

MIT Open Access Articles

Signs: Increasing Expression and Clarity in Instant Messaging

The MIT Faculty has made this article openly available. **Please share** how this access benefits you. Your story matters.

Citation: Zinman, Aaron and Judith Donath. "Signs: Increasing Expression and Clarity in Instant Messaging." Proceedings of the 42nd Hawaii International Conference on System Sciences (HICSS 2009) (2009): 1-10. © 2009 IEEE

As Published: <http://dx.doi.org/10.1109/HICSS.2009.391>

Publisher: Institute of Electrical and Electronics Engineers (IEEE)

Persistent URL: <http://hdl.handle.net/1721.1/74608>

Version: Final published version: final published article, as it appeared in a journal, conference proceedings, or other formally published context

Terms of Use: Article is made available in accordance with the publisher's policy and may be subject to US copyright law. Please refer to the publisher's site for terms of use.



Signs: Increasing Expression and Clarity in Instant Messaging

Aaron Zinman and Judith Donath
 MIT Media Lab
 Sociable Media Group
 {azinman, judith}@media.mit.edu

Abstract

Despite its popularity, commercial instant messaging has changed little in the past 15 years. Conversations are linear, immutable, and susceptible to errors in turn-taking and referent resolution. Problems of incoherency occur with high frequency, yet no design has emerged that alleviates these problems in discourse sufficiently to achieve commercial adaption. We present Signs, an instant messaging design philosophy and implementation. We aim to reduce confusion while increasing expressive power. In Signs, the mutation of persistent discussion spaces facilitates repair of sequencing problems and functions as a proxy for new communication acts. This paper addresses the theory behind Signs, our specific design choices, and feedback from a brief user study.

1. Introduction

The structure of a medium directly impacts its communicative practices and efficiency [17, 33]. The typical implementation of instant messaging is prone to cycles of ambiguity and repair [11]. Its asynchronous nature leads authors to send short messages in bursty fragments, often interleaving parallel topics, to overcome immediacy issues in the medium. The combination of parallel thoughts and unnatural time-windows complicates turn-taking by forcing recipients to either reply as the stream comes in or wait until they perceive that it is their turn to reply. Unlike email, referential misunderstandings can more easily occur because replies are often not adjacent to the text they address. To fix these and other problems, we present the design, rationale, and early critique of Signs, an instant messenger that aims to augment communication by providing structural and gestural features to correct mistakes, clarify misunderstandings, and expand the expressive power of Instant Messaging (IM).

2. Motivation

It would be an understatement to say that semi-synchronous text-based communication is popular. One estimate from 2006 stated that 49% of the European population used desktop-based IM, in addition to Short Message Service (SMS) on mobile phones [4]. Clearly, the ability to communicate cheaply in near real-time using text has widespread appeal, despite the medium's ill affordances [11]. We are interested in enhancing the communicative efficiency of IM by adding features that 1) increase awareness of the other user's actions and mental state, 2) helping repair problems that arise from inherent deficiencies of the medium's use, and 3) permitting new gestures that are only possible by computer-mediated means [13]. To reduce the number of variables while we craft our basic design, we currently only consider the design and analysis of dyadic conversations. Some of our techniques might need fundamental changes to support group conversations. We begin with the problems of current commercial instant messaging designs.

Instant messaging is semi-synchronous, principally textual, chronological, and non-linear. This is partly in direct contrast to the synchronous serial aural nature of face-to-face communication, the context in which our existing social processes of turn-taking and discourse structure has evolved. Freeing ourselves of this constraint is a double-edged sword. While we are now able to stream longer dialogues from our consciousness -- sometimes coherent and logically structured and other times tangential and haphazard -- our recipients must process parallel fragments while simultaneously replying to a subset therein. Despite the organic evolution of strategies to navigate around these issues, incoherence remains a frequent problem [11, 14, 21, 31].

A simple set of examples will help demonstrate some of the problems that people face everyday. See Traum [28] for a deeper discussion on conversational grounding in collaborative chat.

A: Mary is now working for Frank
B: Wait, who's that?

This example illustrates one typical pattern of ambiguity, where the breakdown occurs at the level of a shared cognitive frame. *Who*, the indexical linguistic pointer, is ambiguous. This pattern is by no means restricted to instant messaging, but occurs in most forms of communication. It is expected by B, to varying degrees of self-awareness, that A is able to disambiguate the referent *who*. The resolution could occur using the immediate context, a shared knowledge of actors, or other means of grounding the conversation [3]. Yet despite the ubiquity of this problem to all media, the qualities of instant messaging exacerbate difficulties in referent resolution.

Consider the following conversation:

A: I got a new job yesterday, are you still looking for yours?
A: Oh that reminds me, have you used craigslist before?
B: Yeah

Due to the asynchronous, non-dedicated nature of IM as a communication channel, this pattern of ambiguity and partial replies occurs frequently. It can be caused by delays in typing, delays in network delivery, and shifting user attention. B could have just as easily only seen and replied to the first message before switching to another task, and be in the middle of typing a second and longer reply. To A, the conversation is stuck in either case, without any resolution to which question in which B was replying. Many instant messengers try to indicate to A when B is typing to create short-term expectations. If A can see that B is still typing, it boosts the expectation that *Yeah* was a reply to the first question. Yet in the majority of IM implementations, A receives the same "B is typing" indication whether the response is extremely long, or if B typed a single character and then stepped away from the computer. Without further modification of the interface, A is missing key information to assess and build communicative expectations.

Another example demonstrates some of the subtleties of ambiguity resolution and its associated cost structures.

A: You know I hate my job
A: my boss is always hanging on me,
A: do this, do that
A: no fun, do you like yours?
B: Yeah


Many would read this and assume, perhaps as A did, that B likes his job. But there are several alternative

explanations that are just as likely. Because the placement of B's response on A's screen is subject to network latencies rather than the order in which B actually received the message and responded, B, who might in fact hate his job, could have actually only seen the first message and quickly replied. Another explanation is that B saw all of A's messages, but B is responding to any of the lines *but* the last. In either case, we could expect that B would follow with an explanation of what he meant should he catch the ambiguity. Yet his repair would have to continue in the same costly medium of text. Despite the simplicity of the example, B would have to verbosely explain that he is aware of and shares compassion with A's dislike of his job, but has not yet answered A's last sequential message in order to completely disambiguate himself:

A: no fun, do you like yours?
B: Yeah
B: By yes I mean that I know your boss is always hanging on you telling you do this do that.

Instead, consider that B is able to resolve the ambiguity by a graphical affordance in the medium:

A: You know I hate my job
A: My boss is always hanging on me,
A: do this, do that
A: no fun, do you like yours?
B: Yeah



Using a simple graphical vocabulary, two arrows significantly compress the time required to both create and interpret the otherwise verbose text-based disambiguation. They also function as a new communicative act, as a repair process or otherwise. Further, such manipulations of the chat history are powerful speech acts that cannot be accomplished in synchronous voice-based communication. The chat history can become a primary advantage of using Computer Mediated Communications (CMC) rather than a side effect of the medium.

We believe significant improvements in communicative efficacy can be made to IM by refactoring the traditional design. Once such method is to provide explicit support to help structure and restructure discourse, such as the arrows above. We have devised a suite of such elements to address issues in repair, reference, and semantic clarity. We have also expanded our design to improve expressivity, addressing issues in non-textual communication, attention awareness and negotiation, and conversational linearity.

We now present related work, our choice of design philosophies and their implementation, a survey of

resulting usage patterns and informal feedback, and suggestions for future work.

3. Related work

Other attempts have been made at resolving issues in turn-taking and incoherence by providing structure or discourse visualization directly in the chat environment. Shankar's Fugue [23] uses a visualization that places words horizontally by time, rather than in vertical clusters. The hope is that the overlap of concurrent words will become more apparent. Vronay et. al. [32] attempted a similar technique of horizontal placement. Smith et. al's Conversation trees [24] allows users to directly reply below the related message rather than add directly to the bottom, similar to Pimentel et. al's system [22]. Fono and Baecker [7] tried to address issues in Smith's interface by putting messages at both the bottom and contextually in the log.

In contrast to the above systems, we opt for a mutability approach where users modify the persistent space as needed, rather than make repair strategies a primary element of the interface. Chen and Sun [1] argue for a similar approach to incoherency resolution, contrasting IM with collaborative text editing. Mühlpfordt and Wessner [18] also elect to retain the typical design, using arrow-based referents to link messages within the chat log or to external web-based elements. However, their system stresses external referents as a primary element, appropriate to their group learning-specific needs.

4. Design

In contrast to many of the works mentioned above, we have opted for a design that is oriented towards casual, mostly-synchronous chat between two users. In doing so, we have elected not to heavily re-design the default message layout, maintaining a similar experience at first glance to existing commercial IM implementations. This restriction ensures we do not over-favor an enhancement such as incoherency repair to any other, keeping the interface simpler and more familiar. One subtle side effect is that we must remain mode-less, in contrast to systems like SharedShell [34]. Instead, functions are contextually revealed upon hovering the mouse over the desired object, such as an existing message.

Given the baseline requirement of keeping the IM experience roughly similar to user expectations, we modify and augment the interface to support coherence, repair, reference, and increased expression. To accomplish these goals, we use a stricter interpretation of What You See Is What I See (WYISIWIS), remove restrictions on linearity and

immutability, and increase the use of non-textual elements.

4.1. WYISIWIS

WYISIWIS is an important principle for designing collaborative systems. If we wish to enable free manipulation as gesture in a co-habited space, everything that can be interpreted as a speech act should be synchronously shared [10, 29]. If the user knows the chat space consistently operates in a WYISIWIS manner, they can expect the remote participant to immediately understand any action according to the language visible on screen. That said, WYISIWIS can also be too restrictive, as discussed at length by Stefik et al. [26]. We have therefore relaxed WYISIWIS in select cases to facilitate a practical chat environment, i.e. window management is only partially shared.

WYISIWIS also allows us to cue users towards the attention of remote participants. By synchronizing scrolling across users, it becomes apparent when the remote participant is re-reading a previous portion of the chat log. This subtle detail yields a useful passive insight into the remote participant's mental state, explaining delays in communication while roughly indicating messages under reconsideration.

4.2. Non-linearity and mutability

An overarching theme in Signs is the removal of immutability assumptions. When past actions in the log become mutable, they gain potential for new shortening communications or off-loading mental computation [16]. We mutate messages to correct errors or avoid quotation, and we mutate the order of messages to repair incoherence. The entire chat space thus becomes a common ground for communication, removing previous linear assumptions as well. This decision is at odds with highly asynchronous behavior, where new actions might go unnoticed by the remote participant. We rely on users to act appropriately, inferring the level of attention of remote participants, and to repair as necessary.

4.3. Non-textual communication

Text-only interfaces limit our communicative abilities [12]. While many commercial IM clients are mixed-media, where users can inject existing photos into the chat space, this heavy-weight approach neglects more free-form graphical communication. Signs allows users to draw anywhere in the chat space much like a shared whiteboard. Unlike most whiteboard implementations which separate chat from drawing, Signs users can draw anywhere in the chat

space, similar to Sun's SharedShell [34] but without the modes. Additionally, Signs provides a limited set of graphical markers as structuring agents.

5. Implementation

Signs is implemented using Flex such that it can be accessed inside a web browser, or as a stand-alone application using the Adobe AIR framework. It uses the open Jabber chat protocol for maximum flexibility and compatibility. The Jabber protocol allows Signs to communicate with other Signs members in its own protocol using the Out Of Band (OOB) communications channel. Signs maintains backwards compatibility with ordinary chat clients by disabling its enhanced features upon detection. The scalable open source Openfire Jabber server allows us to implement future extensions using a plug-in architecture and bridge popular chat networks such as Google Talk and AOL Instant Messenger. We felt this bridge was critical for the adaption of Signs, and removes the need to maintain a Signs-specific buddy list by using existing social networks. OpenSocial and Facebook Connect can be used as they become available.

5.1. Basic application design

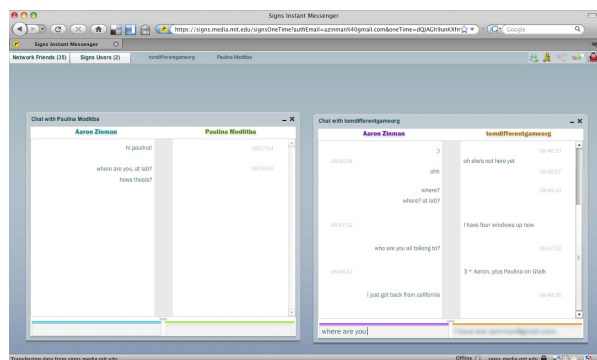


Figure 1. A Signs chat session with two active conversations

Figure 1 shows a typical Signs session. On the top bar we put the "background state" of Signs: buddy lists, active chats, status of the bridge to other networks, and the ability to file bug reports. In the main area we have two concurrent chats, each conducted in their own window. Working under the WYSIWIS principle, the size of a chat window is fixed to ensure participants always see the same view. We discuss issues around resizing windows in future work.

5.2. Chat windows

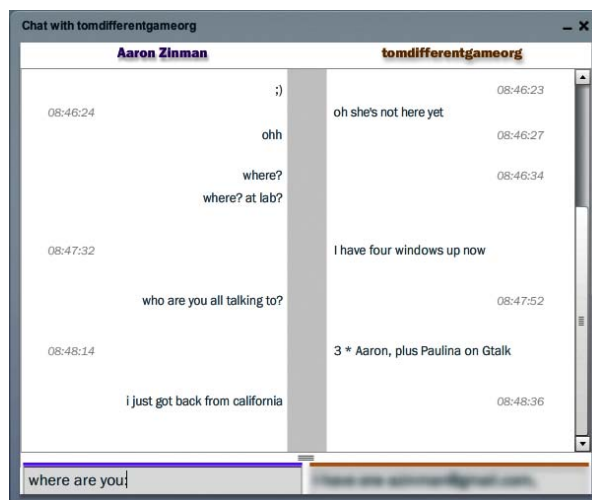


Figure 2. An active chat window

Figure 2 shows a detail view of a Signs chat window. Each participant has a side in the window for text entry and log, as indicated by name and color assignment. Applying the WYSIWIS principle, text entry for remote users is shown character-by-character in real-time, akin to the original Unix talk. This technique allows users to better estimate the level of attention, hesitation, and other discernable attributes by observing the rhythm of participation. However, we relax WYSIWIS for privacy sake, blurring text entry until the complete message is sent to the log. While faster comprehension could be achieved by not blurring the text as demonstrated in the Awarenex interface [27], it would prevent the use of the chat box to offload mental computation [16] in situations where users need to be careful with word choice.

True to most IM designs, Figure 2 shows how incoming messages vertically stack in chronological order. We emphasize the original chronology by increasing the vertical space in proportion to the time elapsed between messages. Thus large breaks in the conversation are reflected spatially. To prevent large breaks from leaving too much white space, a sigmoidal function dampens the distance.

5.3. Mutability

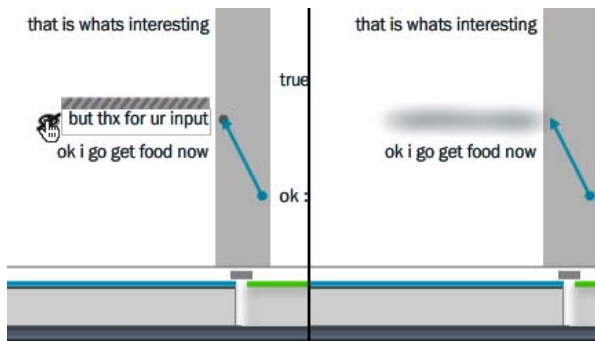


Figure 3. A message is blurred by toggling its visibility

Messages in Signs are mutable. Clicking once inside a message allows a user to modify its content. Modifications are shown using a similar style to Microsoft Word's tracking changes feature, where deleted text is given a strike-through while new text is colored to indicate authorship. Despite separations for entry, users are free to modify the text of any participant. A shortcut to retracting an entire message is provided by a simple toggle shown next to a message on hover. Instead of a strike-thru, this mode blurs and de-blurs the message, as shown in Figure 3. We chose blurring to emphasize that the reader should ignore the message entirely, however an argument for using a strike-through could just as easily be made.

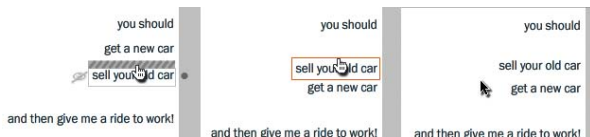


Figure 4. Messages can be re-ordered by a simple dragging motion. The message being moved is highlighted in orange for both participants.

Message order is similarly mutable. Any message can be dragging by its frame to another slot in the conversation. Re-ordering is one technique to accomplish the repair of an unintended sequence, as shown in Figure 4. Movement alone can be useful as a communication act, as the resulting animation is synchronized in real-time. Wiggling a message functions as an indexical pointer, providing an alternative for copy-and-paste or other forms of explicit text-based reference.

5.4. Referents

Indexical pointers are an important structuring element in Signs, which are principally implemented as an arrow between messages, much like in ConcertChat [18]. Hovering over any message reveals a small adjacent circle that functions as a source and sink for graphical arrows, as depicted in 4. Dragging from one circle to another creates an arrow in the gutter between participant logs, as shown in Figure 3. Because both sides are separated, patterns between source and destination participants are visually emphasized across the x-axis. The visual reminder provides a kind of subtle proxy for social roles and behavior [6].

Users can also point to an existing message by double clicking it. This low-cost mechanism triggers an animation that highlights the message border, as shown in Figure 5. Our motivation comes from anecdotal conversations with heavy IM users who said they frequently copy and pasted previous messages to make a point. Note that only because we have synchronized scrolling can A be sure that B is seeing the same animation if the message is from the distant past.



Figure 5. A message can be emphasized using animation by double clicking on it

5.5. Doodling

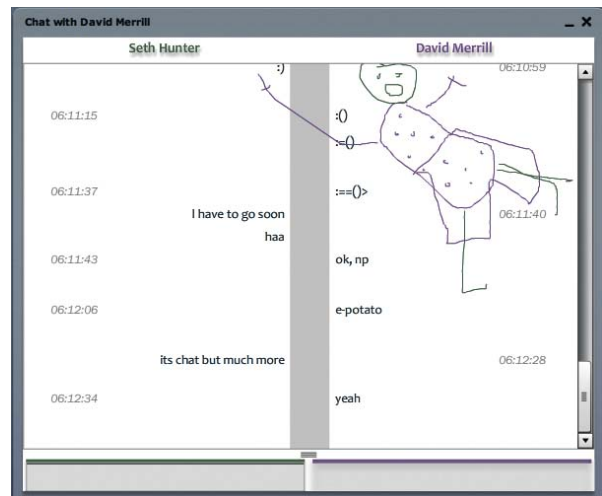


Figure 6. Free-form doodles are combined in a spontaneous collaborative drawing event.

Free-form drawing on the chat space is accomplished by simply clicking and dragging anywhere in the window. We call this doodling. Doodles stick to the area relative to nearby messages in order to maintain their original context. Doodles can be deleted or repositioned using the control frame that surrounds a doodle on hover. Figure 6 depicts a collaborative drawing session that organically emerged between both participants. Notice the two different colors that reflect authorship.

5.5. Window management

Adhering to a mostly strict WYSIWIS interpretation, window presence (but not position) is mirrored. Upon creation, a chat window will immediately appear on the recipient's screen. Closing, minimizing, and maximizing a window is also synchronized. Such a strict use of WYISIWIS is motivated by the desire to integrate outeraction [20] into the window itself, which in turn functions as a proxy for negotiating communication. For example, one can signal that they are unwilling to embark or continue a discussion by closing the window. Equally, one can minimize a window to signal the desire for a temporary break, which stays minimized unless contested. We hypothesize this feature will be particularly important in future iterations where parallel windows are used to support multi-threading.

6. Evaluation

We have conducted a brief initial study of Signs. Over the past two weeks, 27 adults used Signs with varying regularity. The group mostly consisted of graduate students who are self-reportedly heavy users of instant messaging. We conducted free-form interviews with a subset of 9 users to question their perceptions of instant messaging and the Signs methodology. We were chiefly interested in their experience of incoherency in IM and whether Signs could support repair. We also questioned the usefulness of our approach, and any general feelings on the research product. We now itemize the reaction to each major feature and the philosophy behind Signs.

6.1. Incoherence

All 9 users agreed that incoherence is a problem, and one participant went so far as to predict that it occurs at least twice in any conversation over 30 minutes. Only one participant felt they had a satisfactory strategy to prevent incoherence, but that Signs would help alleviate the rigidity of his strategy. He continued, "It's definitely a problem. It happens in almost every conversation, especially if the other

person is not being very synchronous. I might tell them three or so things before they reply, and it's not clear what they're replying to."

6.2. Visibility of text before commitment

All 9 users liked the obscured character-by-character revealing of text entry. Two users reported that blurring looks like an error, and that it caused eyestrain. Both suggested the use of nonsensical symbols to replace blurring universally, or to use a strike-through to redact messages.

6.3. Redaction

One user found an inconsistency in that the blurring of text was not colored. He felt that every manipulation over time should retain the author's color. Thus even de-blurred text should leave behind some evidence that it had been previously blurred.

6.4. Arrows

All users agreed with varying enthusiasm that arrows could help the process of repairing incoherence. Despite any successes, almost all users reported that our mechanism for creating the arrows was too sensitive. One noticed the lack of an elegant way to connect a new message to one in the distant past.

6.5. Message re-ordering

Most users enjoyed re-ordering messages by dragging. One conjectured it would be more useful than arrows for repair. Another wanted drag messages off-screen to delete them. Multiple users suggested that re-ordering could also become merge, adding visual emphasis for message flow. Finally, it was suggested that arrows could be used to maintain a history of re-ordering, potentially addressing practical issues in synchronicity.

6.6. Doodling

Doodling was discovered by all participants (a testament to ease of use), and was universally liked. Many thought it might help more than arrows or re-ordering to repair incoherence. It is important to note that while doodles can accomplish many of the same tasks as native structuring elements, only a long-term study can reveal how and when such functions are used. Without a pen-based touch screen, doodling with a mouse is inexact, and thus might be more awkward than the native pointers we also support.

6.7. Split sides

Because Signs separates its users into two columns, many users immediately remarked about the departure from the familiar. Three users wanted a single view, but only because of habit rather than a defect in our design. Three others did not like the perceived inconsistency that messages could be re-ordered vertically but not across the gutter, despite issues of ownership. Two users felt aware of "chat property" from the gutter, pressuring them not to manipulate the other side. However, only one user felt too uncomfortable in any situation to manipulate another's messages. We interpret these preliminary results such that our separation enabled a new kind of power dynamic that will likely be developed through long-term social engagement.

6.8. Synchronized Scrolling

Five users reported feeling a new insight into the mental state of their chat partner by watching them scroll back to re-read portions of the log. They happily reported it was one of the most dramatic and desirable differences from IM as they previously knew it. However, another three felt contention with being able to add or view recent entries when their partner scrolled back. All three suggested some kind of split-screen where the most recent messages remain visible when the log is scrolled. An implementation fault allowed scrolling to occur while an arrow was being dragged, disabling the arrow creation. This error demonstrates that all resources should be locked during manipulation, not just the resource under contention.

6.9. Vertical spacing

Two users suggested doing away with the extra vertical spacing, preferring a layout that indicated time using well placed time stamps. Skype's implementation was specifically suggested as exemplary.

6.10. History

Three users suggested that they wanted to see a separate abbreviated history of the chat to quickly find Signs-centric annotations.

6.11. Synchronized window manipulation

While most users enjoyed the synchronization of window management, it stressed the semi-to-asynchronous nature of IM. Many wanted the ability to keep the asynchronous aspect of IM, as it was one of the primary advantages of the medium. They suggested instead highlighting gestures in the window

during long pauses. De-synchronization of window closing and minimization was also requested.

6.12. Miscellaneous Suggestions

It was suggested that a variable slider could grow or shrink the chat log to aid searching for previous annotations. Another noted that since doodles can be created over past messages, a set of user-assigned icons or emoticons could be dragged on messages like stamps to more easily annotate the conversation.

Three users felt that the flow of the messages could be better illustrated. While this problem exists in most commercial IM clients, Signs prompted the inspiration for larger architectural changes. It was suggested that Natural Language Processing (NLP) could be used to understand the discourse structure to drive a novel display algorithm. There already exists some attempt to use NLP to help structure and automate features of a chat environment, such as automating the threading annotations [15, 19]. Vilhjálmsson's Spark avatar-based chat system uses a multitude of discourse analysis algorithms to automate avatar gestures [30]. We have been philosophically opposed to any automation that could falsely express a communicative act or collective state, but it might be possible to find an appropriate middle ground that errors on the conservative side.

Several users suggested that keyboard shortcuts could be used in lieu of switching to using the mouse, alleviating many perceived usability problems. Keyboard shortcuts could be aided with information obtained from discourse analysis using the techniques alluded to above.

7. Sample usage patterns

Signs has been used for a long enough period to generate a wide variety of contexts in which its features were employed. To demonstrate the utility of Signs, we present select screenshots to highlight some interesting usage patterns that naturally emerged. Note that we add speckled noise to anonymize the participants. Because the names are removed, the left side will be referred to as A and the right B.

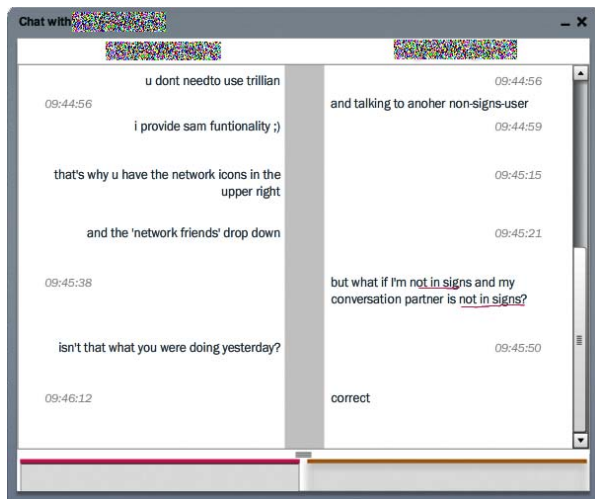


Figure 7. Doodle to resolve confusions

In Figure 7, A is confused as to what B is asking. A uses doodles to reemphasize what A thinks is the source of the confusion, suggesting that referents could be added on a sub-message level.

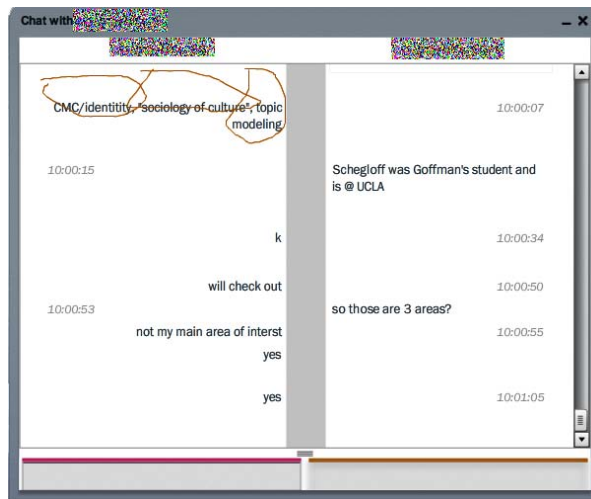


Figure 9. Doodle for sequencing

Figure 9 shows how annotation can separate a sequence of items to aid B's confusion. Because doodling is real-time and synchronous, circles appear one at a time despite the inexact process of drawing with a mouse.

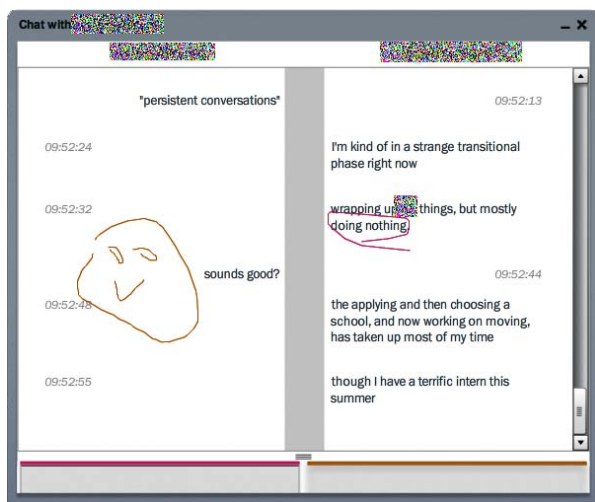


Figure 8. Doodle for emphasis with reply

In Figure 8, A uses a circle reference a sub-clause of B's message, then adds the question *sounds good?* In response, B draws a large happy face to next to B's own referent to continue the doodling spirit.

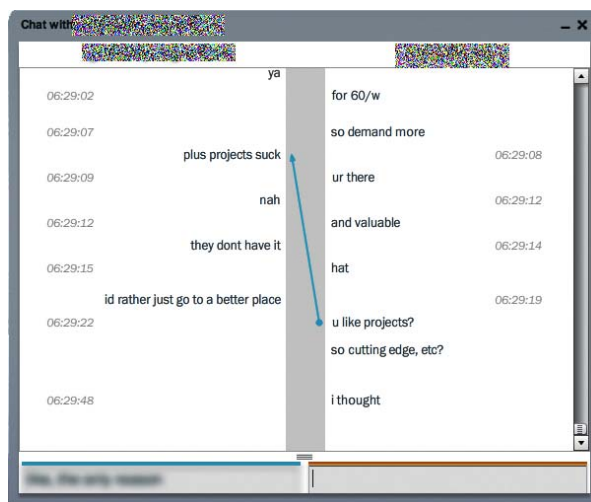


Figure 10. Arrows as reply

Arrows can also be used to reduce confusion outside of referents. In Figure 10, A reinforces his dislike of his projects by drawing an arrow from B's point of confusion.

8. Conclusions and Future Work

Instant messaging induces problems of coherence and structure. Despite emergent processes to facilitate turn-taking and threading, difficulties exist in most lengthy conversations. Recognizing this well-published problem, a few alternative solutions have been previously suggested [7, 22, 23, 24, 32]. However, none have reached maturity in design or have been well received enough to gain commercial adaption.

We have presented Signs, a design for instant messaging that strives to improve communicative efficiency by adding tools to directly help structure the conversation. By synchronizing the displays of participants and allowing the manipulation of the persistent chat log, we introduce new mechanisms for expression and clarification. Our methods have been well received in our limited user study, but not enough evaluation has occurred to determine any clear winners or losers in our feature set.

Our choice of WYSIWIS has been a double-edged sword. While users have appreciated the increased power of gesture and insight through synchronicity, it is directly at odds with the use of instant messaging as an asynchronous medium. Future work must first resolve this divide, either by removing any support for asynchronous conversations or by emphasizing history while relaxing some assumptions of synchronicity.

We conclude that the combination of tools in our design can lead to major improvements in user enjoyment of instant messaging. Our design choices are not radical enough to prevent adaption, and are powerful enough to have been valued by our study's participants. We foresee a strong future in manipulating persistent chat spaces, freeing ourselves from the artificial restrictions of an immutable history.

9. References

- [1.] D. Chen, and C. Sun, "Real-time text chat via collaborative editing systems". In *Proceedings of the ACM CSCW 2002 Workshop on Collaborative Editing*, New Orleans, USA, 2002.
- [2.] E. F. Churchill, J. Trevor, S. Bly, L. Nelson, and D. Cubranic, "Anchored conversations: chatting in the context of a document," in *CHI '00: Proceedings of the SIGCHI conference on Human factors in computing systems*, New York, NY, USA, ACM Press, 2000, pp. 454-461.
- [3.] H.H. Clark, *Using Language*, Cambridge Univ. Press, 1996.
- [4.] comScore, "Europe Surpasses North America In Instant Messenger Users, comScore Study Reveals", Press Release, London, England, April 10, 2006.
- [5.] P. Dourish and V. Bellotti, "Awareness and coordination in shared workspaces," in *Proceedings of the 2004 ACM conference on Computer Supported Cooperative Work*, New York, NY, USA, ACM Press, 1992, pp. 107-114.
- [6.] T. Erickson and W. A. Kellogg, "Social translucence: an approach to designing systems that support social processes," *ACM Transactions in Computer-Human Interaction*, March 2000, vol. 7, no. 1, pp. 59-83.
- [7.] D. Fono, and R. Baecker, "Structuring and supporting persistent chat conversations," in *Proceedings of the 2006 20th Anniversary Conference on Computer Supported Cooperative Work (Banff, Alberta, Canada, November 04 - 08, 2006)*. CSCW '06. New York, NY, ACM, 2006, pp. 455-458
- [8.] H. Fuks, M. Pimentel, and C. J. Pereira de Lucena. "RU-Typing-2-Me? Evolving a chat tool to increase understanding in learning activities," in *International Journal of Computer-Supported Collaborative Learning*, 2006, vol 1, no. 1, pp. 117-142.
- [9.] D. Gergle, D. R. Millen, R. E. Kraut, and S. R. Fussell, "Persistence matters: making the most of chat in tightly-coupled work," in *Proceedings of the SIGCHI conference on Human factors in computing systems*. New York, NY, USA, ACM Press, 2004, pp. 431-438.
- [10.] S. Golder and J. Donath. "Hiding and revealing in online poker games," in *Proceedings of the 2004 ACM conference on Computer Supported Cooperative Work*, Chicago, Illinois, USA, 2004.
- [11.] S. Herring, "Interactional Coherence," *Journal of Computer-Mediated Communication*, 1999, vol. 4, no. 4.
- [12.] W. C. Hill, J. D. Hollan, D. Wroblewski, and T. Mccandless, "Edit wear and read wear," in *Proceedings of the SIGCHI conference on Human factors in computing systems*. New York, NY, USA, ACM Press, 1992, pp. 3-9.
- [13.] J. Hollan and S. Stornetta, "Beyond being there," in *Proceedings of the SIGCHI conference on Human factors in computing systems*. New York, NY, USA, ACM Press, 1992, pp. 119-125.
- [14.] E. Isaacs, C. Kamm, D. J. Schiano, A. Walendowski, and S. Whittaker, "Characterizing instant messaging from recorded logs," in *CHI '02 extended abstracts on Human factors in computing systems*. New York, NY, USA, ACM Press, 2002, pp. 720-721.
- [15.] E. Ivanovic, "Dialogue Act Tagging for Instant Messaging Chat Sessions", in *Proceedings of the ACL Student Research Workshop*, 2005, pp.79-84.
- [16.] D. Kirsh, "The intelligent use of space," *Artificial Intelligence*, vol. 73, no. 1-2, pp. 31-68, 1995.

- [17.] M. McLuhan, Q. Fiore, and J. Agel, *The medium is the message: An inventory of effects*. New York: Bantam Books, 1967.
- [18.] M. Mühlfordt and M. Wessner, "Explicit referencing in chat supports collaborative learning," in *Proceedings of the 2005 conference on Computer Support for Collaborative Learning*, International Society of the Learning Sciences, 2005, pp. 460-469.
- [19.] J. Nakamura, Y. Tajima, and Y. Kotani, "Detecting the links between utterances in character based multi-party conversation by machine learning with meta-information," in *Proceedings of the 2007 Annual Conference on international Conference on Computer Engineering and Applications*, World Scientific and Engineering Academy and Society (WSEAS), Stevens Point, Wisconsin, 2007, pp. 41-46.
- [20.] B. A. Nardi, S. Whittaker, and E. Bradner, "Interaction and outinteraction: instant messaging in action," in *Proceedings of the 2000 ACM conference on Computer supported cooperative work*, New York, NY, USA, ACM Press, 2000, pp. 79-88.
- [21.] J. O'Neill and D. Martin, "Text chat in action," in *Proceedings of the 2003 international ACM SIGGROUP conference on Supporting group work*, New York, NY, USA: ACM, 2003, pp. 40-49.
- [22.] M. Pimentel, H. Fuks, and Carlos, "Mediated chat development process: Avoiding chat confusion on educational debates," in *Proceedings of the Computer Supported Collaborative Learning Conference – CSCL 2005*, Taiwan, June 2005, pp. 499-503.
- [23.] T. R. Shankar, M. Van Kleek, A. Vicente, and B.K. Smith, "Fugue: A Computer Mediated Conversational System that Supports Turn Negotiation," in *Proceedings of the 33rd Hawaii international Conference on System Sciences*, IEEE Computer Society, Washington, DC, 2000, vol. 3.
- [24.] M. Smith, J. J. Cadiz, and B. Burkhalter, "Conversation trees and threaded chats," in *Proceedings of the 2000 ACM conference on Computer Supported Cooperative Work*, New York, NY, USA, ACM Press, 2000, pp. 97-105.
- [25.] G. Stahl, A. Zemel, J. Sarmiento, M. Cakir, S. Weimar, M. Wessner, and M. Mühlfordt, "Shared referencing of mathematical objects in online chat," in *Proceedings of the 7th International Conference on Learning Sciences*, International Society of the Learning Sciences, 2006, pp. 716-722.
- [26.] M. Stefik, D. G. Bobrow, S. Lanning, D. Tatar, and G. Foster, "Wysiwis revised: early experiences with multi-user interfaces," in *Proceedings of the 1986 ACM conference on Computer-Supported Cooperative Work*. New York, NY, USA, ACM, 1986, pp. 276-290.
- [27.] J. C. Tang, N. Yankelovich, J. Begole, M. Van Kleek, F. Li, and J. Bhalodia, "Connexus to awareness: extending awareness to mobile users," in *Proceedings of the SIGCHI conference on Human Factors in Computing Systems*, New York, NY, USA, ACM Press, 2001, pp. 221-228.
- [28.] D. R. Traum, "Computational models of grounding in collaborative systems," in Working Papers of the AAAI Fall Symposium on Psychological Models of Communication in Collaborative Systems, Menlo Park, California: American Association for Artificial Intelligence, 1999, pp. 124-131.
- [29.] F. B. Viégas and J. S. Donath, "Chat circles," in *Proceedings of the SIGCHI conference on Human factors in computing systems*, New York, NY, USA, ACM Press, 1999, pp. 9-16.
- [30.] H.H. Vilhjálmsón, "Avatar Augmented Online Conversation", Ph.D. thesis, Media Arts and Sciences, Massachusetts Institute of Technology, Media Laboratory, Cambridge, MA, 2003.
- [31.] A. Voids, W. C. Newstetter, and E. D. Mynatt, "When conventions collide: the tensions of instant messaging attributed," in *Proceedings of the SIGCHI conference on Human factors in computing systems*, ACM Press, 2002, pp. 187-194.
- [32.] D. Vronay, M. Smith, and S. Drucker, "Alternative interfaces for chat," in *Proceedings of the 12th annual ACM symposium on User Interface Software and Technology*, New York, NY, USA, ACM Press, 1999, pp. 19-26.
- [33.] S. Whittaker, "Theories and methods in mediated communication", in Handbook of discourse processes, Erlbaum, Mahwah, NJ, 2003, pp. 243-286
- [34.] N. Yankelovich, J. Begole, and J. C. Tang, "Sun SharedShell tool," in *Proceedings of the 2000 ACM Conference on Computer Supported Cooperative Work*, ACM, New York, NY, 2000, pp. 351.