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Bringing Representational Practice From Log to Light

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Abstract: People implicitly negotiate use of representations during learning, even in distributed online settings, but due to the temporally and spatially distributed nature of interaction, special analytic tools are required to uncover the development of representational practices in such settings. In this paper we show how logs of online activity can be analyzed to recognize patterns in use of representations and show how negotiated representational practices affect how learners collaborate and influence each other.
Keywords: Representational practices, Interaction analysis, Online collaboration

Introduction

Prior work has examined how shared representations—constructed, manipulated and interpreted by participants—both influence and are appropriated by participants in the course of their collaborative interaction (Roschelle, 1996, Suthers & Hundhausen, 2003). Representational practices (e.g., how inscriptions are interpreted as representations, and role specialization with respect to construction and maintenance of these representations) are implicitly negotiated through cycles of innovation, adoption and revision (Danish & Eneydy, 2006; Dwyer & Suthers; Shipman & McCall, 1994; Stahl, 2006). Although much of this research has been undertaken in face-to-face contexts, our data as well as others' (Overdijk & van Diggelen, in press) shows that this happens in online settings as well as face-to-face, and can even take place over extended periods of asynchronous interactions. The practices and roles so negotiated have implications for learning, as they can affect the extent to and ways in which learners collaborate and influence each other's views. However, it can be difficult to see implicit negotiations and their consequences when interaction is distributed over time and across workspaces, as is common in media-rich asynchronous online learning. We have developed an abstract transcript format, the contingency graph, and tools for manipulating this graph that are a first step towards a toolkit for finding negotiated patterns of interaction and other relevant phenomena. A contingency (previously termed "dependency") is a way in which participants' actions are visibly contingent upon prior actions and their artifacts, for example, through media dependencies, representational similarity, and semantic overlap, as discussed in Suthers, Dwyer, Medina & Vatrapu (2007a). A contingency graph provides the basis for analytic interpretation in terms of concepts such as argumentation, co-construction, transactivity, etc. This paper reports on how we used the contingency graph in conjunction with video screen capture data to identify meaningful episodes of activity that illustrate the negotiation of representational practices, and how these practices led to specific observed outcomes in a collaborative problem solving session.

Computer generated log files of user interaction in collaborative online environments are commonly used as source data for analysis of collaborative interaction (e.g., Bruckman, 2006; De Wever et al., 2006; Larusson & Alterman, in press; Martinez et al., 2003). These machine readable histories of software events are amenable to computational methods for aggregating, searching, filtering, or visualizing sequential data in support of a range of analytical approaches (e.g., Aviv, 2003; Barcellini et al., 2005; Hmelo-Silver, 2003, Landauer, Foltz & Laham 1998; Sanderson & Fisher, 1994). In our developing work on uptake analysis (Suthers, 2006; Suthers et al., 2007a), we've also begun to explore computational environments for analyzing collaboration from log files. In this paper we report on analyses undertaken using a prototype visualization tool constructed by the first author, the Uptake Graph Utility (UGU). UGU is a collection of scripts packaged into a small application that controls interaction between a MySQL database and Omnigraffle™, a commercial application for diagramming and graphing. UGU allows the analyst to control the visual rendering of a graph of contingencies between logged events. Using UGU and Omnigraffle, the analyst can selectively filter elements of the graph from view, generate subgraphs, or isolate certain structural or temporal properties of the data. Figure 1 shows an example of a contingency graph and a portion of the UGU interface. The full contingency graph constructed from even dyadic sessions is very complex. Strategies are needed to select relevant portions and make analytic interpretations. We used two practices for analytical exploration of a contingency graph.

Segmentation (or chunking) is a way to shape the data into discrete partitions or episodes that provide reference points for analysis (Jordan & Henderson, 1995). Segmentation supports micro and macro analysis, and the granularity and scale are adjusted accordingly. The present analysis begins with individual acts of media manipulations and contingency relationships between them as the initial units of analysis, but then chunks subgraphs of contingencies into episodes of recognizable activity on the part of the participants.

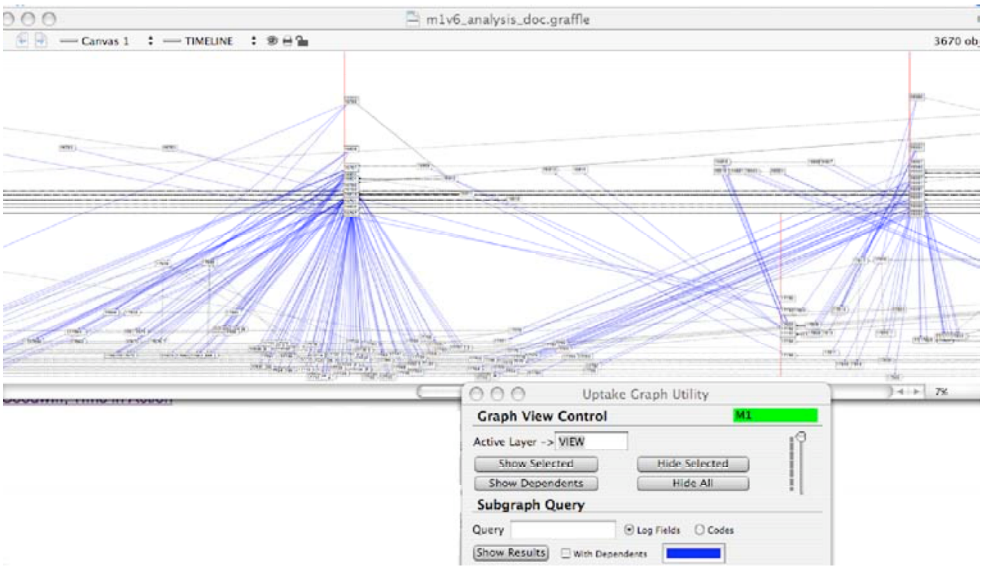

Figure 1. Portion of initial contingency graph with UGU panel visible.

Tracing is the act of identifying certain elements of interest as reference points, and then moving forward or backward along pathways in the graph to unravel the interaction context in which those elements were formed. The rationale for following a path is analytically motivated. At any given moment in the process, new elements uncovered may or may not warrant the definition of another data chunk, may inspire subsequent traces, may induce a closer examination of the data, or require establishment of new contingencies previously unidentified. The analytic strategy taken in this paper follows that of our previous work (Suthers et al., 2007a). In that work, we looked at post-interaction essays composed individually by participants to determine what each person concluded about the problem posed to them. We then traced back from these acts of writing through contingency relationships to identify interactional sequences of expressive and perceptual acts that could potentially account for their conclusions. In the case study presented below, we trace interactional sequences back from actions of the participants at the end of their interactive session rather than in their essays.

Case Study

The case study presented here illustrates a pattern of interaction between two individuals engaged in a joint-problem solving exercise while using a shared networked workspace environment. The data is drawn from a experimental study conducted for purposes reported in detail elsewhere (Suthers, Vatrapu, Medina, Joseph & Dwyer, 2007b). Using informational materials we provided in the workspace, the two participants (P1 and P2) worked to identify possible causes of a disease in Guam, ALS-PD (Amyotrophic Lateral Sclerosis-Parkinsonism Dementia complex). The software used by these participants provided both threaded discussion and graphical evidence mapping tools. The session took place over the course of approximately two hours. Participants were at different locations, and each participant's view of the shared environment was updated using a software protocol that enforced asynchronous interaction by distributing respective workspace changes at intermittent times during the interaction (participants were also able to manually request updates by selecting a refresh button). The analysis undertaken here seeks to account for ways in which participants both converged and diverged in their interpretations of causes of ALS-PD, by tracing out sequential patterns of representational practices enacted within the workspace. The analysis highlights an evolving transformation of a collaborative representational practice. These practices and the artifacts left in their wake provide an explanation for the conceptual convergence and divergence in the conclusions expressed by each participant.

Episode: Concluding Work

The analysis begins with an important reference point in the interaction, a sequence of activity in which both participants express conclusions concerning the possible causes of ALS-PD. This episode takes place in a time span of approximately 10 minutes towards the end of the session. The beginning of this episode is indicated by P1's prompting for a conclusion ([17028] in contingency graph of Figure 2: nodes represent events such as participants' actions and arcs represent contingencies). P1 makes this request using a discussion posting. Despite the fact that P2 does not read the message (P2 did not initiate further requests for workspace updates), it indicates P1's plans to initiate a negotiated conclusion. This is evidenced by a subsequent act that proposes a "final" conclusion [17085] incorporating formative elements of P2's concluding work, [17897], which coincidentally begins and is concurrently developed by P2 [17905], at approximately the same time as P1's (unread) request. The episode ending is negotiated when P2 asks whether P1 is done [17919]. P1 reads and responds by stating; "Done" [17135] then immediately makes a final "For" link between P1's and P2's hypothesis node [17136].

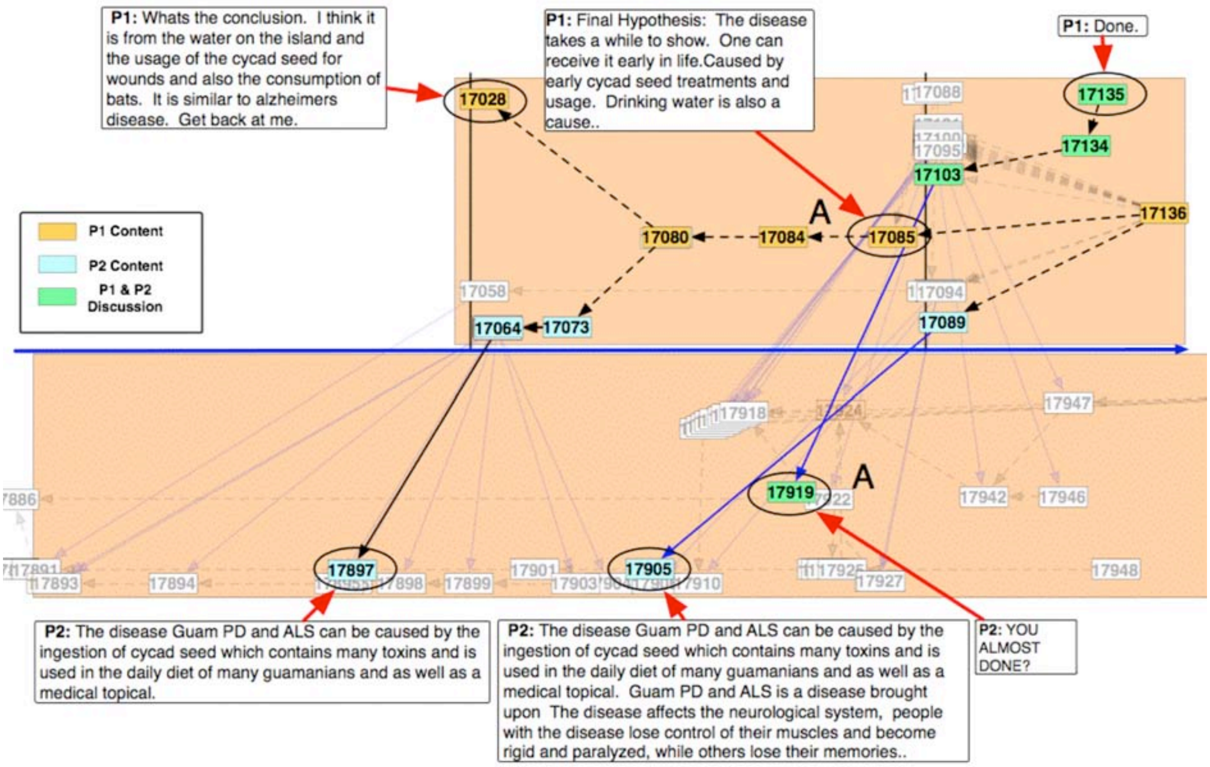

Figure 2. Subset of contingency graph showing the conclusions expressed by both participants

Figure 3 shows the concepts expressed by participants in this episode. Each person integrated information shared during their prior work into their respective fully developed conclusions. We are able to trace this because information was originally distributed in a hidden profile design (Stasser, 1992.) "Cycad usage" is cited in each person's final conclusion. This is significant because both participants cite multiple specific hypotheses but only converge on one. Given that very little linguistically explicit negotiation concerning hypotheses took place during the interaction, an analytic trace was initiated to provide an interactional account of this convergence on "Cycad usage". Also, within this segment P1 makes "drinking water" a salient factor in her hypothesis, [17028 & 17085], while P2 does not cite drinking water at all, although information referencing "drinking water" was previously shared during interaction. Another analytic trace was generated to account for this divergence. The challenge presented by this pair's interaction is that it involved numerous graph manipulations. Video screen capture of the session was used to assist in interpreting their actions. The contingency graph served as an index into the video data as needed.

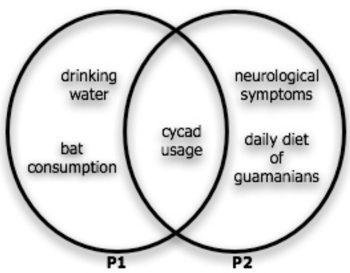

Figure 3. Mapping of concepts expressed by participant 1 and 2.

The following episodes are presented to provide an understanding of representational practices shared by the participants during the sequential unfolding of the interaction. We present the trace concerning "drinking water" first because it uncovered a larger scale phenomenon that led to understanding of the manipulations that turned out to be important in the cycad convergence. Thus this sequence of examples illustrates how analysis changes granularities, from tracing out relations between individual acts of media manipulations to relations between episodes of such manipulations and back to fine-grained analysis of appropriation of graphical resources.

Trace of conceptual divergence uncovers representational practices and roles

One of the consistent concepts indicated in P1's argument during Segment A is that "drinking water" is one possible cause for the disease. An attempt to build an account of this concept through the interaction history began by forming a query (input into UGU) in order to highlight acts that reference that text string and the contingencies between those acts. The graph revealed references to "drinking water" that were included in the information provided to P1 in relation to aluminum as a potential cause of the disease. A second query was invoked to capture acts that also referenced aluminum, extending the trace. The resulting contingency graph is summarized schematically in Figure 4. In two particular instances P1 shares information with P2 related to the contamination of drinking water by aluminum. P2 *acts upon* this information by performing a series of moves evidenced by clumps of move events in the graph. These acts by P2 do not contain linguistic responses; only a series of moves (drag and drop acts) in the graph space. This pattern is consistent throughout the remaining portions of the session. The trace shown in Figure 4 could indicate that P2 is moving nodes around in order to see them, or to get them out of the way: dragging and dropping of graphical objects for these reasons is frequent. In this case however, the periodic-like pattern of P2's series of movements induced us to explore the video record for these episodes.

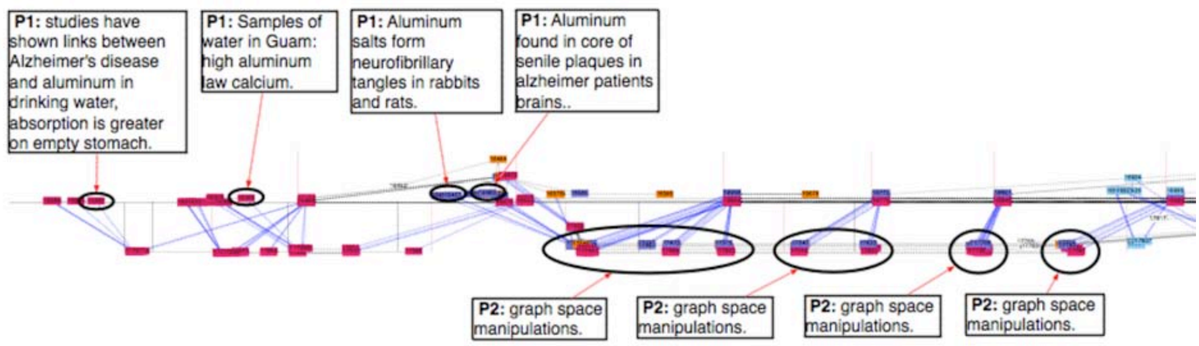

Figure 4. Information sharing by P1 followed by systematic graph manipulations by P2 during the first hour of the session.

The video shows that P2 is not randomly moving nodes around, but performing a series of graph space *reconfigurations* to organize information previously shared during the session. After P1 contributes new information, P2 moves nodes to create spatially distinct groups that provide conceptual delineation. In addition to this spatial organization, both participants create links between nodes within groups that further clarify their inclusion in the group. (Their work will be illustrated in detail in the next section.)

Figure 5 illustrates this same trace at a higher level of abstraction, as a series of uptake relations between episodic segments. Beginning at the left, P1 shares information containing a reference to aluminum in water as a contaminant in the first two segments [B1 & B3]. The third information-sharing event by P1 contains two references that correlate aluminum and neurological symptoms of ALS-PD [B6]. The reaction to the three sharing acts by P2 is shown as series of graph space manipulations [B2, B4, B5 & B7-10]. Intersubjective uptake is indicated by P2's visual transformation of the shared information nodes and is followed by a series of intrasubjective transformative acts on the part of P2, who continually appropriates the relation-indicating power of the graphical nodes. The fact that there is very little related action on the part of P1 during these acts indicates that P2 is accountable for subsequent transformations. As shown on the far right of the diagram, intersubjective acts again occur as the concluding work segment discussed above, is initiated [A1 & A2].

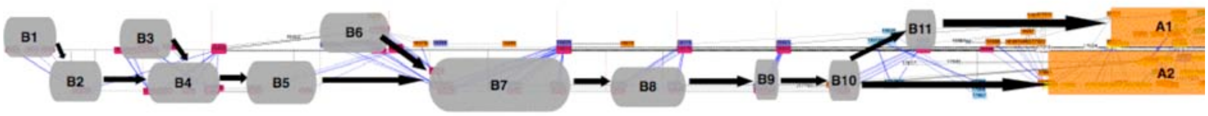

Figure 5. High level view of uptake over the entire session.

These grouping acts form a representational artifact that foreshadows each participant's concluding work. P2's organizing work creates two separate groupings, among others, for the information containing aluminum: as an agent in metal intoxication and as water contaminant. One explanation for the divergence on this concept is that the resulting visual organization provides a selection context from which each participant performs his or her concluding work. The emergent representational artifact, the graph, facilitated multiple

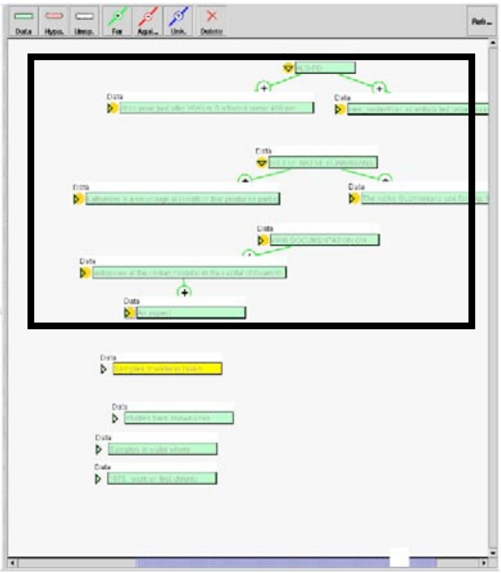

Figure 6. P2's screen, initial configuration.

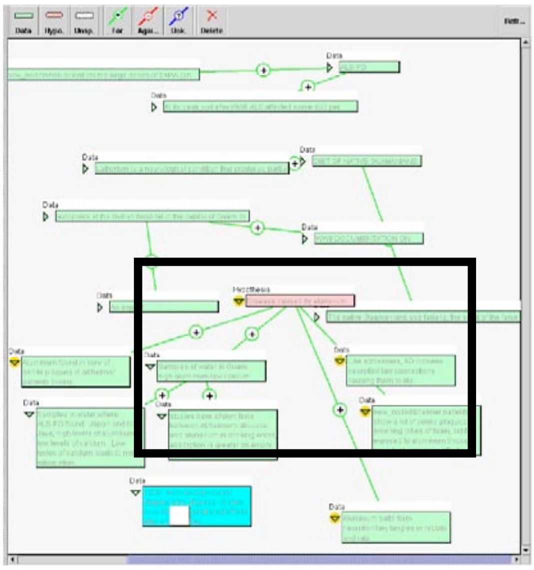

Figure 7. P1's screen, appropriation of representational grouping practice.

meanings for each participant to appropriate in conceptually convergent and divergent ways. P1 apparently appropriates this representational scheme initially enacted by P2 with a slightly divergent interpretation.

Episode: Appropriation of Representational Practice

We turn now to a closer look at P2's organization of the graph, and P1's appropriation of this practice. Their practices converged partially in the handling of data about cycads as a potential disease agent, providing a representational practices account of this conceptual convergence. The patterns represented in the contingency graph provided frames of reference and direct pointers, via timestamps, to relevant locations in the video record. More significantly, this framing made the interrelation between the two separate video streams salient for determining the emergence of a shared representational practice.

At the beginning of the session, P2 creates and organizes data nodes into conceptual groups. These groupings are specified through spatial proximity and the use of links between nodes. Figure 6 is a screenshot of P2's screen after having constructed such an initial graph configuration. An important dimension of these grouping configurations is that topic-based nodes are positioned as hubs to conceptually related information nodes. At the bottom left of the graph workspace are four nodes that were rendered on P2's screen as a result of a recent update from P1. At this point we see two distinct representational practices that are expressed at the inception of the interaction. P2 has made conceptual organization a dominant method for representation. P1's groupings show a less defined representational practice. Later, having received a series of updates of P2's organizational work, P1 demonstrates appropriation of P2's practice. Figure 7 shows the state of P1's screen after she has created additional nodes and grouped them into a visual configuration that resembles P2's scheme. In addition to visual organization, P2's conceptual structure is adopted, as P1 orients the nodes towards a central conceptually labeled node. This node also represents an explicit expression of a hypothesis, /Disease caused by aluminum/ which reveals P1's practice of articulating hypotheses through language (not adopted by P2).

A concurrent activity during the episode depicted in figure 7 occurs on P2's machine. Figure 8 shows the introduction of cycad information into the graph space. Following his own representational convention, P2 positions the label, /cycad info/, and three related data nodes into an identical configuration as the others. Figure 9 shows a subsequent act on P1's machine where she introduces a data node containing information about /cycad/. (Time has elapsed, so P1's screen reflects the ongoing work of the two participants.) In this context, a /cycad/ related node is created and positioned in a somewhat arbitrary location with regard to the ongoing visual grouping. On receiving an update from P1 containing the cycad data, P2 reads the contents of the node, then drags the node to a "member" position of the cycad conceptual grouping (circled in Figure 10). P2 then follows this repositioning with the creation of a link between the node and the /CYCAD INFO/ hub, further expressing its group membership.

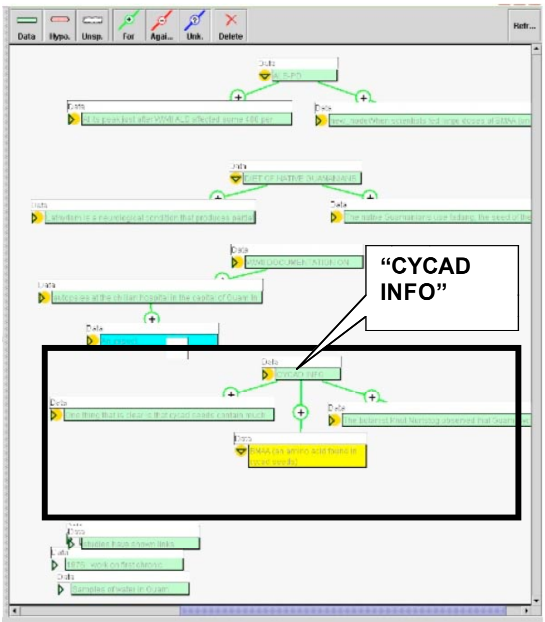

Figure 8. P2 creates cycad representation.

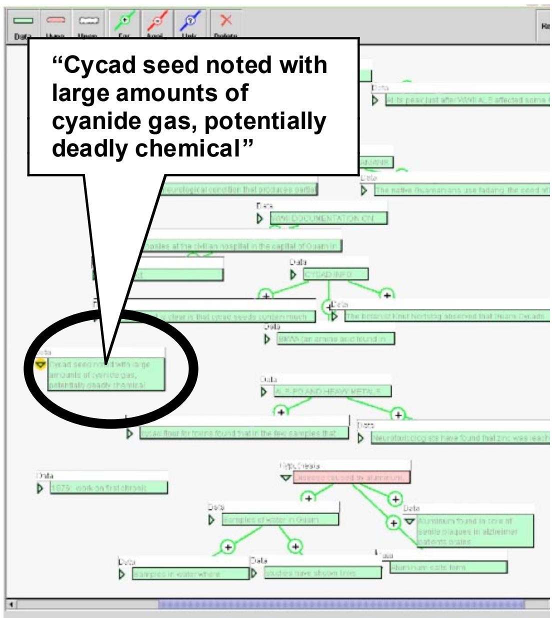

Figure 9. P1 creates a cycad data node.

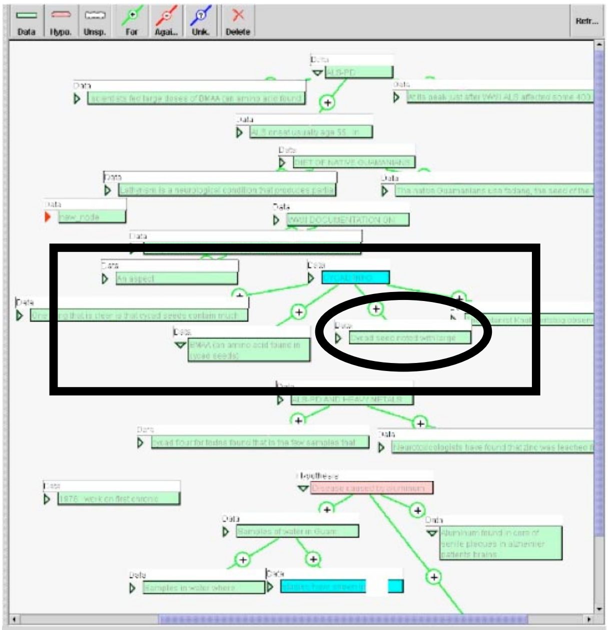

Figure 10. P2 receives cycad data node from P1 (Fig. 9) and repositions and links into cycad group (Fig. 8)

Subsequently, each participant brings "cycad usage" forward in distinct ways. P1 articulates cycad salience through a statement placed in a Hypothesis node, /Disease caused by cycad seed usage/ (Figure 11, left side), while P2 posts a short "themed" node expressing /USES OF CYCAD/ (Figure 11, right side). Each participant without knowledge of the other performs these respective acts. They coincidentally indicate cycad usage at approximately the same time. In addition to posting her hypothesis node, P1 integrates it into the /CYCAD INFO/ group configuration by creating four links to supporting data. P2 also groups and links data nodes to their expression ("USES OF CYCAD”). It is a mutual appropriation of a grouping practice. P1 and P2 both begin wrapping up their work within five minutes after this episode and thus initiate the concluding work episode presented above.

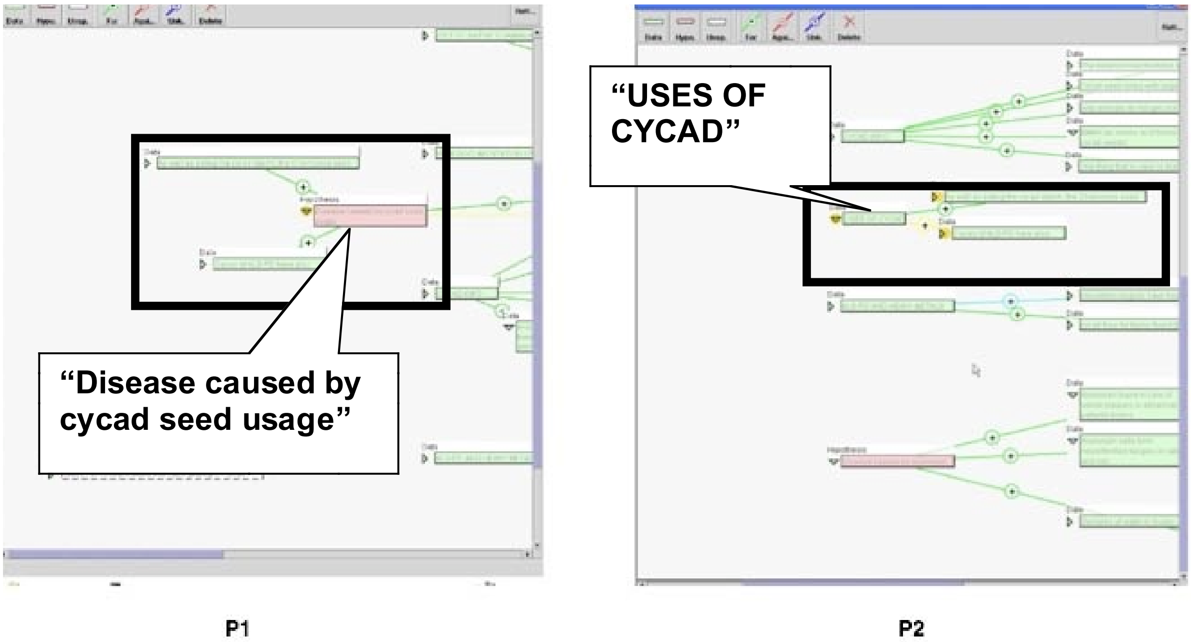

Figure 11. P1 and P2 articulate new cycad groupings independently.

Conclusions

The above analysis provides an explanation of one aspect of how the two participants converged and did not converge on conclusions in a joint problem-solving task. The goal was to explore an application of the uptake analysis framework, its representation and praxis, by way of taking a detailed look at how interactions through shared representations might account for particular instances of conceptual convergence and divergence. We uncovered a case of interactional negotiation of representational practices, implicitly proposed by one participant (P2) through demonstration, and taken up by the other participant. This shared representational practice was particularly apparent in their handling of the question of cycad seeds as a potential cause of the disease in question, a finding that is consistent with the fact that this was the one cause on which both participants agreed. In contrast, information about the role of drinking water in relation to aluminum was distributed in the graph in a manner that seems consistent with the lack of agreement on the importance of this element and the fact that P2 received the bulk of evidence against the associated aluminum hypothesis.

The primary significance of this analysis is that negotiated representational practices can be found in asynchronous interactional settings, and can influence outcomes of a collaborative session. Such phenomena merit further study to understand how learning is accomplished (Koschmann et al., 2005). However, due to the fact that interaction is not immediately salient in asynchronous online settings, representations and tools that make interaction patterns visible are needed. We have prototyped one such tool, and propose to develop further tools based on the contingency graph as an abstract transcript, transcending differences in log file formats and the distribution of interaction across media. The contingency graph is an abstraction of what is traditionally thought of as a transcript. Enabling its representation and its relational structure in a computationally accessible format promises to support sophisticated and scaleable analytical practices. Segmentation and tracing are two such practices that are fundamental in working with relationally represented sequential data. It is through cycles of segmentation and tracing that one is able to isolate aspects of interaction under investigation. One danger in isolating data elements in this way is the potential for decontextualization – losing sight of the full breadth of contingencies at play in a given context. To counter this tendency, the video record was examined regularly. In practice, the visual distinction between selected and non-selected acts can be leveraged within cycles of selective transformation. The Uptake Graph Utility was developed around these two ideas and provides a prototype for planned further development of related tools based on the contingency graph representation.

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