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Reasoning with and without Reasons: The Effects of Professional Culture and Information Access in Educational and Clinical Settings

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Biography

Barry Saferstein is a cognitive sociologist, who applies discourse analysis and ethnography to study the interrelationship of understanding, interaction, and authority in organizational settings. His recent research examines clinical consultations, explaining the effects of communication patterns, information resources, and professional culture on patients' understandings of their medical conditions and treatment options. He has also studied explanations and understandings of genetics in schools and science centres. Prof. Saferstein examines how professional authority affects the development of understandings, explaining how unintended strategies that limit understanding are embedded within explicit strategies for comprehension of medical conditions and scientific concepts. His research has also included studies of agenda setting activities and the interactional construction of ideology in television production settings in the United Kingdom and the United States. He is a Professor in the Communication Department at California State University San Marcos.

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Barry Saferstein

Abstract

This study examines routine interpretation activities in commonplace settings, which integrate environmental information resources and cultural conventions as components of reasoning and reason. It expands on research about coherence based reasoning, mental models, and cognitive sociology. Analysis of recorded genetics learning activities and interventional radiology consultations shows how the operations of reasoning and reason develop through the interpretation activities of producing brief chains of information, process narratives. What counts as a reason relevant to a particular setting is often related to the ways that people cope with an absence of information. Modus tollens problems, the traditional Mendelian genetics curriculum, and conventional medical consultations include forms of expression that restrict information and lead to the interpretive contingencies, which complicate reasoning and understanding. The interpretation activities related to the restriction of information add contingencies that complicate reasoning. Those interpretive contingencies include the activities of seeking, assessing, culling, and applying information. The genetics education data feature the recognition and application of placeholders, grey boxes, to reduce the interpretive contingencies related to restricted information. Grey boxes are meta-information, marking the suspended interpretation activities of searching for more substantive information. They function syntactically by contributing to process narratives that are coherent in relation to particular localized information resources and interpretation activities.

Examples of recorded data from two settings explicate these findings. One setting features high school biology students learning to use the nomenclature and computational devices for explaining the genetic inheritance of traits. The genetics examples show how curricular conventions of biology teachers' professional culture restrict information resources and guide students toward depending on grey boxes to link available information resources as acceptable forms of reasoning. The clinical data further explicate how information resources and interpretation activities become part of reasoning, and constitute the type of reason that is useful in a particular situation. Recordings of an interventional radiology consultation and a post-consultation discussion show how a patient develops an understanding of a medical procedure and the reasoning related to deciding on medical treatment. The patient's recall of reasons and reasoning correlates with particular actions and information resources in the consultation setting. Both the restricted reasoning of the genetics curriculum and the expansive reasoning of the radiology consultations show how interpretation activities and information resources operate as part of the reasons and reasoning that count as particular forms of reason.

Keywords

Reasoning, understanding, professional culture, coherence based reasoning, mental models, modus tollens, process narratives, grey boxes, patient-practitioner interaction, Mendelian genetics

Reason and reasoning are often treated as mental processing. However, analysis of routine interpretation activities in commonplace settings shows that environmental information resources and cultural conventions function as components of reasoning and reason. Reason, reasons, and reasoning often reflect the contingencies of seeking and interpreting information to develop coherent strings of information, process narratives, that are key to understanding and recall. Process narratives are short information chains that link objects, actions, and events, expressing sequential, causal, or temporal relationships (Saferstein 2007; 2014). They distill information and concepts into a memorable form. Process narratives do not necessarily link information as logical propositions. They may involve fuzzy relationships such as categorical associations, shared settings, and particular time frames.

Interpretive Contingencies and Grey Boxes

The contingencies that affect reasoning include the activities of interpreting the variables—i.e., of interpreting, organizing, and seeking information in order to develop understandings. Interpretive contingencies also include the effort of simultaneously interpreting information while dealing with organizational and cultural constraints, such as time limits and authority, expressed through patterns of interaction.

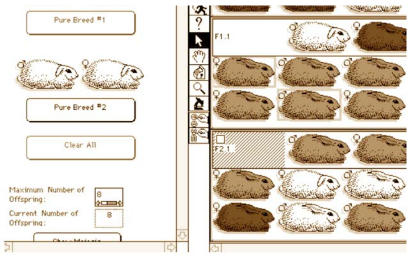
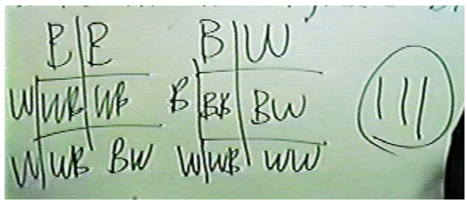
What counts as a reason is often related to the ways that people cope with an absence of information—e.g., by recognizing that information is missing and searching for it. However, such searching is often constrained by the resource environment and communication patterns. When that occurs, people develop process narratives by applying placeholders, grey boxes, to mark missing information and link the available information (Saferstein 2007; 2014). Grey boxes are meta-information, marking the suspended interpretation activities of searching for more substantive information. As reasons, they function syntactically by contributing to process narratives that are coherent only in relation to particular localized information resources and interpretation activities. Grey boxes often facilitate reasoning by eliminating the contingencies related to searching for missing information. Locally and culturally specific grey boxes are the basis of what seem to be different modes of reasoning.

For example, the professional culture of biology teachers and clinicians has been constituted and sustained through the patterns of communication that emphasize certain information and discourage students and patients from seeking other information (Fisher and Groce 1990; Maseide 1991, 2007; Saferstein 2007, 2014). Consequently, what counts as a reason in educational and clinical settings often is related to the absence of information and the way that the participants in those settings cope with that absence—i.e., not just by recognizing missing information or searching for it, but by applying particular types of grey boxes to mark missing information, and then linking the information that is present by means of those grey boxes.

Reasoning without Reasons

Reasoning without reasons is a feature of certain organizational activities and settings. In the following examples, genetic inheritance learning activities restrict students' use of information about the cellular and molecular processes by which genes affect traits. What counts as reason and reasoning in the conventional Mendelian curriculum is the use of nomenclature and tabulation/computation devices as grey boxes for the missing information. The reasons that contribute to the linking of information as process narratives that explain specific cases of trait inheritance include words and nomenclature that conflate qualities of traits and the biochemical operations of genes. They omit information about the cellular processes by which genes affect the development of traits.

Figure 1: Visual and Linguistic Grey Boxes for Cellular Processes

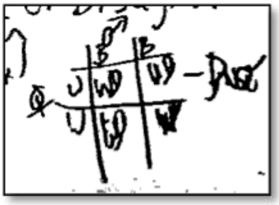
1	A. Computer Simulation's Representation of Codominant Trait Inheritance	B. Acceptable Punnett Square Representation of Codominant Trait Inheritance
		
2	Acceptable Mendelian Linguistic Representation of Codominant Trait Inheritance (Codominance Test Transcript, Lines 121–123)	
	Student B21: Because in the first line you had two pure breeding rabbits (????) two whites, right? These two genes . you cross bred . them both. All of them became beige . alright . . Alright. And then in the second one there's two genes. That means the two genes they have in them are brown and white. Right? Then when you cross like this one you have two browns a brown and white, white and brown, and a white and white. This is the reason that we came up with three different colors. (??) these two made a beige . and that's one . and we had a darker color. That's two. Then we had a white . three. That's why we got the three colors.	

The following examples occurred during a verbal testing session in a high school biology class.1 The teacher (T1) asked for an explanation of codominance, which the students had studied by using a computer simulation showing the effects of breeding a rabbit having brown fur and a rabbit having white fur (Figure 1, Row 1, Image A). The rabbits' offspring had beige fur. Breeding the beige rabbits produced a heterogeneous generation of offspring respectively having white, brown, or beige fur. An acceptable Mendelian explanation was presented by a student, B21 (Figure 1). It featured the standard Mendelian grey box, the Punnett square (Figure 1, Row 1, Image B), which tabulates nomenclature representing both genes and traits in order to compute the probable outcomes of breeding individuals having particular sets of genes and traits. Neither the Punnett square nor the linguistic description of its application involves reasoning or reasons related to the cellular genetic processes by which genes affect trait development. Those processes are grey-boxed by the Punnett square and by linguistic descriptions such as, "became beige" and "these two made a beige" (Figure 1, Row 2).

The acceptable Mendelian explanation of codominance features two Punnett squares (Figure 1, Row 1, Image B). The first counts as an explanation of the first generation beige offspring (labeled F1.1 in the simulation [Figure 1, Row 1, Image A]). The second Punnett square counts as an explanation of the heterogeneous second generation (F2.1). The discussion here focuses on an explanation of codominance offered by another student, B23. He began by presenting a verbal explanation. The teacher asked him to clarify it by using Punnett squares (Figure 2).

1. The discussion of genetics learning activities is based on studies in high school biology classrooms and science education centers over a period of 15 years. The classroom data discussed here were recorded in a California High School biology class, as part of the Community of Explorers Project (National Science Foundation RED-9154815).

Figure 2: B23's Attempts to Explain Codominance with Punnett Squares



A

B

After B23 completed one acceptable Punnett square (Figure 2, image A) related to the mating of a brown-furred and white-furred rabbit to produce beige-furred offspring, he did not immediately draw a second Punnett square to explain how the mating of two beige rabbits would produce beige, brown, and white offspring. Instead, he presented a verbal explanation emphasizing the combining of genes to produce the beige rabbits. The teacher then urged him to draw a second Punnett square based on the offspring indexed by the cells of the first Punnett square, i.e., beige rabbits characterized as WB.

However, B23 had not developed an understanding of how to use a Punnett square as a grey box for the missing cellular process information. He proceeded to set up the second Punnett square differently than the first. The teacher did not accept B23's erroneous second Punnett square (Figure 2, Image B) as an explanation of codominance. Nor did he recognize B23's verbal explanation of codominance as an example of reason and reasoning about codominant trait inheritance. However, examining B23's verbal explanation reveals reasoning that would count as reason in regard to the cellular processes involved in codominance.

Rather than presenting the conventional tabular and computational explanations of operating a Punnett square, B23's reasoning consisted of descriptive comments that correlated with computer simulation's images of generations of rabbits, such as:

> "these two they met in the midpoint codominant" (line 59)
>
> "They share two dominant--the dominant brown gene and the dominant white gene come together and they form uh somewhere at midpoint like . beige. " (line 89)
>
> "this brown and the white both made the beige" (line 93)

> "these two genes white--white and brown, are in the beige ones are in the beige rabbit" (line 97)

> "you would have--you would have the two dominant genes and they would come out in the gener--in the F2 generation" (line 101)

B23 linked information as process narratives, imputing a direct causal connection between the presence of certain genes in the bodies of the rabbits and the fur color of those rabbits. He accurately suggested that mating two of the beige rabbits, each having a gene for brown fur and a gene for white fur, would result in a set of their offspring having the two dominant genes. He recognizes that there was no specific gene for beige.

Utterances referring to dominant genes that "come together" to "form . . . somewhere in the midpoint" and "made the beige" could index cellular genetic processes, and function as a display of reason based on the reasoning related to the production and effects of enzymes and proteins on the development of rabbits' fur color. However, due to an absence of such cellular process information B23 relies on 'form' and 'made' as grey boxes in his process narratives.

As a description, B23's process narratives are not without reason, reasoning, or reasons. The explanation is reasonable in the context of reasoning based on genes having properties that affect the development of traits. It combines observation of the computer simulation images (Figure 1, Row 1, Image A) with some of the Mendelian terminology (e.g., 'dominant', 'F2 generation'). However, B23's reasoning was not recognized as reasoning or as a display of reason by the teacher, because it did not feature the Mendelian grey box, a Punnett square.

The teacher's response shows that his interpretive frame of reference emphasizes the customary linguistic and graphical representations that function as reasons within the professional culture related to teaching Mendelian genetics. In that context, he does not recognize the reasons expressed by B23 as components of reasoning. The teacher says, "I'm trying to understand. You're throwing words at me. I can't understand" (line 96). The teacher's response displays the effects of professional culture on recognizing reason.

Even if B23 were to some extent improvising an explanation, the process narratives he expressed display the reasoning indicating that the genes come together to affect traits. As much as it might seem that he is just "throwing words" at the teacher, they are not just random words. He links certain words representing combinations of types of genes to words that represent particular fur colors as a model of causation. There is reason in B23's utterances.

B23's reasons and reasoning not only reflect the absence of cellular process information and the availability of the computer simulation's visual information, but also his interpretation activities during his task group's prior work with the computer simulation. At that time, he had monitored how other task groups developed explanations of the codominance simulation and reported back to his group. Consequently, he did not fully participate in the interpretation activities by which the other student, B21, developed his acceptable Mendelian explanation of codominance (Figure 1, Row 2). B23's interpretation activities related to available information resources and his searching for additional information shaped his reasons and reasoning.

Missing Reasons: The Interpretive Contingencies of Modus Tollens

In the conventional curriculum and pedagogy for Mendelian genetics, the professional culture of biology teachers has featured communication patterns that discourage students searching for cellular process information (Saferstein 2014). This limits the information that students can use to link as reasons about types of genes and types of traits in order to explain trait inheritance. Such patterns of explanatory interaction between students and teachers create a 'not cellular processes' contingency. The teachers apply particular types of grey boxes as placeholders for the missing information. These include linguistic terms (e.g., 'recessive'), nomenclature conflating genes and traits (e.g., WB), and Punnett squares (Saferstein and Sarangi 2010). However, none of these provide reasons that would contribute to reasoning explaining the cellular and molecular processes by which genes function within the body to produce traits.

Such restriction of information also occurs in formal logic problems. For example, studies of reasoning have noted the difficulty in solving modus tollens logic problems (i.e., If *p* then *q*. Not *q*. Therefore, not *p*) (cf., D'Andrade 1989; Johnson-Laird 1983; Johnson-Laird and Byrne 2002; Johnson-Laird et al. 1972; Wason 1968). The difficulty some people have in solving modus tollens problems and the difficulty some students have in accepting the Mendelian grey boxes are analogous. In the 'not q' expression of a variable, negation can be problematic due to its lack of specificity, a condition that routinely triggers the contingencies of searching for relevant information.

In regard to effects on the interpretation activities that produce reasoning, there is a similarity between the genetics curriculum's emphasis on *not applying cellular process information* and the premise of modus tollens problems of *not applying contextual information regarding some real-world relationship between the variables*. In both cases, the difficulties in producing acceptable reasoning do not result from the expressed logical contingency between variables. Rather, they result from the contingency of interpreting the variables or a relationship between the variables in a way that transcends the grounds stated by the problem.

When explanations or problems do not provide adequate information for developing coherent process narratives that would contribute to understandings or solutions, people face the interpretive contingencies of searching for missing information (Saferstein 2007; 2014). In that context, it is difficult not to search for reasons in order to engage in reasoning—i.e., reasons in the form of contextual relationships based on experiential recall or inference. This often involves comparing available information with previously developed process narratives in regard to categorical distinctions such as typology, situation, and setting. In the cases of Mendelian explanations of trait inheritance and modus tollens problems, such comparison involves considering information that is not expressed by the problem as stated (Saferstein 2014; D'Andrade 1989). The comparison contributes to a frame of reference that supports searching for relevant information, rather than applying a restrictive puzzle-solving frame of reference that emphasizes literal use of the stated variables.

For example, contemporary high school students have encountered information inside and outside of the biology classroom about genomics and the role of DNA in the development of organisms (Saferstein 2014). Yet, the conventional Mendelian curriculum requires that the students do not apply that information when trying to explain trait inheritance. Thus, like some formulations of modus tollens problems, the students are presented with information ('the inheritance of genes affects the expression of traits') that relates to process narratives they have already created (e.g., 'DNA and RNA in cells affect traits'). When biology students initially encounter the emphasis on the abstract Mendelian grey boxes and the de-emphasis of cellular processes, some of them continue to mention commonplace topics such as families, breeding of animals, and DNA, in attempts to form explanatory process narratives (Saferstein 2014). In the preceding example, B23's explanation of codominance suggests the operation of cellular processes (the blending of genes), rather than applying the computational grey box of a Punnett square. However, applying information or a frame of reference related to biochemical cellular processes results in an unacceptable answer based on unacceptable reasoning.

As biology teachers restrict discussion of cellular processes during genetic inheritance learning activities they guide students toward reducing the interpretive contingencies related to the 'not cellular processes' restriction by accepting and applying the conventional Mendelian grey boxes. Rather than repeatedly confronting the interpretive contingences presented by constraints on seeking missing information, students ultimately reduce those contingencies by relating nomenclature and Punnett squares to trait inheritance (Saferstein 2014). For the students, Mendelian grey boxes become reasons. For the teachers, correct manipulation of those grey boxes functions as a student's display of reasoning and understanding. The encompassing framework of reason is shaped by interpretation activities that include the particular communication patterns, which constitute the professional culture of biology teachers. Such reason involves the use of the grey boxes in particular ways. The reasoning is the linking of the grey boxes with other information to create the process narratives.

Modus tollens problems, the traditional Mendelian genetics curriculum, and conventional medical consultations include forms of expression that restrict information and lead to the interpretive contingencies, which complicate reasoning and understanding. Johnson-Laird (1972) and D'Andrade (1989) conducted experiments finding that the use of commonplace objects and activities improved the understanding and solving of modus tollens problems. D'Andrade concluded that such changes resulted from replacing a contentless sense of contingency with a contentful sense of contingency. However, examining the production of process narratives provides another approach to understanding why abstractly expressed modus tollens problems are more difficult to solve than problems expressed in terms of common experience. It is not a particular *sense* of contingency, but the interpretation activities of contending with contingencies that inhibit or lead to reasoned understandings.

Information Components That Become Reasons: Interpreting Linguistic, Pictorial, and Gestural Information

Like the Mendelian genetics students, patients in conventional clinical consultations, often experience limited forms of explanatory information and restricted opportunities to seek such information (cf. Fisher 1986, 1993; Fisher and Groce 1990; Frankel 1990; Maseide 1991, 2007; Mishler 1984). The resulting interpretive contingencies lead to situations that are familiar to many patients: i.e., not knowing what questions to ask of practitioners during a consultation, thinking of the questions after the consultation has concluded, and not recalling or understanding medical information discussed during a consultation (cf. Entwistle et al. 2006; Price et al. 2006; Skea et al. 2004). As a result, patients often do not develop reasons relevant to reasoning about the nature of medical conditions and the effects of treatment options. This creates 'you had to be there' moments, when a patient has difficulty reconstructing a practitioner's explanation of a medical procedure, which had seemed clear during the consultation. Missing information or constraints on searching for information change the production of the process narratives central to reasoning from the linking of substantive information to the use of culturally specific grey boxes that are only syntactically meaningful in regard to a particular setting.

The following example provides a contrast to conventional clinical consultations and the Mendelian genetics learning activities. During an interventional radiology consultation, a patient, P1, and nurse, N1, verbally and gesturally respond to each other and to a series of images displayed on a computer in order to explain uterine fibroid tumors, their symptoms, and treatment options, which included uterine fibroid embolization (UFE). The consultation involves interpretation activities that avoid the contingencies related to missing information and support the patient's creation of recallable process narratives.[2]

The process narratives that P1 recalled four days later, during a recorded telephone discussion with the author, linked and condensed information expressed by the verbal and visual information she encountered at the consultation. For example, during the telephone discussion, P1 expressed process narratives concerning what she should do if she recognized symptoms of a dangerous complication, sloughed necrotic fibroid (SNF), consequent to a uterine fibroid embolization procedure. She presented an overview of a nurse's explanation, which had linked the term, 'sloughed necrotic fibroid', to symptoms and treatment. The reasons and reasoning constituting those process narratives correlate with the moments during the radiology consultation when the patient completed the nurse's utterances, voiced comprehension or participation, and turned her head toward images and gestures that related to the nurse's verbal explanation.

During the telephone discussion, P1 expressed process narratives concerning the possibility of needing a D & C procedure (dilation and curettage) due to a sloughed necrotic fibroid (SNF) that could lead to a uterine infection:

> some of the . things that I can . are uh they want me to be aware of after the procedure. Right that-that I may need a D & C--I mean there--I forget what the percentage . uh what'd she say? . Two or three percent I think (Recorded P1 Telephone Discussion, lines 1, 3, 5)
>
> afterwards when the fibroids are . you know if they die or whatever eh-eh uh I might have . there's a possibility of a . hu uterine infection. I

2. This data is part of an ongoing study of the effects of discussing images on patterns of patient-practitioner communication that affect patients' understandings of medical information about medical conditions and their treatment.

> have to be aware of the um . . yeah of the symptoms of that (Recorded P1 Telephone Discussion, lines 13, 15, 17)

P1's reasoning combines a cause (*for approximately 2 or 3 percent of UFE patients, a type of fibroid tumor may 'die' as a result of UFE*) and an effect (*the 'dead' tumor causes a uterine infection*) with actions (*patient awareness of the potential symptoms of infection, treatment with a D & C procedure*). The reasons and reasoning P1 expressed during the telephone discussion correlated with particular talk, gestures, and images presented during the radiology consultation.

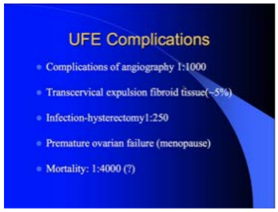
Turning Actions into Reasons

During the radiology consultation, P1's interpretation of the nurse's verbal explanations occurred in the context of pointing and looking at the images on the computer screen as well as displays of attention to the nurse's utterances. For example, the information about a fibroid falling from the lining of the uterus into the uterine cavity included gestures by the nurse as she explained the screen text concerning SNF (Figure 3, Row B). As she said, "a fibroid is closer to the lining of the uterus and it actually falls . . . into the center cavity of the uterus," the nurse made a fist with her right hand, illustrating the fibroid tumor, and moved it down to her left cupped left hand, illustrating the tumor falling into the uterine cavity (Figure 3, Row B). P1 looked at the nurse gesturing, and then completed the nurse's explanation of the fibroid falling into the uterus, saying, "and tries to come out through the uterus." The nurse's gestures also functioned as reasons contributing to the reasoning expressed by the process narratives that P1 recalled during the post-consultation telephone interviews.

Figure 3: Modes of Representation for Sloughed Necrotic Fibroid[3]

A

1



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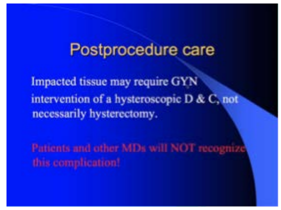
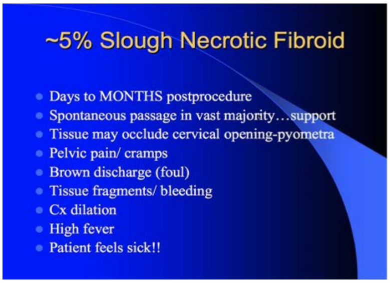


3

B



505. N1: this is actually our main concern. And it happens in less than 5 percent of the patients and it's called sloughing a necrotic fibroid. In other words a fibroid is closer to the lining . of the uterus and it actually falls into the lining of—or into the center cavity of the uterus.

506. P1: and tries to come out through the cervix

507. N1: Well um eh . of those five percent, 95 percent of them just get passed in your cycle.

508. P1: Okay.

3. Pictures of the consultation have been captured from the video data and faces have been blurred in order to protect the participants' privacy.

Turning Images into Reasons

During the post-consultation telephone discussion, P1 recalled a picture that had been presented 7 minutes and 50 seconds prior to the nurse's explanation of SNF:

2.2.17	Researcher:	You mentioned uh the possibility of infection afterwards as something that you hadn't uh you
2.2.17	P1:	I hadn't yeah I didn't I I knew nothing about yeah.
2.2.19	Researcher:	Do you remember any of the um discussion or the the PowerPoint that related to . to that—that sticks in your mind?
2.2.19	P1:	Um . okay. Yyeah .. the th-um there was a diagram of a uterus . annd fibroids um and I guess there was a picture of one right over the . at the cervix or something.

The picture showed a large fibroid tumor within the uterine cavity, which blocked the cervix. This visual information was consistent with N1's later gesture of her fist falling into her cupped hand as she said, "a fibroid is closer to the lining of the uterus and it actually falls into the lining of—or into the center cavity of the uterus."

Just prior to the nurse's verbal and gestural information about SNF, the computer screen had displayed following textual information:

- Infection-hysterectomy 1:250 (Figure 3, Row A, Image 2)
- Impacted tissue may require GYN intervention of a hysteroscopic D & C, not necessarily hysterectomy. (Figure 3, Row A, Image 3)

While the computer screen displayed the list concerning SNF (Figure 3, Row B), the nurse's explanation presented eleven pieces of information that the patient could interpret as reasons and link as process narratives (bold text) (Figure 3, Row B, lines 505, 507, 509):

- "This is actually **our main concern**
- And it happens **in less than 5 percent of the patients**
- And **it's called sloughing a necrotic fibroid**.
- In other words **a fibroid is closer to the lining of the uterus and it actually falls** into the lining of—or **into the center cavity of the uterus**
- Well um eh **of those five percent, 95 percent** of them [sloughed necrotic fibroids] **just get passed in your cycle**
- **That five percent that's left over if they get stuck there and they can't go out, then it's gonna set you up for infection**.
- So what da we need to do? **You need to call us**.

- **We need to do an MRI right away—bring you in the hospital**.
- **I.V. antibiotics**.
- Do an MRI. **See what's going on,**
- And **we may ask your gynecologist to do a D & C**."

During the telephone discussion four days after the consultation, P1 linked some of the verbal and visual information encountered during the consultation as reasons for SNF: a 'dead' fibroid blocks the cervix, the fibroid is trapped in the uterus, infection develops, treatment with D & C. Her process narratives correlate with certain interpretation activities and information resources of the radiology consultation. The culling and organizing of the initial set of information constitutes P1's reasoning.

Discussion of images at the radiology consultation provided patients with options for interpreting and linking information—i.e., opportunities for constructing the reasons and reasoning that contribute to reasonable explanations of medical conditions and treatments. Such options not only included multiple types of information, but also a communication pattern by which the patients developed frames of reference supporting unanticipated linkages of information. These interpretation activities avoid the modus tollens-like interpretive contingencies that entail the use of grey boxes to mark missing information. Both the restricted, grey-boxed reason of the genetics curriculum and the expansive reason of the radiology consultations show how interpretation activities related to the information resources of a setting produce the reasons and reasoning that count as particular forms of reason.

Process Narratives and Mental Models

The preceding examples explicate the differences between mental model research and the process narrative approach to understanding/recall. As relevant interpretive contingencies, the mental model approach emphasizes contingent relationships among available variables (cf. Bauer and Johnson-Laird 1993; Johnson-Laird 2002). For example, Johnson-Laird compares the use of visual representations of variables and conditions developed by Peirce with mental models in order to explain fundamental operations of reasoning:

> The fundamental operations of reasoning based on mental models are insertion (the addition of entities, properties, or relations to models), and deletion (the elimination of models when they are combined with other, inconsistent, models). In the case of reasoning based

> on quantifiers, the theory also proposes that individuals search for alternative models. (Johnson-Laird 2002, 91)

That approach emphasizes the mental organization of interpretive artifacts rather than the processes of interpretation. It does not consider the contingencies of creating, finding, and organizing alternative models as part of the reasoning. Information constituting the "entities, properties, or relations to models" mentioned by Johnson-Laird must be interpreted in order to function in such capacities. However, as the preceding clinical example shows, such interpretation is not separate from the resulting "operations of reasoning." Insertion and deletion of interpreted information are not just mental operations, but also involve a complex of interrelated interpretation activities, information resources, and sociocultural constraints of settings. Johnson-Laird's "elimination of models when they are combined with other, inconsistent, models" occurs during the interpretation of information as well as during the reasoning involving the interpretations (Saferstein 2007; 2014). Examining recorded interpretation activities, such as P1's medical consultation, and their effects on understanding shows people interpreting information prior to and while inserting and deleting it. This reveals the interrelated development of reason, reasoning, and reasons. That interrelationship is due to the function of environmental information resources as components of mind in regard to organizing and recalling information as understandings.

Mind and cognition do not just rely on resources in settings as opportunities for perception to obtain information that is then subjected to mental operations in order to produce reason or meaning. Rather, environmental information resources, sometimes including social interactions, are also part of the operations of reason. They function as placeholders when information related to producing coherent linkages is absent, i.e., as external 'storage' that relieves the burden on memory during reasoning, and as components of recall afterward (Saferstein 2014).

Reconfiguring Cognitive Systems and Reasoning

Analyzing the creation and use of process narratives and grey boxes reveals the interpretation activities that constitute a cognitive system of reason, reasoning, and reasons. This elucidates a central concern of coherence-based reasoning research, the idea that a cognitive system *imposes* coherence on decision tasks (Simon 2004: 517, 522–523; cf. Holyoak and Simon 1999). Moreover, by considering the effects of material resources and professional cultures on reason and reasoning, such analysis changes the conceptualization of 'cognitive system' from a focus on mental calculations, logical choices between predetermined decision options, or mental models. It explicates how a cognitive system includes the resources of the setting and the cultural conventions that support the use of the resources in the setting (cf. Simon 2004: 517, 522–523). Such analysis expands and elucidates the simultaneous development of interpretations of information and frames of reference discussed in studies of coherence based reasoning (e.g., Holyoak and Simon 1999; Simon 2004; Simon et al. 2004; Pennington and Hastie 1992; Thagard 1989), as well as the reflexive relationship of interpretation activities and social organization discussed in cognitive sociological research (Cicourel 1973; Saferstein 1994; 2007; 2010). It also clarifies abstract categories, such as retrieval, segment linkage, and distillation of memories, which focus on mental operations (cf. Schank and Abelson 1995, 31–33, 71–72).

The genetics examples show that the teacher's restricting of information led the biology students toward depending on grey boxes to link available information resources of the setting in order to create coherent process narratives. The external information resources of the setting, including the Mendelian grey boxes and the interpretive interaction, were as much a part of the reasons and reasoning as the mental operations. This was explicated in the second example when the patient's recall of reasons and reasoning correlated with the actions and information resources in the consultation setting. The access to relevant information resources in the clinical example shows how interpretation activities, including the culling and recognition of information to produce coherent recallable process narratives that function as reasons, become part of reasoning, and constitute the type of reason deemed useful in a particular situation.

Such findings emphasize that accurate models of reasoning, cognition, and memory would incorporate interpretation activities that feature information resources. Recognizing such material components of reason is particularly relevant to understanding the relationship between repeated routine reasoning related to commonplace settings and the neuroplastic development of the brain's organization of information as reason.

Reasoning is the set of interpretation activities that develop coherence by emphasizing or excluding the particular information to be linked. Reasons consist of both the frames of reference resulting from those interpretation activities and the process narratives produced by linking the selected pieces of information. These are concurrently developed. However, when professional or organizational culture introduces barriers to these activities, interpretive contingencies trouble reasoning and understanding. Pragmatically, reason is a result of reasoning activities; not a template controlling them.

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