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Elements of design conversation in the interconnected HIS

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To ideate, designers talk and exteriorize ambiguous mental images in external representations. Verbalization is the most common means of externalizing design intentions during collaborative design. This paper presents the different elements of Design Conversation: Collaborative Ideation Loops, Collaborative Conversations and Collaborative Moving. They were observed using the interconnected Hybrid Ideation Space (HIS) in the context of a multidisciplinary collaborative case study. In this project, two teams of students from two universities designed a bus shelter. This study highlights the relevance of these elements of Design Conversation as methodological tools to assess and understand the ideation process using computer collaborative environments.

Keywords: design conversation, collaborative ideation loop, process-based assessment, methodological tools, interconnected hybrid ideation space

1 Introduction

"Yeah, well, here it looks kinda high; I was thinking more about this high" is a typical verbal communication between designers during collaborative ideation (CI). At the onset of a concept there are always words expressing the designer's thought, before any graphical or physical representation. While collaborating, these thoughts are *extroverted* in their conversation, letting others help in unfolding the meaning. Consequently, to assess CI we decided to assess the design conversation. Yet design conversation will be affected by the logic of the tool that is used. Therefore we opted to observe the design conversation in the specific setting of the interconnected Hybrid Ideation Space (HIS) because it appeared in past studies to be transparent to the logic of design and to better support ideation as well as remote and local CI.[1] In CI, we have observed that the designer's dialogue change inside the HIS, compared to other traditional design tools (analogues and digitals), and seems to be amplified. Therefore the HIS is considered in this research as *a playground* and *a magnify lens* to study these dialogs. The HIS is a hybrid technology, analogue and digital we developed to allow designers to be inside their shared representations, locally and remotely.[2] It is an intuitive immersive system (life-size) that uses manual representations, freehand sketches and rough models to exteriorize conceptual intentions.

To assess the CI process we have developed a methodological and theoretical framework presented here as the three elements of Design Conversation: the CI Loops,[3] Collaborative Conversations (CC) and Collaborative Moving (CM). We have found that these elements, based on the known design actions of *naming*, *constraining*, *negotiating*, *decision making*, and *moving*,[4] [5] [6] have recognizable forms and patterns and appear to follow a progression that matches the design

1 Dorta, T. et al (2009). Design tools and collaborative ideation. In: Tidafi, T. & Dorta, T eds, Joining Languages, Cultures and Visions: CAADFutures 2009, PUM, Montreal, pp 65-79

2 Dorta, T. (2007). Implementing and assessing the hybrid ideation space: a cognitive artefact for conceptual design, International Journal of Design Sciences and Technology, 14:2, pp 119-133

3 Dorta, T. et al (2010). Signs of collaborative ideation and the hybrid ideation space. In: Taura, T. & Nagai, Y. eds, Design Creativity 2010, Springer, Kobe, Japan, pp 199-206

4 Goldschmidt, G. (1990). Linkography: assessing design productivity. In: Trappl, R. ed, World Scientific, Singapore, pp 291-298

project's development. As a methodological framework, these Design Conversations capture this most sensitive as well as elusive dimension of the design process: the verbal and gestural conversation during CI. In turn, as process-based assessment tools bypassing the subjectivity of outcome-based evaluations, the elements of Design Conversation could provide better understanding of CI in the context of computer-mediated CI tools.

2 Collaborative Ideation (CI)

In order to exteriorize verbally and visually an idea (Goldschmidt 1990),[7] designers link qualitative and ambiguous mental images and external representations in a continuous interaction.[8] Typically, designers see more in their sketches and physical models than what they put in when they made them.[9] They often work with incomplete information, assuming and taking provisional decisions that need to be revisited. Inaccuracy (flexibility), ambiguity (alternative meanings), and abstraction (simplification) are the main characteristics of this kind of reflective representations.[10]

Furthermore, designing is considered a social process.[11] Teams locally and remotely discuss and negotiate between participants whose representations of the design are not aligned, and they do so by respecting the ambiguity while fostering a design conversation between the parties.

Verbal communication is considered to be the first design tool and the principal way of explaining ideas, even before visual representations.[12] In a collaborative work setting, the designers communicate their ideas to others using verbal communication, gestures and physical and graphical representations. Verbalization on its own or in combination with other design tools drives ideation and is the most common means of externalizing design intentions.[13] The strength of verbalization relies on words, in face-to-face settings or in computer-mediated environments.[14] Words are more than just medium for communication: they are part of the thinking process. Creativity and information exchange are mediated by the social nature of design. And in turn, the collaborative and social aspects of design are supported by verbalization.[15] Linguists see the conversation found in CI as *consensus building rhetoric*, which is a specific kind of rhetoric where all parties strive toward a common resolution. This is very different from political debate for example, where the parties try to differentiate through their respective positions, or even from casual conversation where the dominant goal is to renew contact.[16] With CI we are in a mode where participants build together the concept idea through verbal conversation.

3 Assessing CI

Cognitive science and design theory have studied ideation, with controlled lab experiments mostly concerned with task execution, and through experiments using idea generation methods. There are two approaches to evaluate the effectiveness of CI: *process-based* assessing the process, and *outcome-based* looking at the results.[17] For the first approach, data collection comes from protocol analysis. However, process-based assessment is often unfortunately based on simple problems or tasks as opposed to real design issues.[18] On the other hand, the *outcome-based* approach is questionable because it is based on the designer's performance. Evaluating the results of CI is hard because it depends on the designers

5 Buccarelli , L. (1988). An ethnographic perspective on engineering design, Design Studies, 14:3, pp 159-168

6 Schön, D. (1983). The reflective practitioner: How professionals think in action, Basic Books, New York

7 Goldschmidt, G. (1990). ibid

8 Visser, W. (2006). The cognitive artefacts of designing, Lawrence Erlbaum Associates, Mahwah

9 Schön, D. (1983). ibid

10 Goel, V. (1995). Sketches of Thought, MIT Press, Cambridge, MA

11 Buccarelli , L. (1988). ibid

12 Jonson, B. (2005). Design Ideation: The conceptual sketch in the digital age, Design Stu-dies, 26:6, pp 613-624

13 ibid

14 Lawson, B. & **Loke, S.** (1997). Computers, words and pictures, Design Studies, 18:2, pp 171–83

15 Cross, N. & **Cross, A.** (1995). Observations of teamwork and social processes in design, Design Studies, 16:2, pp 143-70

16 Asher, N. & **Lascarides, A.** (2003). Logics of conversation, Studies in Natural Language Processing. Cambridge University Press

17 Shah, J. & **Vargas-Hernandez, N.** (2003). Metrics for measuring ideation effectiveness, Design Studies, 24:2, pp 111-34

18 ibid

practice and capabilities, which relies on subjectivity. Thus assessing the elements of Design Conversation allows us to observe the CI process by tapping into the designers' minds as it is extroverted by conversation and made transparent to the logic of design by the use of the HIS, while avoiding subjectivity or intrusive approaches like the *thinking aloud* technique.

4 Elements of Design Conversation

In order to measure the collaborative design, Kvan and Geo have proposed the use of design framing,[19] as stated by Minsky's four-level frames: synthetic and narrative as *depicting* frames and semantic and thematic as *descriptive* ones (Figure 1). However, aspects related to negotiation and moving during ideation are not considered. The elements of Design Conversation are methodological compound instruments grounded in Bucciarelli's design as social process,[20] Schön's reflective conversation[21] and Goldschmidt's graphical representation of concepts and actions.[22] They are based on five main elements common in the analysis of the conversation of designers and the design process among those three authors: *naming, constraining, negotiating, decision making* and *moving*, with sub-elements for each one and their relationship with gestures namely pointing and gesturing—our shorthand for drawing in the air.[23]

	Minsky's four-level frames	Description
Depicting	Synthetic	Mainly verb and noun structures. Prepositional and word-order indicator conventions.
	Narrative	Explanations and arguments. Conventions about foci, protagonists, plot forms etc., designed to help a listener construct a new, instantiated thematic Frame in his own mind.
Descriptive	Semantic	Action-centered meanings of words. Qualifiers and relations concerning participants, instruments, trajectories and strategies, goals, consequences and side effects.
	Thematic	Scenarios concerned with topics, activities, portraits, setting. Outstanding problems and strategies commonly connected with topic.

Figure 1 Minsky's four-level frames[24]

Designers will be *naming* the object of design or the specific element being discussed, *constraining* the project through its requirements and boundaries (time, budget and other constraints). They will be *negotiating* or articulating verbal meanings associated to visual images. This category is expanded to three subcategories: *proposing*, verbally making a design proposal, *explaining*, substantiating, and *questioning*, raising issues about or giving a rebuttal to a given proposal. They will be *making decisions*, specifically agreeing or disagreeing, on a proposal, thus marking the end of the negotiation. They will be *moving*, by adding to the representation and making pointing and sketching gestures. The first four actions are usually in the form of verbal exchange, while the moving is an act, which transforms the design situation.[25] [26]

4.1 Collaborative Ideation Loop (CI loop)

The most recognizable element of Design Conversation, the CI Loop pattern is called a *loop* because it repeats itself, and it seems to spring from one to the next, often creating sequences of loops.[27] Frequently, the participant who sealed a loop

19 Kvan, T. & **Gao, S.** (2004). Frames, knowledge and media - An investigative study of frame systems within computer and paper supported collaborative design process. In: Archi-tecture in the Network Society, 22nd eCAADe Conference proceedings, Copenhagen, pp 410-417

20 Buccarelli , L. (1988). ibid

21 Schön, D. (1983). ibid

22 Goldschmidt, G. (1990). ibid

23 Dorta, T. et al (2010). ibid

24 Modified from Kvan, T. & Gao, S. (2004). ibid

25 Goldschmidt, G. (1990). ibid

26 Valkenburg, R.C. & **Dorst, K.** (1998). The reflective practice of design teams, Design Studies, 19:3, pp 249-271

27 Dorta, T. et al (2010). ibid

with an agreement will initiate the next loop. To be considered a CI Loop, a collaborative exchange has to:
- involve two or more participants
- start with a naming
- have a verbal exchange, with at least one constraining, proposing or questioning before a decision is made
- has to end with a decision making (agreeing or disagreeing)
- has to have at least one occurrence of moving or proposing, or both

4.2 Collaborative Conversations (CC) and Collaborative Moving (CM)

We also consider two other types of conversations linked to the ideation process: the Collaborative Conversations (CC) and Collaborative Moving (CM). CCs are either a discussion about concepts indirectly related to the design, or the presentation of a resolved design solution. CMs happen once the concept is secured. It is a bout of rapid ideation where a number of small decisions are being made on the sketch as it progresses. The verbal exchanges are few and short, decision-making agreement replaced by an immediate moving on proposals. It is often an exciting moment where both designers are involved — by drawing, or by following the progression, analysing the coming result and making punctual proposals.

5 Collaborative design studio issues

Graphic ideation should not be confused with graphic communication. Ideation is an active formative process related to idea generation and maturation, usually considered as visually talking to oneself. Graphic communication is a passive explanatory process that presents fully formed ideas as visually talking to others.[28] In the context of CI, ideation conversation is collective and can be synchronous (considered co-design: doing simultaneously the task), or asynchronous (considered cooperation: putting together individual tasks).[29] Passive communication in the context of collaboration is reduced to presentations, done locally or remotely. These distinctions are important to better appreciate the CI exchanges. With the arrival of computers in design practices and the replacement of physical representations (sketches and physical models) by digital files, design studios have lost much of their ability to act as collective incubators. Two people sharing individual representation from a laptop does not replace the design studio's collective exchange over simultaneously viewed multiple representations, and its group synergy.

For ideation purposes, traditional and digital media used in the studio can be considered in essence inadequate for ideation (and CI) because of basic problems: for the former, proportion issues of traditional sketches and models and workload of working with technical documents (plans); and for the latter, the need of a digital know-how (commands and interaction) and precise instructions delivering precise representations (finish and photorealistic), which is premature at the ideation stage. Designers are not able to be inside their sketches and models mastering scale and proportions during individual or collective ideation, while plans require information coding and decoding, hindering mental images and personal interpretation. Computers demand specialization to face the needed digital thinking or digital logic in addition to the design thinking.[30] Even with a title like "Against ambiguity", Stacey and Eckert recognize that the computer of-

28 Marshall, T. (1992). The computer as a graphic medium in conceptual design. In: Kensek, K., & Noble, D. eds, Computer support design in architecture, Mission, Method, Madness ACADIA'92, California, pp 39-47

29 Achten, H.H. (2002). Requirements for collaborative design in architecture, In: Timmermans, H. ed, 6th Design and Decision Support Systems in Architecture & Urban Planning Conference, Eindhoven, pp 1-13

30 Dorta, T. (2007). ibid

fers a limited, narrow perceptual space ill-suited to ideation (exteriorising ambiguous concepts),[31] which calls for inaccuracy, ambiguity and abstraction in order to foster reflexive conversation with the representations.

5.1 Individual vs. collective ideation

Designers frequently switch between moments of individual and collective ideation, focusing on their own or jointly resolving specific project issues. Because of the studio configuration, they can be isolated from the group to converse with themselves through traditional representations (sketches and models), moving to the computer to further this individual reflective conversation (Schön 1983).[32] In addition to these media, they can do CI through real or virtual meetings. Kvan and Gao have found that remote collaboration through chat lines, because it keeps traces, supports higher quality of design framing (addressing problem and context) than verbal communication.[33] They can do CI locally or remotely by phone, by chat and videoconference (e.g. Skype™), by shared online digital sketching (whiteboard) or through virtual worlds. Following up on contributions, cooperation is possible by exchanging physical information and annotations, digital files or models through electronic messages, in the local network or remotely in virtual worlds by Internet.

5.2 Virtual design studios

Virtual design studios are computer-mediated environments, from simple email to collaborative virtual worlds. They adopt different metaphors, from a desktop to a virtual place. They can be centralised or distributed depending on file transfer and storage.[34] Originally developed on VRML, virtual environments allow collective 3D modelling and visualisation (e.g. Second Life™). This media is particularly relevant to CAD since digital models can be shared and explored through their worlds. As they are accessed through computer screens and avatar projections, the immersion they provide is disembodied (loss of awareness of physical self) without offering the explorations a real, physical, fully sensorial immersion does. There, avatars are used to evaluate proportions and, according to Abdellatif and Calderon, offer high perceptual and spatial qualities, and presence. They can also allow verbal and chat exchanges.[35] However, these environments suffer basic problems when it comes to ideation. Most of the models are made outside the world (e.g. with Autodesk 3DS Max), because of 3D modelling limitations (complex shapes) and system's performance in terms of real-time rendering and interaction to accelerate navigation and visualization.[36] Furthermore, the real design studio exchange is imitated in a virtual world, down to reproducing the participants, bringing fundamental technical problems such as heavy calculations involved in getting an avatar to properly imitate human gestures, to moderating the collaboration, to making annotations or to sketch asynchronously only.[37] In the Renaissance, once geometry was mastered, architects moved from the construction site to the studio, keeping crucial proximity to the project's context. Current technology allows virtual visits[38] but without the telepresence of life-size proportions,[39] which is important to achieve a more effective ideation. Finally, the design project involves many disciplines requiring, during synchronous exchanges, representations that do not demand particular specialisation. Basic annotations through sketches combined with gestures and

31 Stacey, M.K. & **Eckert, C.M.** (2003). Against ambiguity, computer supported cooperative work, 12:2, pp 153-183

32 Schön, D. (1983). ibid

33 Kvan, T. & **Gao, S.** (2004). ibid

34 Maher, M.L. & **Simoff, S.** (2004). Variations on a virtual Design Studio. In: Barthes, J-P., Lin, Z. and Ramos, M. eds, Proceedings of 4th International Workshop on CSCW in Design, Université de Technologie de Compiegne, pp 159-165

35 Abdellatif, R. & **Calderon, C.** (2007). SecondLife: A computer-mediated tool for distance-learning. In: Architecture education?, Em'body'ing Virtual Architecture, 3rd International Conference ASCAAD 2007, Alexandria, Egypt, pp 17-34

36 Heidrich, F. et al (2007). Intervision 3D: online 3D visualisation and conferencing, predicting the future, 25th eCAADe Conference Proceedings, Frankfurt am Main, pp 757-764

37 Jung, T. et al (2001). Space Pen, Annotation and sketching on 3D models on the Internet, Proceedings of the 9th International Conference on Computer Aided Architectural Design Futures, Eindhoven, pp 17-34

38 Google Street View™

39 Porter, T. (1979). How architects visualize. Van Nostrand Reinhold, New York

explanations are fundamental to sustain ideation and have been least supported by 3D modellers as seen in previous comparative studies with the HIS and traditional sketch and physical models.[40] In the HIS, the sense of presence is maintained by real-time direct interaction with the graphical representation (sketch) supported by voice conversation. The life-size scale of the shared immersive space reinforces this sense of presence.

5.3 Immersive environments and whiteboard applications

Remote design collaboration raises new challenges, calling for new approaches. Using only CAAD systems in conjunction with the Internet is not enough.[41] Immersive environments and whiteboard applications are options that offer an alternative for remote design collaboration. The possibility of designing in an immersive environment that provides spatial awareness, stronger sense of presence, stereoscopic depth and sharing information seems ideal. A few examples of these systems are the "Virtual to Virtual Environment V2V"[42] for detail shape modelling and CALVIN[43] with applications for collaborative Architectural Layout Via Immersive Navigation. Even if these systems look to improve remote and local design collaboration, their main focus is still managing large groups, effective data sharing based on detailed 3D models but not on ideation sketches. There are also Collaborative Virtual Design Environments (CVDEs) with a specific application taking in account the needs of design teams and design task.[44] [45] Up to now the whiteboard is used in design meetings as a visual support for sketching, allowing design teams to express their ideas. This is not a problem in face-to-face design collaboration, but when the participants are distributed, the requirements for whiteboard applications are different. Several systems that use a whiteboard have been developed, such as NetDraw[46] and the SYCODE object-based drawing application,[47] which were remote collaborative drawing programs. But these had issues with the time delay in remote design collaboration and the lack of detail in the sketch.

The advanced EsQUIsE system allows architects to ideate by sketching.[48] [49] It also permits the generation of 3D models based on sketch extrusions. These 3D capabilities where the abstract sketch is transformed into finish shapes (or primitives), were already explored by Do,[50] and share a fundamental flaw: the representation is basically in 2D and the shaded 3D model is non-abstract, unambiguous and accurate, in contrast to the sketch itself, and not adapted to the designers' mental images during ideation, as observed by Darses (2005).[51] Another related system named SketSha (Sketch sharing), without the 3D modelling capabilities, was interconnected to allow the Distributed Collaborative Design Studio for remote exchanges 3D capabilities set aside, these systems can also be categorized as whiteboards.[52] [53] Although the authors argue that the hardware proposes a Virtual Desktop metaphor[54] mixing analogue techniques (real plans and documents) with digital sketches, these systems are non-immersive: they offer no life-size scale or embodied presence in the project itself.

6 The interconnected HIS

Implemented in 2007[55] and assessed and compared as ideation and co-located collaboration tool,[56] the HIS permits freehand sketching and physical model making layered with in-context images, in immersion (life size and real-time). It

40 Dorta, T. et al (2009). ibid

41 Horváth, I. et al (2002). Six ingredients of collaborative virtual environments. International Design Conference, pp 67-74

42 Arangarasan, R. (2000). Geometric modelling and collaborative design in multi-modal, multi-sensory virtual environment. Proceedings of DETC'00, ASME 2000, pp 1-9

43 Leigh, J. & **Johnson, A.E.** (1996). Supporting transcontinental collaborative work in persistent virtual environments. IEEE Computer Graphics and Applications, pp 47-51

44 Horváth, I. et al (2002). ibid

45 Siddique, Z. & **Rosen, D.** (1997). A virtual prototyping approach to product disassembly reasoning. Computer-Aided Design, 29:12, pp 847-860

46 Qian, D. & **Gross, M.D.** (1999). Collaborative design with NetDraw. In: Proceedings of the 8th International Conference on Computer Aided Architectural Design Futures, Atlanta, pp 213-226

47 Jabi, W.M. & **Hall, T.W.** (1995). Beyond the shared whiteboard: Issues in computer supported collaborative design. In: CAAD Futures 95, Singapore, pp 719-725

48 Darses, F. et al (2008). Is there anything to expect from 3D Views in Sketching support tools? In: Gero, J.S. & Goel, A.K. eds, Design Computing and Cognition '08, Springer, pp 283-302

49 Safin, S. et al (2010). Mixed-reality prototypes to support early creative design. In: Dubois, E. et

is a low-tech system: a tablet laptop[57] or a combination of a small computer Mac Mini™ with a 12" Wacom Cintiq™, a HD projector, an HD IP camera and a 360º immersive projection system based on spherical panoramas. The user sketches on the tablet or makes a rough scale model (in the model station) while a single spherical image is projected upwards to a semi-spherical mirror on the ceiling and then reflected on the ceiling-mounted semi-spherical 5m-diameter fabric screen. The user sketches in a normal perspective while the HIS software distorts the sketch in a spherical panorama. The tablet is mounted on a rotating device that allows users to always sketch in front of them inside a drawing area while they look all around at a normal (undistorted) life-size 360º perspective on the screen, thanks to the *trompe l'oeil* effect (from inside the space, users feel inside a 3D environment). Moreover, the drawing area tells who is online (or presence), knowing continuously where the partner is looking and sketching. Based in the same optical distortion, the model station uses the IP camera combined with a tiny semi-spherical mirror to capture in real-time (low fps for better transfer rates between distant locations) the rough scale model while projected at life-size on the semi-spherical screen - avoiding the *Gulliver* effect (Figure 2).

In order to address the above-mentioned collaborative design studio issues, we networked two HIS. The HIS can receive up to four people for co-located synchronic collaboration under a new metaphor, *the hybrid place*, combining real and digital tools, interactions (acquired skills) and data. The sketch and the immersive real-time video of the model can be shared symmetrically (between two HIS). In this distributed setting, sketch data is relayed to a server that sends the information to the other HIS software while the video is accessed directly from the IP camera. A commercial VoIP made verbal exchanges possible. The two HIS were installed in two universities (Figure 3).[58] This setting engaged remote collaboration issues, such as multidisciplinary work, differences in time zones, language and culture.[59]

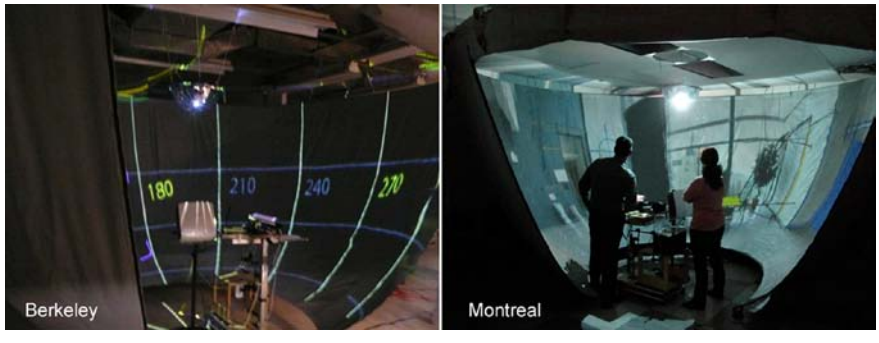

Figure 2 The interconnected HIS, here with part of the spherical screen open

7 Experiment

Two teams of two students, in architecture (Berkeley - team a) and industrial design (Montreal - team b), participated in the ideation of a bus shelter as an ad-hoc project for about 6 hours over 3 days in the following sequence:

– On the first day, after an hour-long introduction and training, the 4 participants launched in a first synchronic ideation of 50 minutes.

al eds, The engineering of mixed reality systems, Springer-Verlag, London, pp 419-445

50 Do, E.Y. (2001). VR Sketchpad. In: Proceedings of the CAAD Futures conference, Eindhoven, pp 161-172

51 Darses, F. et al (2008). ibid

52 Elsen, C. & **Leclercq, P.** (2008). "SketSha" – The sketch power to support collaborative design. In: Luo, Y. ed, CDVE 2008, Springer-Verlag, Berlin, pp 20-27

53 Safin, S. & **Leclercq, P.** (2009). User studies of a sketch-based collaborative distant design solution in industrial context. In: Luo, Y. ed, CDVE 2009, Springer-Verlag, Berlin, pp 117-124

54 Safin, S. et al (2010). ibid

55 Dorta, T. (2007). ibid

56 Dorta, T. et al (2009). ibid

57 Axiotron Modbook™

58 UC Berkeley, School of Architecture and the School of Industrial Design at the Université de Montréal

59 See Dorta, T. (2007). ibid, for the original HIS description

– On the second day, making use of the time difference, before Berkeley woke up, Montreal had a local ideation session, working in the HIS with a rough physical model for 40 minutes (time spent making the model outside the HIS is not accounted here). Then the two Berkeley architects joined them for a remote work session (50 minutes) starting with the presentation of Montreal's three design proposals, interspersed with discussions about relevant supporting concepts (e.g. how snow behaves around a bus shelter), leading to some remote co-design. The Montreal team retired, leaving Berkeley to continue locally for an 80-minute session.
– The last day, both teams worked together at all times. First Berkeley presented their work (60 minutes), and then they co-designed a final concept (75 minutes). Total: roughly 6 hours.
– The teams had to work in a suggested timeframe, which was adapted to make sure they came to a natural stop at the transition times. The CI Loop, CC, and CM were used to code all 6 hours video of recordings that two research assistants coded into 10-second increments, identifying every action and their matching gestures. They reviewed each other's coding to insure the reliability of the results. A 10-second increment allows identifying two or three actions, which gives enough granularity to be meaningful. If an action was longer than 10 seconds (e.g. a particularly long explanation) it was coded again, as long as it lasted, thus showing its importance in time. The CI Loops, CCs and CMs were identified once the video was coded.

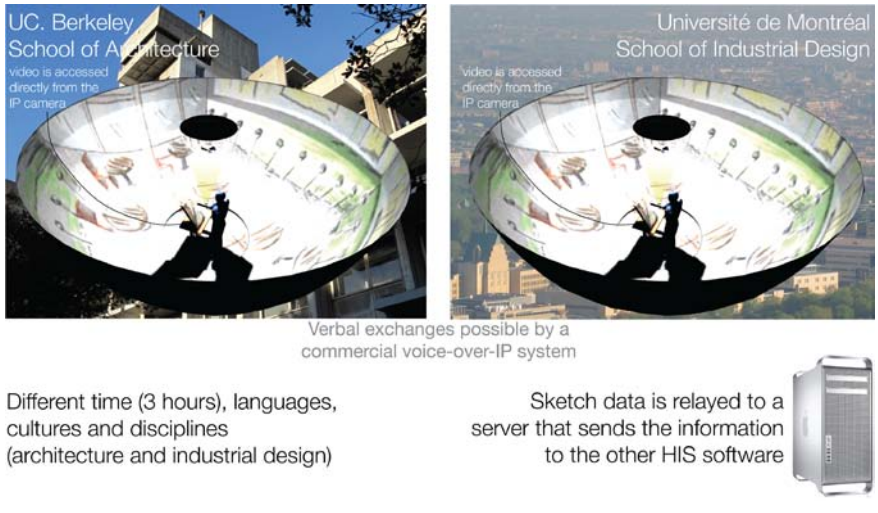

Figure 3 The diagram of the interconnected HIS

8 Results

8.1 CI Loops

We have observed that there are 2 different types of CI Loops, (1 and 2), corresponding to the different lengths of loop observed in a previous study (Dorta et al. 2010). CI Loop 1 (Figure 4) focuses on securing larger design *concepts* (e.g. *let's do a green roof, the bus shelter should be made of modular sections*), which invites wider verbal exchange (more negotiations than moving). CI Loop 2 (Figure 4) focuses on giving *form* to the previously agreed general concepts and is

involved with specific issues that can be resolved in and by the representation (e.g. *should the angle of the roof be that strong? Let's make the structure a little bigger*). These exchanges are usually shorter, having less negotiation and more moving, since they are confined to a specific issue present in the representation. We have also observed that CI Loops (1 and 2) will often come in a sequence as the object of the conversation evolves from being unresolved in the first loops to resolved in the last, giving what we have termed *immature* to *mature* loops. The degree of maturity of a concept does not affect the structure of the CI loop, other than the mature loops may be sealed by vocal agreements from all participants.

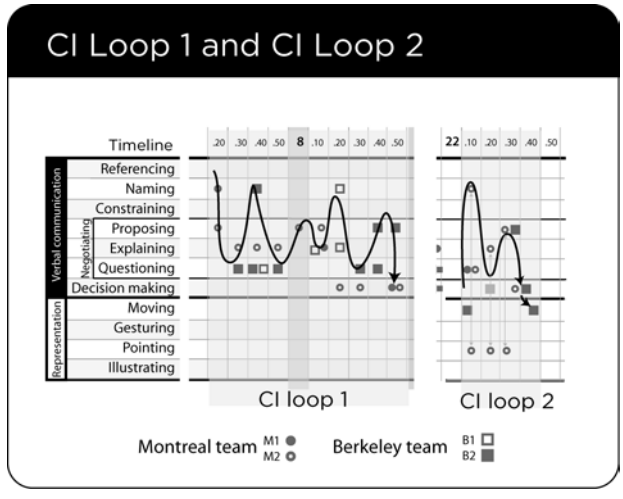

Figure 4 Examples of CI Loops (1 for concepts and 2 for the form)

Verbatim of an example of a *CI Loop 1: Concepts*

(6:03) M1: *We're gonna draw the space* (Explaining, M2 Moving)
(6:08) B1: *We could imagine that the bus stop is actually facing us instead of facing the street, …the other way around so we won't design it from the back* (Naming, Constraining, Explaining)
(6:22) M1: *Yeah* (Decision making); M2: (Moving)
(6:27) B1: *The bus stops somehow…* (6:31) *… So this would be the front side of the bus shelter* (Moving, Explaining, Naming)
(6:42) M1: *So this is the front. Ah okay* (Decision making)
(6:50) M2: *So the bus would stop here* (Proposing, Moving)
(6:53) B1: *Yeah, exactly* (Decision making)
(7:04) M1: [to M2] *…a bit more…just there* (Proposing, Pointing; M2: (Moving)
(7:12) M1: *So the bus would be where we're drawing, right?* (Questioning)
(7:14) B1: *Yeah, let's assume that the bus stop would actually be there* (Decision making, Proposing)
(7:18) M1: *Okay-ok* (Decision making)

Example of the verbatim of a *CI Loop 2: Form*

(21:59) B2 *Is sketching something*
(22:00) M1: *But the ...* (Questioning)
(22:03) M2: *I think it's not necessary to have this wall* (22:10) *above the hole of the door* (Naming, Pointing, Questioning)
(22:17) M2: *Because it's just a hole* (Pointing, Explaining)
(22:20) M2: *The roof could start here* (Pointing, Proposing)
(22: 25) B2: *So you want just a big opening?* (Proposing)
(22: 29) M2: *Yeah* (Decision making)
(22: 32) B2: *Okay* (Decision making, moving)

We have observed that the basic CI Loops structure takes different forms. A CI loop will usually start with a naming unless the object of discussion is implied (using a pronoun) or carried over from the preceding CI Loop, or if, instead of naming it, the participant points to it, substituting a naming for a pointing. Naming and pointing gestures are often paired that way. In a CI Loop, there will be an exchange, meaning at least one (but usually more than one) constraining, proposing, explaining or questioning to which the other participant will respond to by agreeing or disagreeing (a decision making action). Although decision making is a crucial category to the articulation of the CI Loop, it is often the shortest verbal communication, from a nod or a barely audible *yeah*, to a clear articulation of approval. Not all nods and *yeahs* are decision-making actions though; the purpose of some is to nudge the speakers forward in their explanations. A decision-making action is a punctuation that seals the exchange with a (dis)agreement. Moving actions have a particular relationship to the CI Loop; they are non verbal, they often come up in conjunction to a verbal proposal, and sometimes they will act as a *de facto* agreement in CI Loops, replacing the decision-making action (for instance, when a suggestion is silently responded to by an adjustment in the sketch). The final condition defining a CI Loop is that there has to be a moving or a proposing, both being the only two actions directly manipulating the design with words or through representation. If any of these five requirements are missing, it may be a design related conversation, but it is not a CI Loop.

Of all the elements of Design Conversation, the CI Loops have the most recognisable pattern, with its musical scale structure going from naming to negotiations and finishing on decision making and moving, and back up again on the next loop. In this case study, we were also given an opportunity to recognise the shorter CI Loop 2 by sound: two of the participants were Spanish speakers, and a few times they slipped into Spanish for quick conversations. Some of our research assistants not familiar with Spanish realised that in spite of not understanding the content of the conversation, they could recognise the form of the CI Loop 2 through its prosody (i.e. rhythm and intonation), which goes from high-pitch naming/questioning or proposing to a quick negotiation to a low-pitch agreement. The oral dimension of Design Conversations would be an interesting research to pursue, particularly for distant, multicultural CI and for possible automatic recognition.

8.2 Collaborative Conversations (CC)

If only four out five requirements of a CI Loop are met, the exchange was a CC. CCs also have a predictable pattern (Figure 5), but are neither loops (no springing in the argumentation from one pattern to the next), nor do they directly move the design forward. They are either *presentations* of previously agreed design, or *discussions* about concepts indirectly related to the design. They are an unavoidable part of the CI. The two CCs patterns share one key characteristic: they have no moving actions. Presentations are not dialogues, in the sense that there is no negotiation; they have a lot of proposing, as speakers present and explain their proposals, with the listeners stating their agreement punctually after each naming, proposing and possibly explaining sequence. Questioning, if it is to demand clarifications, is part of the CC; but if it questions the presented concept, will

lead to a CI Loop. Discussion about indirectly related topics are dialogues and have much back and forth between explaining and questioning but significantly no proposing nor moving.

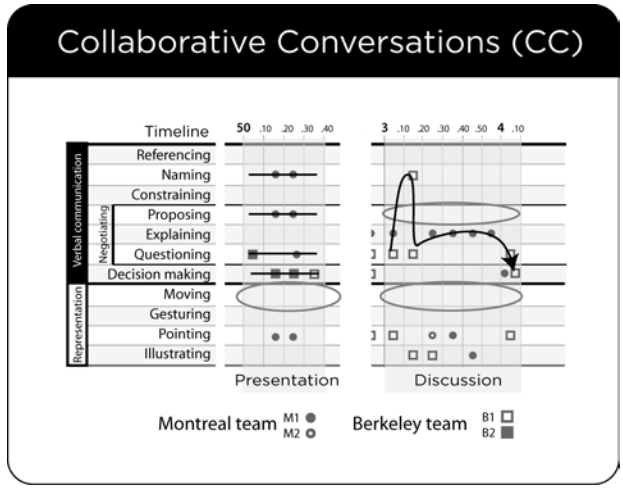

Figure 5 Examples of Collaborative Conversations (Presentation and Discussion)

Verbatim of an example of *CC: Presentation*

(50:03) B2: *The front of the bus shelter: you have closed, semi-closed; what do you want?* (Naming, Questioning);
(50:11) M1: *Like that is fine, no? We have only one opening, here* (Proposal, Pointing);
(50:20) B2: *Uh-hu* (Decision making);
(50:22) *It's all closed, but we have a rotating side* (Proposal, Pointing);
(50:25) B2: *Okay* (Decision making);
(50:29) M1: *Do you think it's enough or you would change something?* (Questioning);
(50:35) B1: *That's … so far so good* (Decision making).

Verbatim of an example of *CC: Discussion*

(2:55) B1: *Yeah, but once it's closed, it means it actually went inside 'till here, at least, right?* (Questioning, Pointing);
(3:02) M1: *Less then that* (Explaining);
(3:05) B1: *It would be like this…* (Questioning, Pointing);
(3:08) M1: *It's kinda like…* (Explaining);
(3:12) B1: *So if this is the ground and you have snow all the way up to here, then I assume that the snow will go at least like this, right?* (Naming, Questioning, Illustrating);
(3:22) M1: *Yeah, well, it would go more like. Here it looks kinda high* (Explaining, Pointing);
(3:32) M1: *I was more thinking about this high* (Proposing, Moving);
(3:40) M1: *Doesn't really matter if it goes a little bit inside, because once blocked, it stays blocked* (Explaining, Illustrating);
(3:52) M1: *And the snow keeps the warmth inside* (Explaining);
(4:00) B1: *Okay, so it's warm inside if it snows, right?* (Questioning, Pointing);
(4:05) M1: *Yup* (Decision making);
(4:07) B1: *Okay then* (Decision making);
(4:08) M1: *Makes sense doesn't it?* (laughter) (Decision making).

8.3 Collaborative Moving (CM)

We have observed CM to occur once the concept has been broadly identified, usually following CI Loops 2. It has a *heartbeat* pattern: a horizontal sequence of continuous moving interrupted by a quick—vertical—conversation (Figure 6).

This kind of conversation accompanies the last stage of ideation before switching to another kind of design tool, which is different from illustrating a concept to better communicate it to a third party. CM occurs while still giving form to a concept for the first time. It is an active moment where a lot of specific design decisions are made and worked out in the representation as it develops. There are mostly moving actions with some questioning, proposing or negotiating. Naming is often replaced by pointing, decision making by moving. CM is the least verbal collaboration where most of the design conversation is done through the representation. As its name states, CM is collaborative. In the HIS, the participants who didn't control the pen, still had full access to the shared immersive representation, therefore they could follow the development of the design and participate by reflecting on it and analysing it in a way that the drawing-participants could not. On its own, an individual reflective conversation with the representation does not constitute a CM.

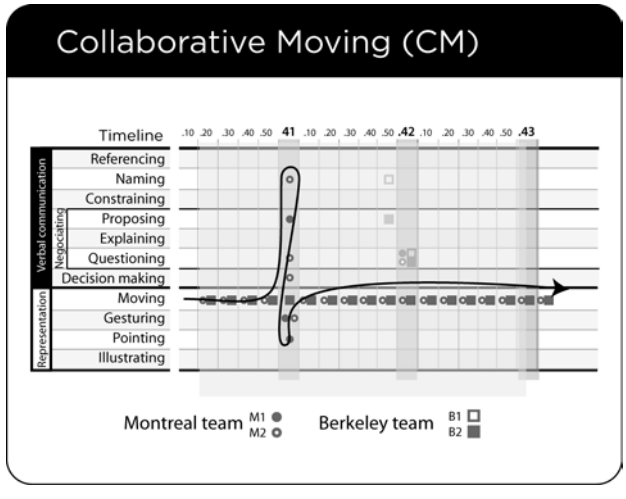

Figure 6 Example of Collaborative Moving

Verbatim of an example of a *CM*

B2 and M2 are sketching the bus shelter's benches simultaneously.
(40:50) M2 to M1: *This seat* (Pointing), *I can't get the curve right…* (Explaining, Gesturing)
(40: 55) M1: *No, no. Make it straight.* (Gesture, Proposing)
(40:58) M2: *Ha. Ok-okay*. (Decision making)
(41:40) B1: *More chairs!... Real chairs!* (Laughs)
(41:47) B2: *They are somewhat just aligned, these chairs, with the bench* [of the bus shelter in the representation]; *we could just be sitting inside…* (More laughs)

8.4 Timeline and length of exchange of Design Conversations

The interconnected HIS has clearly supported collaborative ideation throughout the 6 hours of the protocol, as shown by the Design Conversations recorded from the very beginning until the end of the protocol (Figure 7). The timeline shows the different Design Conversations evolving from one another to form three cycles of ideation over the 6 hours. In the first cycle, the Design Conversations went from mostly CI Loops 1 to CI Loops 2, with only a few instances of CCs/discussion; no CMs. The second cycle started on a large number of CCs/presentations then moved through CI Loops 1 and 2 as well as some CMs.

The last cycle had a progression of CCs—presentation and discussions—CI Loops 1 and 2, and the most CMs. As the project progressed from one cycle to the next, the amount of CMs got increasingly larger, which may be a sign that a resolution was reached.

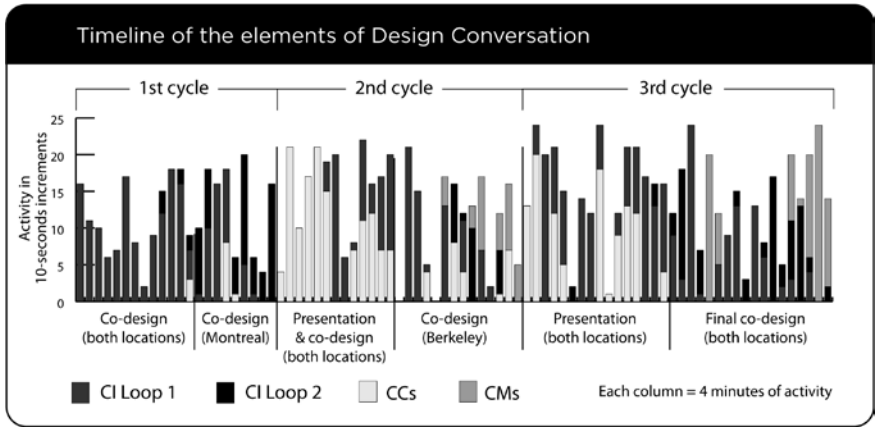

Figure 7 Timeline of the elements of Design Conversation

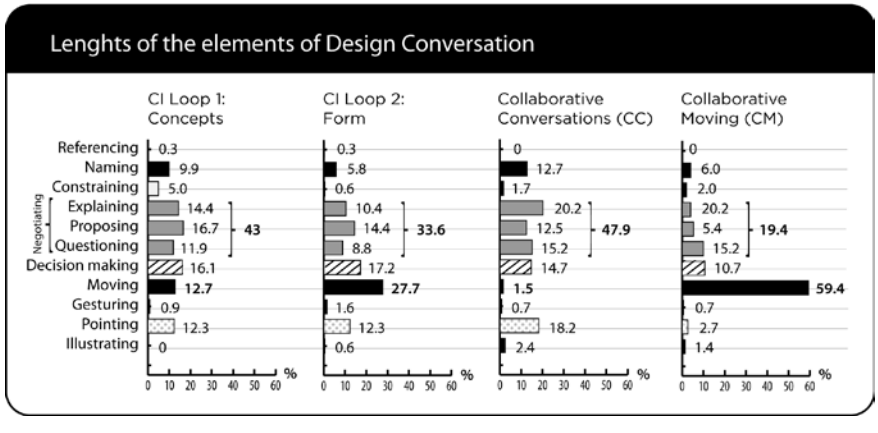

Figure 8 Length of elements of Design Conversation

In CI Loop 1, 43% of the time was spent negotiating (proposing, explaining and questioning), and 12.7% moving (Figure 8). The CI loop 1 were in average 68 seconds, which is longer than the CI Loop 2 averaging 24 seconds. In CI Loop 2, we have observed that the time spent in the negotiation triad was 33.6% versus 27.7% moving. This is close to one to one negotiating to moving, compared to CI Loop 1, where there were over three negotiations for one moving. The CCs (discussion and presentation together) held the most explaining and questioning of all, spending 47.9% in negotiation and only 1.5% moving. In CCs, presenting differed from discussing in that a lot of design proposals were stated when presenting and nearly none were when discussing a concept. In CMs, 19.4% of the time was spent negotiating and 59.4% moving. The verbal exchange (naming, constraining, negotiating and agreeing) averaged of 26 seconds, which is comparable to a CI Loop 2, followed by an average of 58 seconds of moving (roughly one negotiating action for two moving).

9 Conclusion

As fundamentals of the Design Conversation, the recognisable patterns of CI Loops, CCs and CMs should make it easier to harness and evaluate design discourse in CI, a key part that leaves no trace of itself, driving and shaping the CI process as it slips through it, like water through fingers. They are the basis of a methodological framework with which to understand CI activities, and as such they point to needs that should be supported by CI tools. In this study, the CI tool used, the HIS, was apparently able to properly support all stages of the CI process: the qualitative and ambiguous visual representations driven by verbalisations at the beginning (where there is more talking than moving in CI Loop 1) and the levelling of verbalisation and moving actions (CI Loop 2). Then, when the concept was broadly identified, the HIS kept supporting the shaping of a specific form as moving actions drove the CI process forward (CMs). In the HIS, CMs were truly collaborative because the shared immersive representation allowed a shared reflective conversation by all participants simultaneously. Collaboration at this stage should not be overlooked in spite of the conversation being less verbal. This study brought to the fore that a CI tool has to offer well integrated attributes that can evenly support two or more people in verbally driven (at first) and representation-driven CI (shortly after) while supporting their simultaneous collective reflective conversations throughout this process. Compared to Minsky's framing, the elements of Design Conversation show the collaborative exchanges in more detail, although there is a general correspondence between CI loop 1 and the high design descriptive frames, addressing problem and contexts, and CI loop 2 and the depicting frames repeating instructions and creating scenarios from the design brief.[60] The difference is that our framework takes negotiation into account. Considering that design problems are ill defined,[61] it is essential to consider negotiation to assess the *complexity* of the CI process, since it is the crucible through which design problems get redefined. Yet by applying to ideation the current parametric design paradigm, omnipresent in CAAD and CI solutions, the parameters of the solution are set before the problem has been redefined. As Csikszentmihalyi aptly put it, the unique property of creativity is problem finding, not problem solving.[62] Consequently, we feel the elements of Design Conversation can act as CI fundamentals, since they are able to capture the ideation process, from problem finding to problem solving.

60 Kvan, T. & **Gao, S.** (2004). ibid

61 Rittel, H. & **Webber, M.M.** (1973). Dilemmas in a general theory of planning. Policy Sciences. 4:2, pp.155-169

62 Csikszentmihalyi, M. (1988). Motivation and creativity: Toward a synthesis of structural and energistic approaches to cognition, New Ideas in Psychology, 6:2, pp 159-176

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