period, but the appearance of "from" announces a complement of the verb, which turns out to be "Io's Tvashtar volcano." In the complement again, reading takes a non-letter sign to modify itself. Rather than erupting from Io, which the dust plume also does, in perceiving the apostrophe followed by an "s" in "Io's," reading perceives "Io" not as the place from which the plume can be seen to erupt but as the owner of the thing that does the actual erupting. This something announces itself by a name, which reading knows to come when it meets the "T" in "Tvashtar." Had reading encountered a "t," "tvashtar," the situation would have been strange indeed. The word would have been a category noun, but the absence of a definite or indefinite article did not prepare reading to anticipate and encounter such a thing. It is the word "volcano" that resolves the open issue, allowing "Tvashtar" to be read as the name of a volcano that belongs to Io.

Reading has already encountered Io in the previous paragraph and knows it to be (one of) Jupiter's moon(s). In the volcano, reading also finds again a category that fits with the collection repeatedly denoted and produced in reading so far. On the other hand, in encountering the indefinite article preceding the "massive dust plume," reading finds a new topic. This announcement of a new topic stands in contrast with the definite article with the same noun "plume" that has announced it as a known entity. This fact points to what reading may encounter as a contradiction between the physical arrangement of text and image|caption, where the trajectory reading normally takes leads to the introduction of the topic *after* it was already used in the article as an introduced (known) topic.

As it continues, reading encounters additional features, generally introduced as objects of the actions of familiar agents and entities, in clauses and modifiers, as complements of nouns and verbs. Thus, the categories first announced in paragraph 3 of the first section (Figure 1) are repeated in various paragraphs of the second section. It finds the time of the encounter between spacecraft and Io ("Wednesday") to be elaborated in the first paragraph of the second section ("at 0543 GMT (1243 EST) I Wednesday"); it finds again the fact that the probe was "flying by" the planet Jupiter; it reads again about the role of Jupiter's gravity in boosting the probe's speed in the second paragraph of the second section; and it finds a restatement of the "ultimate target" of the probe, Pluto.

ONLINE NEWS MEDIA: OPPORTUNITIES FOR RETHINKING SCIENTIFIC LITERACY, INTEREST, AND SCIENCE

In this chapter, I exhibit the normally invisible work of reading online science texts by moving slowly and meticulously through the resources that the display offers to the reading process. Here, the text and reading have a curious relationship that repeatedly and glaringly jump into the reading eyes: The text no only is the object of the activity of reading but also it provides the instructions for *how* it is to be read. The text therefore also is a description and articulation of the work of reading itself. On first sight, this ethnomethodological formulation of reading might appear strange. Let us therefore consider another situation where the focus of the action is on producing something other than a reading—e.g., instructions for putting together prefabricated furniture pieces that require assembly after purchase. If we accomplish the assembly efficiently and competently, that is, when the piece of furniture stands before our eyes, it is said that we have followed the instruction. The instructions will have done beautifully and efficiently so, which is especially clear when we initially do not understand a set of instructions and yet, once familiar with what these describe, find no better alternative (Roth, 2004). In this situation, we have not merely followed the instruction: after the fact, the instructions constitute a description and an account for the construction work that has been done. The instructions for (descriptions of, account of the work of) building the furniture from the materials provided and the building itself stand in a reflexive relation: The instructional text motivates the actions, and the efficient and competent actions are such that they motivate the description. Imagine someone asking how you assembled the furniture, and you might say, "I followed the instructions, which said . . ." or respond by saying something like, "First I did. . . . Then I did. . . .," where your descriptions have a high degree of family resemblance with the instructions found with the furniture in the packaging.

Returning now to reading online science materials (or any other form of text), we note that the question "What have you done (on the plane, train, while waiting)?" might be answered by saying, "I read." The question "What did you read?" might be answered by stating the title of the piece, "Probe spies moon's volcanic plume," by retelling the text read or, in some instances, by reading aloud from it. Here, reading is an action, and the result or outcome of the reading (as process) is the reading (as product). When we follow the instructions in the caption and relevant paragraphs in the main text, then we do precisely what the text describes; and when we find the news in the link (title) of the text then we precisely do the work that the link describes, we find the newsworthy item. The text, after the fact, therefore also is an account of the work that effective and knowledgeable reading has achieved, the reading. Thus, when asked what we think of the article, the response might begin, "In my reading . . ." followed by an account of what the reading (as process) has produced. That is, the response is about the reading as an accomplishment rather than a statement about reading as a process. In the same way that the lived (knowledgeable) work of constructing the furniture and the instruction constitute an inseparable pair, so does the text and the work of reading: The text constitutes not only an instruction for reading but also a description and an account of what knowledgeable reading has achieved once completed. The two moments constitute a dialectically related pair of structure and the embodied agency that mobilizes it. This pair, I denote by the term reading|text, which therefore constitutes a new higher order communicative unit that retains and overcomes the contradictory relation of

the two terms. These cannot be separated and understood independent of one another, because considering one implies considering the other, because the lived work of reading and an account of this reading always go hand in hand.

My analysis not just tells about but actually exhibits how reading organizes itself in the process of reading. This text is already framed because it falls into the section "science." All forms are possible and can be found on the BBC website. So in each case, reading has to self-organize so that can in each case read the text for what is. In the texture emerging from the reading|text dialectic, new resources become available for reading that change how reading engages with the text. The text provides reading with instructions for how it has to read so that prospectively the text read will become a description and articulation of the lived work of reading.

In reading the hyperlink (title) for the newsworthy item, reading encounters its outcome ("the reading") in the way one might encounter the finished painting when apperceiving the first sketches that come to configure the space of the canvas. What comes thereafter fills in, elaborates, provides detail, and, in repeating forms and aspects, provides resources for reading. (On many days, I personally only scan the headlines without actually reading the texts, providing me with a sufficient sense of "what newsworthy events have happened in the world.") This subsequent reading makes the connections that result in a unique and singular reading of "the news" rather than dispersed reading that arises in and from texts intended to give rise to multiple readings: many poems and literary texts such as in the following opening of a well-known and infamous text, *Finnegans Wake*: "riverrun, past Eve and Adam's, from swerve of short to bend of bay, brings us by a commodius vicus of recirculation back to Howth Castle and Environs" (Joyce, 2000, p. 3). Confronted with unusual organization of text, categories, reading has to make greater efforts in producing a reading, which, because of the nature of the text as an open work, will be only one in a range of many different possible readings. Thus,

> in language, Joyce finds the possibility for a range of coexisting perspectives which, at the level of rigorous scientific conceptualization, would be mutually exclusive.
>
> *Finnegans Wake*, for example, produces a crisis in the notions of time, identity and causal connections that suggests certain cosmological hypotheses that go beyond the theory of relativity itself. (Eco, 1989, p. 74)

Such is not the kind of reading that I am concerned with here, as the links, titles, and texts in news outlets are not constructed in the same way as poems or literary texts but precisely such that reading can configure itself to find the newsworthy item. It is only when the newsworthy item has been found and disclosed that reading has achieved what it was intended to; and precisely at this point does the text describe the accomplishment of reading. Reading the science news in an online medium therefore has a normative component constitutive of competent reading. Only when reading finds the news as intended has the work embedded in and exhibited by the text been accomplished; in this case, the text constitutes a precise description the work accomplished. In this instance, reading online science news features is the cultural practice that I studied here. If, on the other hand, reading was to configure itself to produce readings in the way it does with *Finnegans Wake*, then my anthropology would have been a different one: that of poetic texts.

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REFERENCES

Anderson, T. H., West, C. K., Beck, D. P., MacDonell, E. S., & Frisbie, D. S. (1997). Integrating reading and science education: On developing and evaluating WEE science. *Journal of Curriculum Studies, 29,* 711–733.

Craig, M. T., & Yore, L. D. (1995). Middle school students' metacognitive knowledge about science reading and science text: An interview study. *Reading Psychology, 16*, 169–213.

Deleuze, G. (1994). *Repetition and difference* (P. Patton, Trans.). New York: Columbia University Press. (First published in 1968)

Eco, U. (1989). *The aesthetics of chaosmos: The middle ages of James Joyce*. Cambridge, MA: Harvard University Press.

Garfinkel, H. (1967). *Studies in ethnomethodology*. Englewood Cliffs, NJ: Prentice-Hall.

Gregory, B. (1990). *Inventing reality: Physics as language*. New York: Wiley

Hawking, S. (1988). *A brief history of time*. New York: Bantam.

Heidegger, M. (1996). *Being and time* (J. Stambaugh, Trans.). Albany: State University of New York Press.

Hester, S., & Eglin, P. (1997). The reflexive constitution of category, predicate and context in two settings. In S. Hester & P. Eglin (Eds.), *Culture in action: Studies in membership categorization analysis* (pp. 25–48). Washington, DC: University Press of America.

Joyce, J. (1986). *Ulysses*. New York: Vintage.

Joyce, J. (2000). *Finnegans wake.* London: Penguin.

Livingston, E. (1987). *Making sense of ethnomethodology*. London: Routledge & Kegan Paul.

Norris, S. P., & Phillips, L M. (2008). Taking seriously reading of science. In W.-M. Roth & K. Tobin (Eds.), *The world of science education: Handbook of research in North America* (pp. •••–•••). Rotterdam: SensePublishers.

Norris, S. P., Phillips, L M., & Korpan, C. A. (2003). University students' interpretation of media reports of science and its relationship to background knowledge, interest, and reading difficulty. *Public Understanding of Science, 12,* 123–145.

Oxford English Dictionary (OED). (2008). Online edition. Accessed January 18, 2008 at www.oed.com.

Pozzer, L. L., & Roth, W.-M. (2003). Prevalence, function, and structure of photographs in high school biology textbooks. *Journal of Research in Science Teaching, 40*, 1089–1114.

Roth, W.-M. (2003a). Competent workplace mathematics: How signs become transparent in use. *International Journal of Computers for Mathematical Learning, 8* (3), 161–189.

Roth, W.-M. (2003b). *Toward an anthropology of graphing*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Roth, W.-M. (2004). A phenomenological anthropology of texts and literacy. In A. Peacock & A. Cleghorn (Eds.), *Missing the meaning: The development and use of print and non-print learning materials* (pp. 253–266). Houndmills, Basingstoke, Hampshire: Palgrave.

Roth, W.-M. (in press). Reading online news media for science content: A social psychological approach. *Reading Psychology, 29*, •••–•••.

Roth, W.-M., & Bowen, G. M. (2003). When are graphs ten thousand words worth? An expert/expert study. *Cognition and Instruction, 21*, 429–473.

Roth, W.-M., Bowen, G. M., & McGinn, M. K. (1999). Differences in graph-related practices between high school biology textbooks and scientific ecology journals. *Journal of Research in Science Teaching, 36*, 977–1019.

Roth, W.-M., & Thom, J. S. (in press). The emergence of 3D geometry from children's (teacher-guided) classification tasks. *Journal of the Learning Sciences.*

Sacks, H. (1974). On the analyzability of stories by children. In R. Turner (Ed.), *Ethnomethodology: Selected readings* (pp. 216–232). Harmondsworth: Penguin.

Schummer, J. (2005). Reading nano: The public interest in nanotechnology as reflected in purchase patterns of books. *Public Understanding of Science, 14*, 163–183.

Sewell, W. H. (1992). A theory of structure: duality, agency and transformation. *American Journal of Sociology, 98*, 1–29.