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► To cite this version:

Lucas Bietti, Michael M Baker. Collaborative remembering at work. *Interaction Studies*, 2018, 19 (3), pp.459-486. 10.1075/is.17010.bie . hal-02170993

HAL Id: hal-02170993

<https://telecom-paris.hal.science/hal-02170993>

Submitted on 5 Dec 2023

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PRE-PRINT version, before final corrections, of:

Bietti, L.M. & Baker, M.J. (2019). Collaborative Remembering at Work. *Interaction Studies: Social Behaviour and Communication in Biological and Artificial Systems*, 19(3), 460-488.
<https://doi.org/10.1075/is.17010.bie> • [\(hal-02170993\)](#)

Collaborative Remembering at Work

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Abstract

Collaborative remembering is essential to enabling teams to build shared understanding of projects and their progress. How are collaborative remembering processes situated in the broader work context, in terms of the nature of the work to be carried out, social roles, multimodal interactions, use of shared artifacts and project timescales? This article presents an analysis of collaborative remembering sequences in a corpus of interactions collected in a workplace where a team of designers developed a video television commercial. On the basis of coding and analyzing linguistic and bodily behaviors in 158 such sequences, extracted from over 45 hours of video recordings, recurrent patterns of multimodal collaborative remembering processes were identified, relating to the co-design task and the interplay of social roles. Collaborative remembering emerges as a process of co-creating and condensing in the present not only a joint understanding of a shared past, but also of a projected future.

Keywords: Collaborative design; Collaborative remembering sequence; Multimodal interaction; Design studio; Time scales; Temporal patterns

1. Introduction

Remembering in the real world often occurs in situated interactions embedded in social and material environments. At the workplace this tends to be the rule rather than the exception. We remember information about work activities while interacting with various types of artefacts, from desktop computers and laptops, to notes, diagrams and sketches drawn quickly on-the-fly in post-its, notebooks, etc. In addition, we also remember in collaboration with co-workers in meetings, informal conversations, etc., including with respect to our previous collaborations. Remembering at work is ubiquitous, highly situated and driven by a history of interactions. After being part of particular social and material environments for a period of time, we already know where to look to find the information we cannot recall or whom to ask at our workplace. In other words, remembering in the workplace is based on routines and patterns, which after a while become second nature to us. Thus, remembering at the workplace becomes action, relying on interactions with artefacts and other people. The type of interactions in which collaboration in remembering occurs, in co-located workspaces, are multimodal and involve the coordination of social, cognitive, bodily and material resources over time (Bietti & Sutton, 2015a). This is not exclusive to collaborative remembering, as it also occurs in other kinds of joint activities, from joint problem-solving to group decision-making. Collaborative remembering means recalling together shared and distributed past experiences. Our study deals with how this takes place in a specific work environment: the design studio.

The goals of this study are: i) to discover recurrent patterns of multimodal collaborative remembering processes during collaborative design in the design studio; ii) to determine how these patterns, occurring over a micro time-scale, are related to social roles and hierarchies at the workplace; and iii) to demonstrate how collaborative remembering is an emerging collaborative and complex activity in the design studio that encapsulates in the present both a shared past and a projected future.

The processes of collaborative design that we study here in the Design Studio are temporally distributed activities, with new phases of projects being built upon previous ones (e.g. Détienne, Baker & Burkhardt, 2012; Wiltchnig, Christensen & Ball, 2013). This means that at almost any point in the co-design process, it will be necessary to successfully recall relevant aspects of previous phases of the project.

Consensus, for example with respect to the planning of future tasks, often relies on joint remembering of previous co-design work and project milestones. Co-design relies on the designers' interactive reflection on the design in real time, by going backwards and forwards during the design process. By doing so, designers can collaborate and reach consensus on successive design project phases. Such consensus is crucial when elaborating solutions and constructing common ground by design teams (Détienne 2006; Détienne, Baker & Burkhardt 2012; Hébert 2012).

Co-design involves contextualized interaction within culturally and historically organized material and social environments. Even when external memory devices are available for recording and representing co-design decisions and their rationales (e.g. Vyas, van der Veer & Nijholt, 2013), the fact that these representations are necessarily selective means that they can not anticipate all that might be relevant in future contexts of their use. In that case, designers working in teams will sometimes need to reconstruct the contextual meaning of previous states of the project — whether external representations are available or not — in on-the-fly situated

interactions with other team members (Bietti & Sutton, 2015b; Bietti, Baker & Détienne, 2015). Thus, a deeper understanding of how and when collaborative remembering occurs within the interactive unfolding of co-design projects is of theoretical and practical importance.

Remembering with other people involves re-evoking a shared or partially shared past, distributed amongst interacting partners (Hirst & Echterhoff, 2012; Sutton et al. 2010). Such re-evoking of past experiences involves the human capacity for mental ‘time travel’, the “faculty that allows humans to mentally project themselves backwards in time to re-live stages of their lives, or forward, to pre-live events” (Suddendorf & Corballis, 2007, p. 299).

Remembering with other people involves people engaged in recalling past experiences, which may themselves have been shared. Sometimes people experienced the same events as a group (e.g. a couple saw movie X at theatre Y on date Z), sometimes they experienced the same event separately (the partners saw the same movie but at different locations and times). So the information re-evoked during collaborative remembering can be the result of either shared or individual encodings of the same or a similar original event (e.g Harris, Barnier, & Sutton, 2013). In addition, collaborative remembering is a powerful trust-based mode for promoting cultural learning and cooperation among in-group members (Wheeler, Allan, Tsivilis, Martin, & Gabbert, 2013) and enables the formation and maintenance of mnemonic communities which are the basis for the emergence, formation and transmission of collective memories (Wertsch, 2002).

In the next section we review relevant literature on collaborative remembering in real-world environments. We then focus on the importance of collaborative remembering in collaborative design. Afterwards, we present the case study we analyzed to gain this insight: a team of professional designers working on a commercial for Russian television. We explain the key role that questions have in the formation of collaborative remembering sequences (CRSs), propose a distinction between instances of collaborative remembering and

collaboration in collaborative remembering, relating these two different types of CRSs to multiple but complementary timescales over the duration of the design project. In the analysis section, we examine the temporal structure of CRSs by means of a detailed analysis of temporal patterns. Finally, we present a qualitative microanalysis of two illustrative examples taken from the most complex and longest behavioral patterns during CRSs, and relate these patterns to the functions of CRSs and the time scales of collaborative remembering. In conclusion, we discuss the main results, the limitations of the study and give pointers towards further work.

1.1 Collaborative remembering as distributed activity in the real world

Several disciplinary traditions have examined how people remember together from naturalistic perspectives in their everyday lives, that is, in the social and material contexts in which they live. These studies demonstrate that remembering in real-life settings needs to be thought of more as a situated activity or resource in order to achieve specific goals, rather than as an instantiation of a storage device or archive located in people's brains (Manier 2004).

Over the last thirty years, discursive psychologists (e.g. Brown & Reavey, 2015; Buchanan & Middleton, 1995; Edwards & Middleton, 1986; Middleton & Edwards, 1990) have employed audio recordings and transcriptions of naturalistic social interactions (e.g. reminiscence groups in residential homes and day-care centres, and teamwork in intensive care units) to understand and explain how people remember in conversation in everyday social and material contexts.

Although the analyses of discursive psychologists have been tied to the verbal transcriptions of conversations about past experiences, they have nevertheless provided important insight into how the body shapes joint remembering (Middleton & Brown, 2005; Brown & Reavey, 2015). Middleton and Brown (2005) claim that in many situations (e.g. commemoration and rituals) the body can be used "as the locus around which remembering is performed" (p. 132).

Within the framework of distributed cognition in cognitive science (Hollan, Hutchins & Kirsh, 2000; Hutchins, 1995a), Hutchins (1995b) analysed collaborative memory activities in airline flight operations. His analysis was based on video and audio recordings in the cockpit environment. The results of these studies showed that in the cockpit “the memory process emerges from the pilots’ activity” (Hutchins, 1995b p. 286). This suggests that ‘the memory of the cockpit’, for example as the pilots took in the aircraft’s speed before landing, does not merely rely on the pilots’ memories but also on continuous “interanimations” between those memories and external resources, such as landing data card or the airspeed indicator. As a result, Hutchins claimed that “a complete theory of individual human memory would not be sufficient to understand what we wish to understand because so much of the memory function takes place outside the individual” (Hutchins, 1995b p. 286). Hutchins’ multimodal analyses of memory collaboration in the cockpit represented one of the first attempts to explore the multimodal and cognitive dimensions of joint remembering in real-world settings. The use of video recordings and artefact analysis to describe how memory collaboration occurs in real-world environments has also been an approach employed by computer scientists working in the field of Human Computer Interaction (HCI) (e.g. O’Hara et al. 2012; Wu et al. 2008). Wu and colleagues investigated the cognitive strategies that families create and use in order to struggle with amnesia in real-world activities. This study involved the recruitment of ten families, some of whose members had severe memory problems, and explored the communicative strategies used to compensate for the memory impairment of one of their members, including the use of technological devices (e.g. calendars, personal digital assistants (PDAs) and journals) as well as discursive practices. The investigation showed how, by means of “distributed cognitive processes across participants and technological devices, families may work as cognitive systems coping with amnesia” (Wu et al., 2008, p. 833).

Investigations of joint remembering in discursive psychology (e.g. Middleton & Brown, 2005), distributed cognition research (e.g. Hutchins, 1995a) and HCI (Wu et al., 2008) reflect how and why people use memories in their daily lives. These represent clear examples of the use of an ecologically valid method for collecting data for memory research.

These approaches were based on the view that reminiscing is an embodied and situated practice that forms part of real world activities. Our study goes further than work previously carried out on the distributed nature of collaborative remembering by accounting for the regularities and temporal patterns amongst participants' roles, team goals, verbal and non-verbal resources, and the material environment during memory collaboration in the design studio.

1.2. Embodied collaboration in collaborative remembering: the case of collaborative design

To our knowledge, little or no research on collaborative memory (e.g. Rajaram & Pereira-Pasarin, 2010) has focused on the multimodal and embodied group aspects of collaborative remembering in teams working in organizations, although some such research has been conducted on couples and dyads (Hollingshead, 1998). For example, Hollingshead (1998) showed that intimate couples in a face-to-face condition scored better in transactive memory tasks than intimate couples interacting through a computer system (Hollingshead, 1998). This result was associated with the fact of having access to the nonverbal resources of each of the interacting partners during the memory recall task (Hollingshead, 1998). Such nonverbal resources are available to the participants studied here, who were engaged in face-to-face collaborative design in the workplace. Given that human cognitive activity is linked to high-level cognitive processes by way of embodied interaction with culturally organized material and in the social world (Hutchins, 2010, p. 712), a detailed description of these embodied interactions during collaborative remembering is required (Bietti, 2015).

During collaborative remembering, deictic gesturing (e.g. hand-pointing) allows speakers to establish the focus of visual attention on sources of relevant information, thereby externally grounding their individual and shared memories (Cienki, Bietti & Kok, 2014). Thus, representational gestures, on the other hand, may be deployed for aiding autobiographical memory retrieval but can also be used communicatively, to evoke a shared conception of a particular feature of an event among interlocutors (Bietti, 2015). Gaze coordination can be deployed to regulate the distribution of interactional turns, for instance, in order to reinforce the accountability of the recipient to respond to a question acting as a reminder or to go on with the description of the events being collaboratively recalled (Bietti & Galiana-Castelló, 2013; Cienki et al. 2014; Goodwin, 1987). Looking away from the interactional participants, furthermore, has been associated with individual semantic retrieval, as well as display of uncertainty (Goodwin, 1987).

Recent studies have extended conversational and interactional approaches to co-design (Kelly & Matthews, 2014; Luck & McDonnell, 2006) by including analyses of the roles played by manual gesture in these creative and collaborative processes in teams (e.g. Luck, 2009). Following the distinction between topic and interactive gestures (Bavelas, Chovil, Lawrie & Wade, 1992), Visser and Maher (2011) found that these specific kinds of manual gestures played different roles in architectural design meetings. The study reported that in those particular working environments, topic gestures (i.e. gestures associated with the semantic content of the speech they go with, Bavelas et al. 1992, p. 473) were used to describe and specify the attributes of the artifacts being designed, their spatial qualities and how they should be employed by potential users (Visser & Maher, 2011, p. 94). On the other hand, the results of this study suggest that interactive gestures (i.e. gestures that refer to some aspect of the process of conversing with another person, Bavelas et al., 1992, p. 473) were associated with

the organization of the group interaction amongst architects. However, these studies have not studied the role of manual gesturing during memory collaboration in collaborative design.

2. The Design Studio study

For a period of five working days, we recorded the activities of a group of graphic and animation designers whilst they developed a commercial video for Russian television. The setting for this real-world study was an animation and video production studio located in Barcelona, Spain. The stakeholders involved in the making of the commercial were the Russian subsidiary of an American multinational food manufacturing company (client), the Russian branch of a major international advertisement company, a Moscow-based film production studio and a Barcelona-based animation and production studio, which was where we conducted our fieldwork in February 2014. The overall production of the commercial lasted from late December 2013 to mid March 2014 (12 March), when it was delivered to the Russian TV channels. The production of the commercial included shooting with real actors in Moscow and the design of animated characters in 3D.

During our fieldwork in Barcelona (11–15 February 2014), the people based at the film production studio in Moscow worked on the music and voice-over (VO) aspects of the commercial (e.g. music presentation and revisions, VO text and artists and approval by the agency and client), whereas the team of 3D designers in Barcelona worked on the composition and rendering of the animated characters and actions (see Figure 1). The specific working week that was studied (Monday to Friday) included several milestones for production of the commercial. On Tuesday, 11 February 2014, the Barcelona-based team had to present the first version of the commercial to the Moscow-based team. The same day, the Moscow-based team sent the first version of the commercial to the advertising agency and client, who responded with some feedback on revisions the following day (Wednesday, 12

February). The next day (Thursday 13), the project leader from Moscow-based agency and leaders of the design project at the video design studio in Barcelona had a meeting via Skype™ in which they discussed the further revisions to be made. The production of the commercial included shooting with real actors and the design of animated characters in 3D.

The team who worked on the commercial comprised four professional designers (see Table 1 for their profiles). Designers A, B, D and M were involved in production of the commercial from the beginning of the project in late December 2014. As M did not speak Spanish, English was the language of interaction when he was present.

Table 1: Description of designers' profiles.

Designers	Specialization	Years of experience	Role in the project	Languages used at work	Work situation
A	Animation and live-action director	<15 Large experience in the field (direction of commercials for major interactional companies in the automobile, telecommunications and foods sectors, major European airlines and Spanish banks)	Leader Responsible for directing shooting with real actors in Moscow in late January 2014	Spanish (native) English (fluent)	Freelancer
B	Animation designer and project manager	9	Project manager	Catalan (native) Spanish (native) English (fluent)	Stable position at the design studio

D	Animation designer	7	Operational designer	Spanish (native) English (fluent)	Freelancer
M	Animation designer	<4	Operational designer	English (fluent)	Freelancer

During the working week we spent at the video design studio, we collected 45+ hours of video and audio recordings. Our recordings (see Figure 3) were made with six static (fixed) cameras (4 GoPro HERO 3+ Black, 1 Canon VIXIA HF S21, and 1 Drift HD Ghost), as well as with one head-mounted wearable video camera (Looxie LX2). Because of his leading role, we anticipated that team member “A” would be involved in more interactional sequences in comparison with the other three members of the team. Hence, we asked him to wear the head-mounted video camera. In addition to this video data-set, we were given copies of documents (e.g. production timing and storyboard) that were used to coordinate efforts amongst the different stakeholders involved in the development of the commercial.

2.1. Collaborative Remembering Sequences: How designers remember in the design studio

It is quite unlikely to find real-world collaborative activities in which participants are engaged exclusively in reconstructing memories of individual and/or shared experiences – unless we were analyzing reminiscence groups, for example. That is, even in cases of shared remembering around the dinner table, the main aspect of the collaborative activity of having lunch or dinner together is not collaboration in remembering, but rather — apart from sharing a meal of course — social bonding. Although joint remembering is crucial for social bonding at the dinner table, it does not rely exclusively on it. A complex collaborative activity such as collaborative design in the design studio is not an exception to this rule. In collaborative design, joint remembering

is not merely a species of joint action for retrieving information about previous phases of work project, but also a future-oriented joint activity, during which decisions are made that have an impact on the entire work process (Bietti & Baker, in press; Bietti & Baker, 2016, Bietti, Baker & Détienne, 2015).

Collaborative remembering of previous design work is a goal-oriented and localized phenomenon within interactional sequences among professional designers. Hence, we had to develop a way to single out those interactional sequences in which joint remembering during collaborative design occurs, and to describe their functions with respect to the ongoing collective activity. One way in which joint remembering is initiated in the collaborative design process is by means of the use of questions, acting as reminders (Bietti, Baker & Détienne, 2015). Reminders are often realized by questions aimed at seeking information from someone who is assumed to know about events that occurred in the past. The use of questions as reminders, such as “Do you remember when. . .?” brings a shared past into the present, in relation to a specific goal (e.g. remembering deadlines in design meetings). We defined these specific types of interactional sequences as *collaborative remembering sequences (CRSs)*. The key point here is that, as situated in the long-term co-design project, such multimodal remembering sequences enable designers to achieve different goals in interaction, from recalling why previous design decision have been made, and thus reaching common ground, to requesting clarifications and information about deadlines in order to make decisions on the fly and plan future actions. Of course, joint remembering can occur without being triggered by explicit questioning; our methodological choice here, in this naturalistic research, is nevertheless to identify clear examples of joint remembering with respect to questions.

We define a collaborative remembering sequence as: *a multimodal unit of collaborative remembering triggered by the compliance with cooperative rules to respond with information*

relating to the past, in relation to the semantic content of questions. The end of a collaborative remembering sequence (CRS) is marked by either an acknowledgement or a change in topic.

CRSs build on the notion of adjacency pairs in Conversation Analysis (e.g. Sacks & Schegloff 1973; Sacks, Schegloff & Jefferson, 1974; Schegloff, 2007), that is, units of conversation composed of two turns or ‘pair types’ (in the present case: Question => Answer); each pair type has to come from a different speaker (A and B), be placed adjacently (1. A: Question => 2. B: Answer) unless separated by an insertion sequence (1. A: Question => (2. B: Request for clarification => 3. A: Answer [turns 2B3A is the insertion sequence]) => 4. B: Answer) and the second pair type is identified as functionally related and relevant (Hutchby & Wooffitt, 2008) to the first pair type (e.g. A: “When do we have to deliver this?” B: “On Friday”). That is, questions acting as reminders (first pair type) impose special constraints on answers (second pair part). In engaging in such sequences, interacting partners impose constraints on one another, and hold each another accountable, to produce coherent and intelligible courses of action in relation to a relevant past’s actions and events.

Besides Question-Answer, other types of adjacency pairs occurring in the corpus included: ‘greeting-greeting’; ‘invitation-acceptance/decline’; and ‘complaint/denial’. In CRSs, the speaker who produces the first pair type (question acting as reminder) assumes that the recipient(s) possess(es) the information/knowledge requested. Thus, as with adjacency pairs in general, CRSs are *recipient-designed* and oriented towards particular interacting partners. Adjacency pairs structuring CRSs may have multiple second pair parts, therefore preference is given to the most relevant answer (Pomerantz, 1984) which is then followed either by an acknowledgement from the partner who has initiated the sequence and/or a change in the topic of conversation.

We did not consider for our study the type of interactional sequences which were associated to other-repair mechanisms in conversation (e.g. Jefferson and Sacks, 1977; Schegloff, 1992).

Interacting partners often use other-repair mechanisms in conversation to solve cases of miscommunication. The difference between self and other-repair mechanisms lies in the fact that in the former the speaker realizes that there might be a problem in understanding and reformulates the previous utterance (1. A: Have you finished with the simulation? (1 sec) I mean, the simulation for shot four?; 2. B: Yes, I have just sent it to you). In this example speaker A introduces a self-repair (“I mean”) and in so doing reformulates her previous utterance in order to avoid the listener having trouble in understanding. Whereas in the latter, the recipient is the interacting partner who signals his problem in understanding (1. A: Have you finished the simulation?; 2. B: *For shot four?* 3. A: Yeah, shot four; 4. B: Yeah, I have just sent it to you). B’s other-repair mechanism in turn two leads A to clarify which shot he was referring to. Although this example represents a valid case of grounding in conversation (Clark & Schaefer, 1989; Clark & Brennan, 1991), which is crucial for the updating of common ground between A and B, it does not represent a CRS for our research purposes. Its object of remembering is a previous turn within the same conversation and not the design process, such as the structure of the commercial, order of the shots and actions and project deadlines.

2.2. Questions as initiators of CRSs

The selection of questions acting as initiators of CRS at different timescales was based on the coding scheme for question-response sequences in conversation that was developed by Stivers & Enfield (2010). Their coding scheme is empirically grounded in a comparative project on question-response sequences in ordinary conversation in 10 languages (Stivers, Enfield & Levinson, 2010). The data that we collected at the design studio was in English and Spanish, since the native language of three of the four designers involved in the project was Spanish. Despite that Spanish was not one of ten languages covered by comparative project on questions-

response in ordinary conversation, their basic differentiation between *Polar Questions*, *Content (Q-) Questions*, and *Alternative Questions* is in line with what has been proposed for Spanish from semantic and pragmatic perspectives (e.g. Escandell-Vidal, 1999). From this coding scheme (Stivers & Enfield, 2010), the basic distinction was retained between *Content (Q-word) Questions* (e.g. What have we done with the last animation?), *Polar Questions* (e.g., Do you remember where we saved the simulation?), and *Alternative Questions* (e.g., Was shot two about the kitchen or the flying cookie?).

2.3 Collaborative remembering vs. collaboration in (collaborative) remembering

In our study, CRSs may take two forms, either as cases of collaborative remembering or of collaborating in (collaborative remembering) – see Figure 1. In collaborative remembering, interacting partners collaborate to recall an event that they have learned of in the past by means of collaborative turn sequences between the partner who asks the question triggering the formation of a CRS and his /her addressee(s). In collaborative remembering, the persons who are doing the remembering are the same as those involved in the previous events that are remembered. For example, this is often the case between two designers, who worked together to finish a shot for the commercial video. In collaboration in (collaborative) remembering, however, one or more partners behave(s) as social and external resources to provide a scaffold for the other partner's (or partners') remembering process. In other terms, a participants collaborates in enabling others to remember together their shared past experience. For example, this is often the case when the manager collaborates in the collaborative remembering of a pair of designers who had worked together. However, in this kind of CRS, the interacting partner who asks the question initiating the sequence does not participate in the remembering process, which can either be individual or collaborative, that is, also governed by collaborative turn sequences. In collaborative turn sequences, interlocutors collaboratively and cooperatively co-construct utterances in conversation (Ford, Fox, & Thompson, 2002;

Lerner, 2004; Sacks et al., 1974). This phenomenon may occur by simply repeating and reusing each others' lexical items and syntactic structures and/or latching onto the other person's turn and completing it without pausing. The collaborative turn sequences are cases in which “not only a collaboration of two speakers produces a single syntactic unit [. . .] but also in which the first speaker ratifies its completion after its occurrence” (Lerner, 2004, pp. 229-230). In the next section we present one example of each type of CRS.

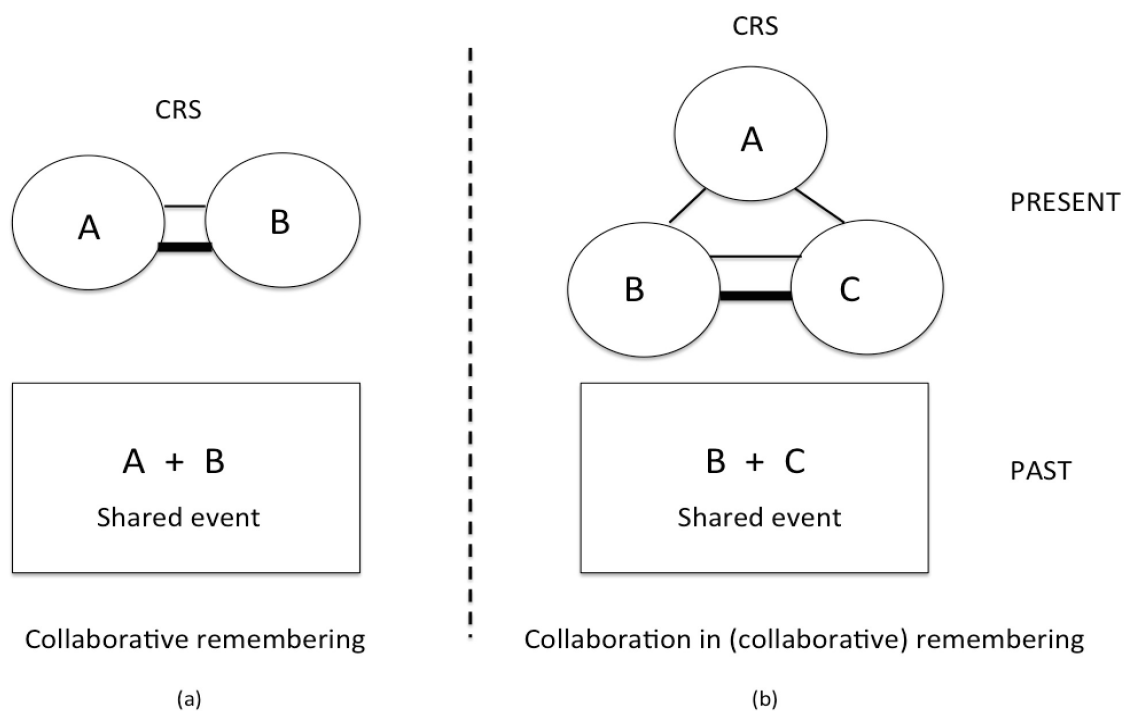


Figure 1: In collaborative remembering (a) designers A and B went through shared events (represented by the thick line), and through multimodal interaction (thin line), through which they are both able to reconstruct the shared event in the present. In collaboration in (collaborative) remembering (b) B and C went through the shared event and because of their interaction with A they are able to reconstruct and communicate that event to A.

2.3.1 Collaborative remembering

The CRS that follows (Figure 2) illustrates how designers rely on external resources to jointly remember information about the projects they are working on. In this CRS, designers are collaboratively recalling one of the project deadlines set in the production timing once the

project was approved in late December 2013.

[00:04.50]
 1. A: When do we have to deliver this? Because I saw Friday=
 [00:06.92]
 2. B: =Friday is the actual date (.) but this=
 [00:10.14]
 3. A: = This Fri[day
 [00:10.73]
 4. B: [Saturday in the actual date
 [00:11.88]
 5. A: What is 24th, 23rd?
 [00:14.60] **** (pic a)
 6. B: The 23rd is the actual date but 22nd is a Friday
 [00:17.18]
 7. A: Alright, perfect=
 **** (b)
 [00:19:42]
 8. B: =Yes
 [00:20.03]
 9. A: Okey, we are delivering this on Friday.
 ***** (c)

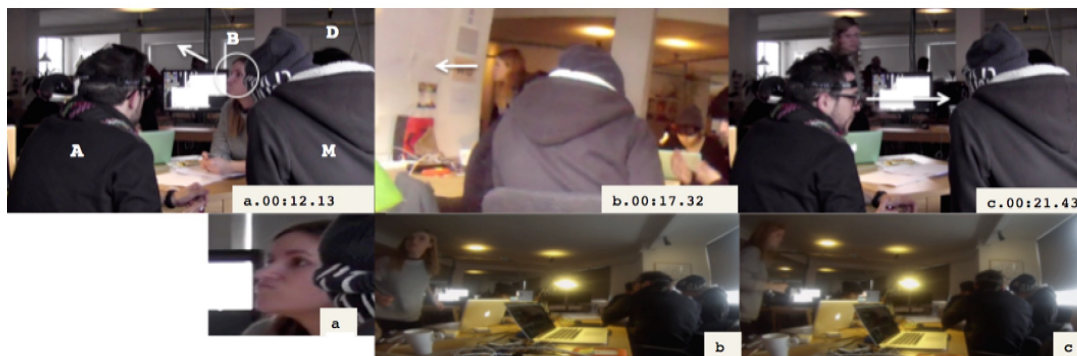


Figure 2: Example of collaborative remembering in CRSs

In line 1 of the example interaction sequence shown above, we observe how A asks B for relevant information about the deadline that they had to meet with the agency supervising the making of the commercial in Moscow ('When do we have to deliver this?'). A's content-Q-word question acted as a reminder in the interaction and triggered the formation of the CRS. In B's response, we note that after a short silence, she introduced the disclaimer 'but' in order to suggest a contrast that is unexpected in the light of the first clause (line 2). A's turn (line 3, Figure 5) repeated some of the lexical items used by A in the previous turn (line 2, Figure 5) but in the middle of A's utterance of the word 'Friday', overlapping talk from B began. B

added new information regarding the actual deadline, which contradicted what she had just suggested (line 4, Figure 5). In the next turn, A asked for a clarification (line 5, Figure 5), focusing on the specific dates rather than the days of the weeks. B's changing gaze direction, towards the wall where a calendar was hung (Figure 5, pic b), was temporally synchronized with her facial expression showing hesitation (b). Due to the small size font used for annotations on the calendar, B stood up almost immediately and walked towards the wall in order to get a closer look at the calendar (line 6). Participant A visually tracked B's movements to some extent by partially rotating his head without changing body position. As soon as B checked that the 23rd was actually Friday, she confirmed it to A (lines 6–8). Meanwhile, A shifted his head orientation towards the other two members of the team and informed them that their deadline was Friday (line 9). This example has shown how A (as initiator of the CRS) and B (as primary addressee), collaborated to construct a shared account of the past. Such collaboration relied on the orchestration of multiple linguistic, social, technological and cognitive resources. This was crucial for the accomplishment of the designers' goal, which in this case was to remember when they had to submit the complete commercial to the production company based in Moscow.

2.3.2 Collaboration in (collaborative) remembering

In this CRS (see Figure 6), designers B, D and M were interacting in order to remember and ground the order of the shots and their main actions. The CRS is about how the team of designers had to recall previous work in order to achieve common ground (actions and events of each shot). The sequence thus comprises grounding of the shot that is being talked about.

[00:00.16]
 1. M: There is one two what's shot three? Is that when he falls off the
 ***** (pic a) ***** (b)
 2. (inaudible) or he falls off the (inaudible) in shot three?
 [00:06.17]
 3. D: In shot two he fa[lls
 ***** (c) and (d)
 [00:07.21]
 4. B: [in shot three
 5. D: In shot three it's on the on the air
 ***** (e) ***** (f)
 [00:11.22]
 6. M: Okay, so three and four are essentially the same.

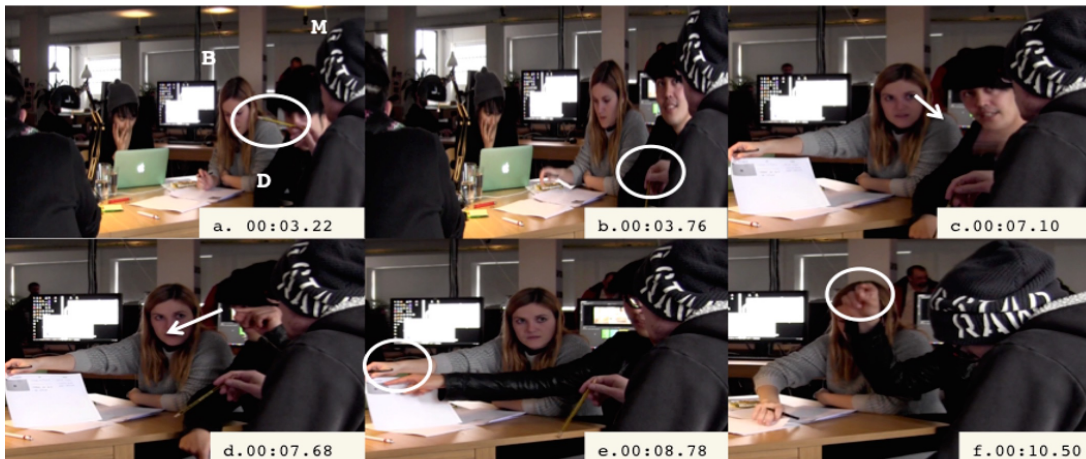


Figure 3: Example of collaboration in (collaborative) remembering

The CRS was composed of only one adjacency pair whose first-pair part was an alternative question made by M. M seemed to have forgotten what actions corresponded to shots two or three of the commercial, despite the fact he was given a copy of the storyboard at the beginning of the project. The answer to M's question came from D and B in the form of a co-constructed collaborative utterance (L. 3-5). The end of the sequence was marked by an acknowledgment by which D and M made explicit the common ground achieved during the CRS. CRS was triggered by the two questions also made by M asking for information about the sequential order of the actions and events in shot three (lines 1-2). In the CRS, environmentally-coupled gestures (Goodwin, 2007) with the storyboard created a common point of reference for collaboratively remembering the actions of the animated characters in shots two and three. Changes in gaze direction and pointing gestures towards the written descriptions enabled expert designers to create a shared focus of attention. This allowed B and D to help M in his search for relevant information about the order of the shots in the commercial. Interacting to remember

the sequential order of the actions and events in shots two and three fostered the reinforcement of common ground about the overall structure of the commercial. Achieving common ground about what each shot was, is and should be about plays an important role as a way of reinforcing shared knowledge about the design process that can be taken for granted later on; thus, designers do not need to waste cognitive resources to bring that information back again.

2.4 Timescales of CRSs in the design studio

Collaborative remembering in the design studio is a complex phenomenon unfolding over shorter and longer timescales, from seconds, and minutes to days, weeks and months depending on the duration of design project. Thus, it is important to take into consideration the multiple timescales that CRSs bring into the present in order to achieve current design goals. These timescales are not only linked with how far in the past the topics of the CRSs are, but also with the type of collaborative activity in which the designers are engaged. Despite the fact CRSs occur in the here and now, their topics may refer to different temporalities or time-scales throughout collaborative work. The topics that CRSs relate to in collaborative design do concern the same temporalities throughout the design project. For example, designers can collaborate to jointly remember: i) the actions and events that are being discussed in the present (designers collaboratively recalling relevant information about their on-going work); ii) previous design decisions such as the general narrative structure of the history they are working on; and iii) the project milestones, goals and deadlines defined by and with the client at the beginning of the design project.

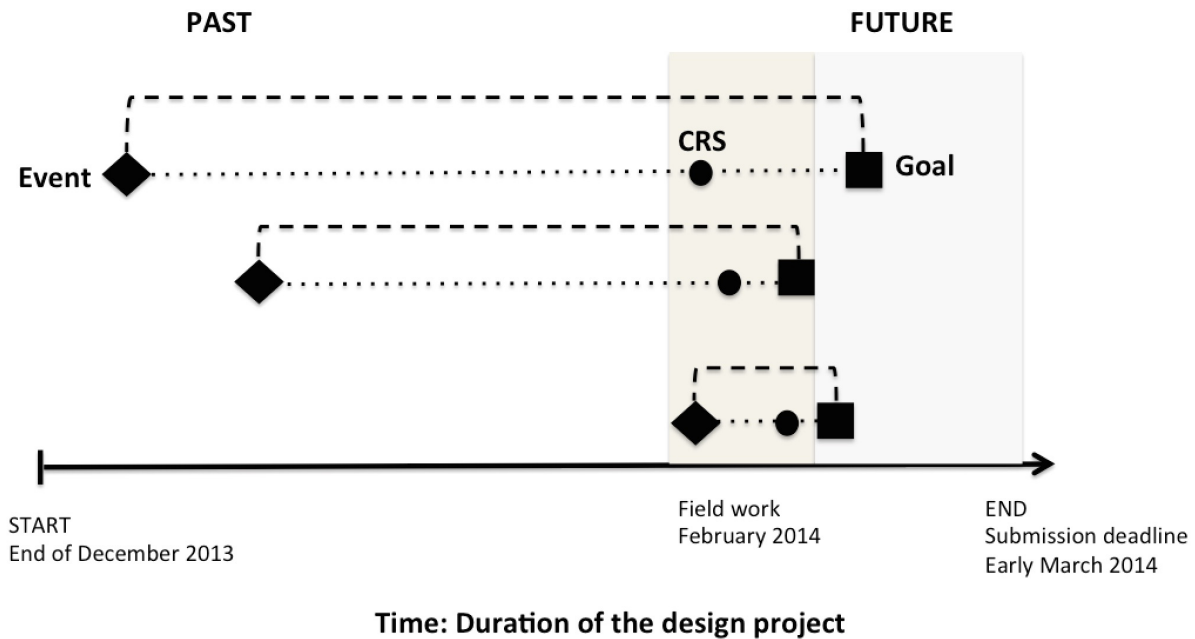


Figure 4: Time scales of collaborative remembering and collaboration in (collaborative) remembering in CRSs in the design studio. The black dot indicates the moment in which a CRS occurs. CRSs link past events to goals during the design process, (e.g. plan future actions).

As Figure 4 shows, CRSs in collaborative work activities such as collaborative design in the design studio should not only be considered as merely a type of joint action whose aim is to retrieve information about previous phases of design projects. CRSs are also future oriented and necessary for maintaining common ground, making decisions and planning future actions in the design studio (Bietti, Baker & D tienne, 2015). In the here and now, CRSs enable team members to jointly remember previous phases of design project, which are situated at different temporalities from the present. The topics of CRSs may be about the on-going actions and events that designers are working on in the present (e.g. the level of shadows, quality of the animations, etc.), but also about design decisions they made some time ago (e.g. the general order of the events in the commercial) as well as the general planning of the project set by the clients (e.g. deadlines and milestones). At different but complementary time-scales, designers also map onto the future, by, for example, anticipating and solving possible designs problems and plan work in accordance to deadlines. The future orientated

aspects of collaborative remembering in collaborative design refer to the elasticity of the past and its co-existence with the present (Bergson, 1990), which in this case is the *here and now* in which CRSs occur.

2.5. Coding of CRSs

In the more than 45 hours of audio and video recording we collected during the time spent at the design studio, we found a total number of 183 questions triggering the formation of CRSs. We had to discard 25 examples due to the low quality of the audio recordings. Thus, we ended up with 158 questions in total. These questions were divided into polar questions ($N=89/56.32\%$), content Q-word questions ($N=38/24.05\%$) and alternative questions ($N=13/8.22\%$). As we have not considered questions acting as other-repair mechanisms (see section 2.1), each of the 158 questions selected for the analyses triggered the formation of CRSs. CRSs lasted from 5.3 seconds to 13.25 minutes in duration. The audio and video recordings were transcribed in detail using specialized software (InqScribe, Inquirium; ChronoViZ: see Fouse et al., 2011). Audio recordings were also transcribed in accordance with the Jefferson Transcription System (Jefferson, 2004). Video and audio recordings were coded for linguistic and bodily behaviours ($N=4222$), including speech ($N=1224$), manual gesture ($N=391$), pointing - whether they pointed to an object or to another designer - ($N=183$), writing, ($N=58$) head-nodding ($N=252$), and eye-gaze - who was gazing at whom or at what - ($N=1921$). The minimum time unit used for coding the CRSs was 100ms. For all time points, a binary value was assigned to each behavior of each designer indicating whether or not they performed that behaviour at that particular moment in time.

3. Analyzing CRSs in the design studio

We examine the time structure of the coded behaviours in CRSs, in order to find recurrent patterns of behaviours in CRSs that occurred more often than expected by chance, i.e. what the designers did recurrently and significantly in a patterned-fashion while remembering together relevant information about the on-going design project. For this analysis we only considered the time when a specific behaviour began, but not its duration. Temporal patterns (or t-patterns) are difficult to identify systematically without the help of specialized software. In order to find the temporal structure of CRSs we used software for pattern recognition (Theme™, see Magnusson, Burgoon & Casarrubea, 2016). Theme™ software provides useful indications for discovering sequential structures in behavior in time series dataset. Theme™ detects statistically significant sequences of event types linked by critical interval relationships. A critical interval designates the time window after the occurrence of an event type during which the occurrence of another event type is considered to be non-random. Theme™ defines as T-patterns those sequences of behaviours that are linked by a specific time interaction more often than would be expected by chance. In our analysis of t-patterns during collaborative remembering, an event type refers to the different kinds of behaviours we coded. To be in line with the interactional structure of CRSs (see section 2.1), the first criteria for searching for t-patterns was to have at least two speech events uttered by different designers in a sequential fashion (e.g. alternation of speech turns in the form of Question-Answer). The second criteria we used was that all the designers involved in the CRS should be part of the t-pattern, that is, if the four designer (A, B, D and M) were engaged in a CRS, t-patterns had to contain events performed by them all and not just a sub-set of designers (A and B). The third criteria we applied was to find the t-pattern that combined the highest possible number of linked events over time and the highest number of repetitions. In other words, we did not consider highly recurrent t-patterns happening in very few events, or with

highly complex t-patterns in the number of events but only with a very low number of repetitions. In the final part of the analysis, we present a qualitative microanalysis of two illustrative examples. These examples were taken from i) an occurrence of the t-pattern with the highest number of events, and ii) an occurrence of the t-pattern with the longest duration. Finally, we relate these t-patterns with the functions of CRSs and the time scales of collaborative remembering explained in section 3.5.

3.1 Behavioural patterns in CRSs

We found 10 different t-patterns in the CRSs based on the criteria for selection explained in section 3 (See Figure 5). T-pattern search was defined in order to take into account the maximum number of related events at a significance level of $p < .005$. We observed that 69.52% (2934/4220) of the events originally coded were part of the t-patterns. The mean duration of the 10 different t-patterns corresponded to 56.74 seconds ($SD=47.22$ seconds). The longest t-pattern (S+S for designers AB, AD, AM, BD, DA, and DB) lasted 155.6 seconds and the minimum (S+MG+S for designers BBA) 5.1 seconds. The mean number of behavioral events that constituted these 10 different t-patterns was $N=293.4$ ($SD=299.07$). The maximum number of events for t-patterns was $N=936$ (S+GPA+S+GM+GM for designers MMBDA) $N=40$ (S+MG+S for designers BBA).

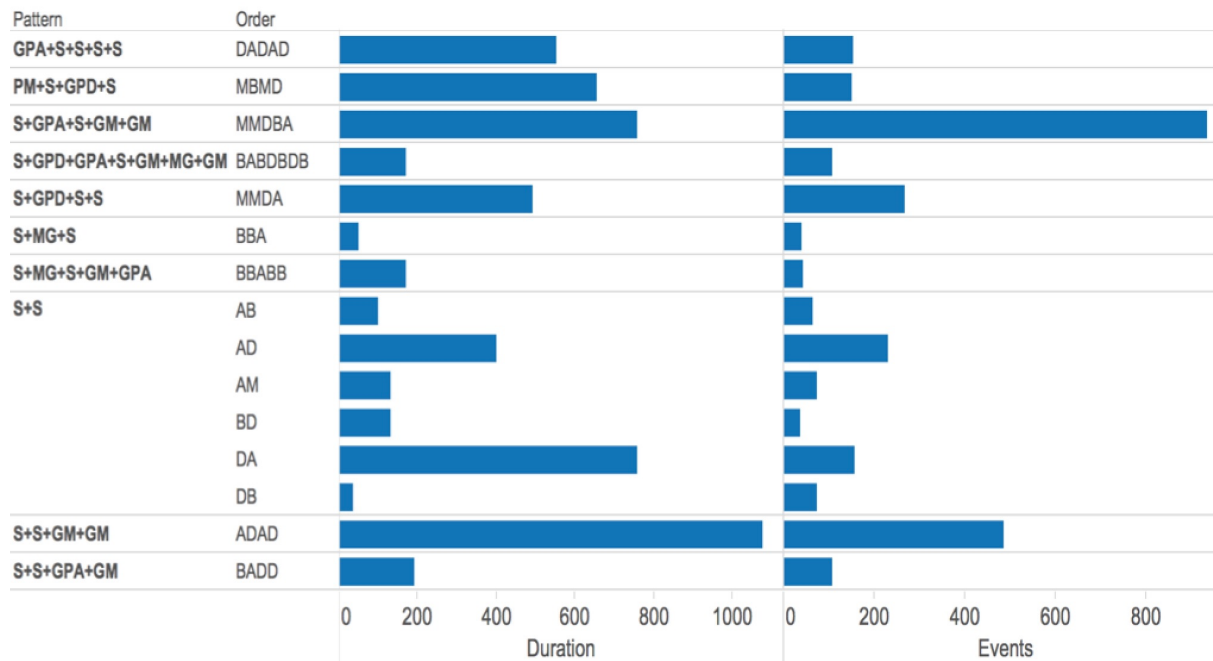


Figure 5: T-patterns in CRSs. The left side of the chart shows the behaviours making the t-patterns that we found in the dataset based on the criteria explained in section 3: ‘S’ (speech), ‘MG’ (manual gesture), ‘GM’ (gaze materials), ‘GPA’ (gaze designer A), ‘GPD’ (gaze designer D), and ‘PM’ (pointing materials). The next column to the right ‘order’ indicates the order of the designer involved in the t-pattern shown in the left one. Next comes the duration of the t-pattern (1 data point stands for 100 milliseconds). The right column shows the number of events (behaviours) involved in the t-pattern.

The group of designers that remembered the most time in patterned fashion was AD (49.13% (Time=278.8 seconds/ $N=1030$)). The most frequent t-pattern we found was S+S ($N=6$; designers AB, AD, AM, BD, DA and DB). The project leader, designer A, was involved in four out of the six variations of the t-pattern. By variations we mean the different combinations of designers that participated in the same t-pattern. In three of those four variations in which A participated, he was the designer initiating the t-patterns during collaborative remembering.

However, the most complex t-pattern for the number of designer involved (designers A, B, D and M) along with the highest number of behavioural events ($N=936$) was (M)S+(M)GPA+(D)S+(B)GM+(A)GM. In this t-pattern, that spanned over 75.7 seconds, firstly designer M said something and looked at A, then D repeated M’s speech behaviour and B gazed at the artifacts; subsequently A mirrored B’s gaze behaviour towards the artifacts.

The most complex t-pattern during collaborative remembering in CRSs suggest that operational designers A and D were in charge of carrying out the verbal recall whereas the project leader, designer A, and the project manager, designer B, coordinated gaze behaviours towards the artifacts (see Figure 6).

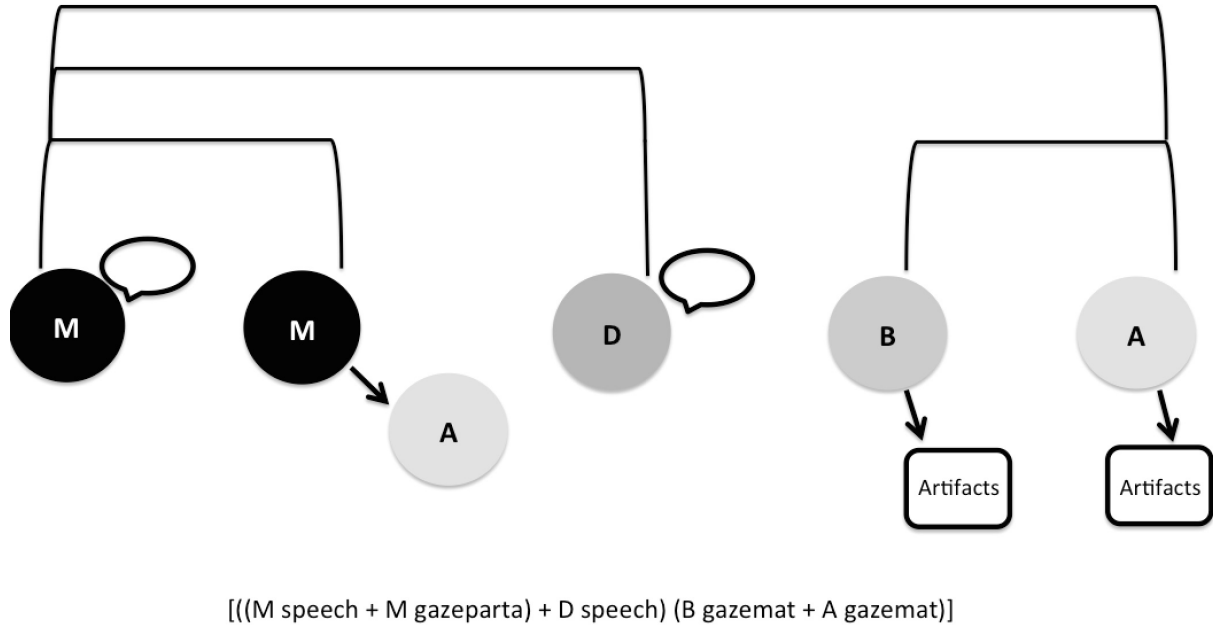


Figure 6: Description of most complex t-pattern observed in CRSs. The four members of the team participated in the t-pattern which included three behaviours: speech, gaze participant A and gaze materials (2).

Designers A and D were involved in the longest individual t-pattern -

((A)S+(D)S+(A)GM+(D)GM) - which spanned over 107.6 seconds (See Figure 7). The

longest individual t-pattern suggests that during collaborative remembering between A and D, first A said something, B copied that speech behaviour, A looked at the artifacts and D again mirrored A's previous gaze behavior. That is, for the most complex (S+GPA+S+GM+GM) and longest individual t-pattern in CRSs (S+S+GM+GM), gazing at the artifacts followed speech, which suggests the collaborative remembering was significantly grounded in external resources.

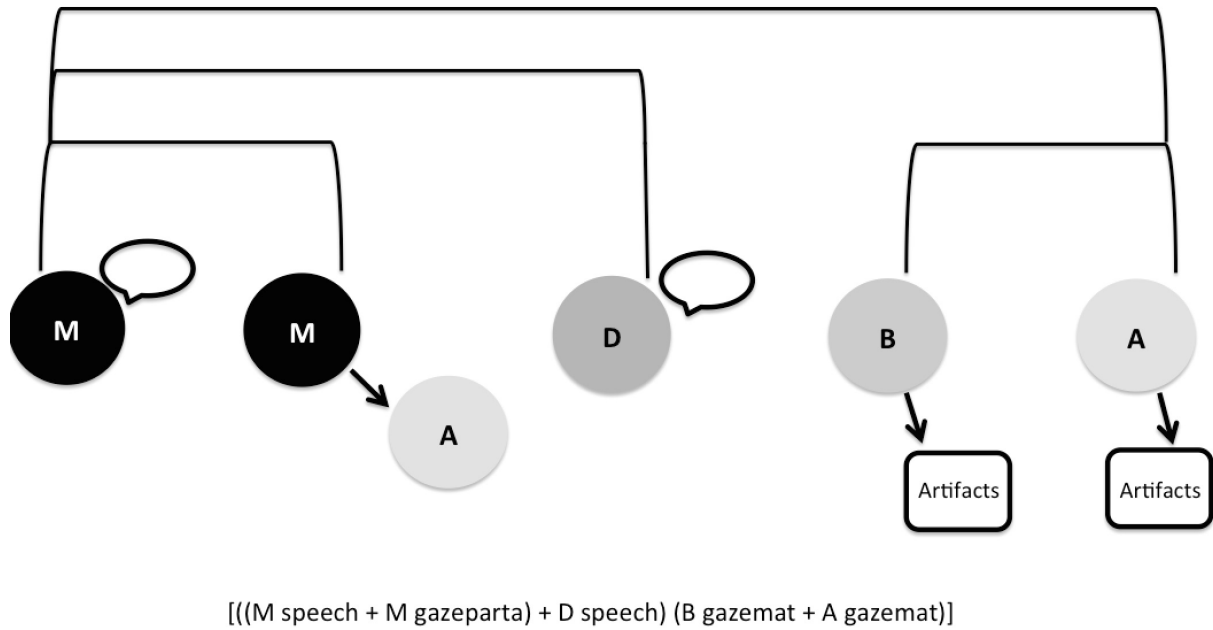


Figure 7: Description of most recurrent t-pattern observed in CRSs. The leader of the project, designer A and operational designer D participated in the t-pattern which included two behaviors (speech and gaze materials).

3.2 Two illustrative examples

In this section we present two illustrative examples of how the team of designers collectively remembered in CRSs. One example represents the occurrence of the most complex t-pattern (see Figure 6) and the other of the longest t-pattern (see Figure 7) in CRSs. The first extract, which corresponded to an occurrence of the most complex t-pattern in CRSs found in the data-set, was taken from a group meeting in which the four members of the team discussed the current state of the animations before a Skype meeting with the production studio based in Moscow. The major part of the meeting was about checking what they had already done and what they would have done by the time of the Skype meeting the following day. The second extract, which corresponded to the longest t-pattern observed in the data-set, was taken from interactional sequences between A and D in which they were involved in creating a list of the tasks that had already been carried out by the team of designers, as well as the tasks they

would have done by the end of the day. The following day (Friday), they had to submit a first version of the commercial to the production studio based in Moscow.

Both CRSs began with a polar question, involved checking work-progression and were cases of collaboration in either individual or collaborative remembering. As we explained above, polar questions and CWP were the types of questions and functions that were more frequent in the 158 CRSs we analysed. After giving a detailed multimodal microanalysis of both examples, taken from the most complex and longest t-patterns in CRSs, we explain how they relate to the multiple and complementary time-scales of collaborative remembering during the design project.

3.2.1 Example 1: Most complex t-pattern in CRSs

```
[00:00.00]
1. A: Shot five
[00:01.18]
2. B: And (.) but is it the lighting ready for this one or not?
          ***** (pic a)
[00:06.23]
3. M: Mmm =
[00:00:07.17]
4. B: =No
[00:08.02]
5. M: No (.) I mean it's a thing, it's like the other shots (.) the same
6.   environment
[00:14.03]
7. D: So as for the characters, for this one it's all faded between (.)
[00:17.09]
8. A: We're going to=
[00:18.04]
9. D: =it's the same as shot three (2 sec) it's not like the one inside of the mill
[00:23.22]
10. M: So like (.) I think it could be maybe with (.) once the square gets added
          ***** (b)
          ***** (c)
11.   in it maybe some (.) curb it (.) it passes by and gets so[me shadows
[00:33.18]
12. A:
          ***** (d) [Yeah exactly
[00:34.23]
13. D: That would be cool.
          ***** (e)
```



Figure 8: Occurrence of most complex t-pattern in CRSs.

In the extract the project leader and project manager, designer A and B respectively were checking what operational designers D and M had already done in relation to the fifth shot of the commercial (see Figure 8). In line 1, A marked the transition to shot five and he was followed by B's polar question (L. 2) about the state of lighting for shot five, which triggered the formation of a CRSs. At this point, as a resource for mobilizing a response (Stivers & Rossano, 2012) from M, B changed his gaze direction towards him (pic. a, Figure 8). B had been the operational designer responsible for the lighting of the animation. M showed some uncertainty in his response, (L.3), which B seemed to have understood as being the reason for the lighting not being ready (L.4). Immediately afterwards, M self-repaired his previous state of uncertainty by remembering and claiming that the lighting and environment were the same as for the other shots (L.5). Subsequently, D recalled that the same also applied to the characters (L.6 and 8). Between lines 2 and 8 we could observe how B's polar question initiated a case of collaborating in collaborative remembering, that is one of the two examples of CRSs we considered for the study.

However, it is only in line 10 that the most complex t-pattern in CRSs began, in terms of the number of designers, duration and events involved (Figure 8) began. The t-pattern started with designer M's speech and A and D changing gaze direction towards him (pic b) and followed by M changing gaze direction towards A (pic c) after a short silence. M's manual gestures (pic c) and subsequently A's overlapping speech (L.12) were not part of the t-pattern. The following behaviors were D's speech and B's changing gaze direction towards the storyboard (d) and A's mirroring it.

3.2.2. Example 2: Longest individual t-pattern in CRSs

[00:01.22]
 1. A: Spikes (.3 sec) the huge spikes are already done, right?
 (A writes)
 [00:05.27]
 2. D: I said it to him but I'm going to check
 ***** (pic a) ***** (b)
 [00:08.24]
 3. A: it doesn't matter we add it to the list anyway.
 ***** (c)

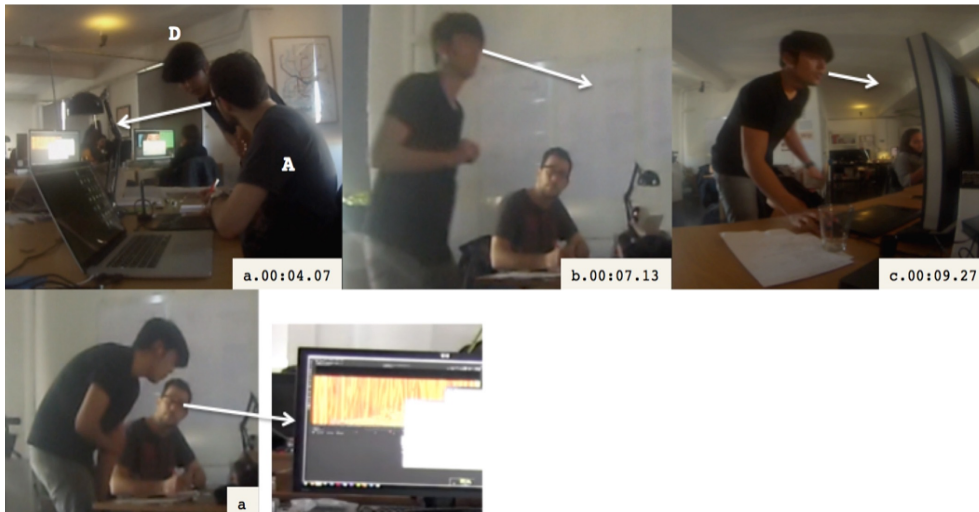


Figure 9: Description of most recurrent t-pattern observed in CRSs. The leader of the project, designer A and operational designer D participated in the t-pattern which included two behaviours (speech and gaze materials).

This is another example of collaboration in remembering, in this case individually, regarding previous design actions. The first behaviour of the second pair of events making the t-pattern is A's changing gaze direction towards the computer screen while D was still looking at him (L.2). A looked at the 'huge spikes' he referred to 3 seconds before (pic a). A's change in gaze direction towards the computer screen was immediately mirrored by D (pic b). D's gaze towards the spikes was event four and thus completed the longest t-pattern observed in the 158 CRSs we analyzed in the data-set. Right after changing gaze direction to the computer screen, D approached his workstation to check whether M had sent him the new version of the huge spikes (pic c).

3.3. Time-scales of CRSs

With respect to the multiple and complementary time-scales involved, the first illustrative example (see Figure 10) which represented an occurrence of the most complex t-pattern in

CRSs, has shown how collaboration (designer B) in collaborative remembering (designers M and D) operated to bring into the present actions and events that occurred in a recent past. B did not want to get information about deadlines and/or the general structure of the commercial as we observed in examples 1 (section 2.3.1) and 2 (section 2.3.2) respectively. In the occurrence of the most complex t-pattern, the CRS referred to a type of time-scale during the design project that concerned the week during which the designers defined the features of the animations as well as the week they worked on the actual making of the animations along with their features (e.g. lighting). The future-oriented nature of CRSs concerned checking work-progression before a Skype meeting with the production studio based in Moscow the following day. The Skype meeting was oriented towards the production studio transmitting feedback with regards to the current state of the work as well as communicating the client's satisfaction with the preliminary version of the commercial to the team of designers in Barcelona.

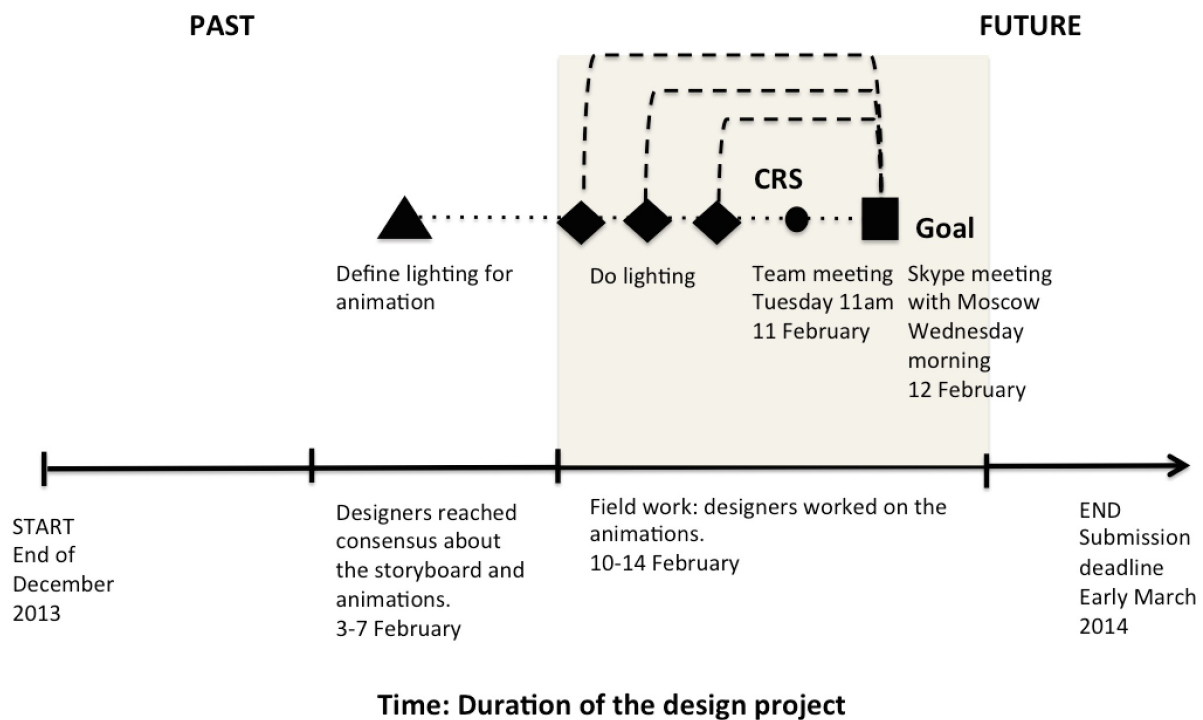


Figure 10: Time scale of the selected occurrence of the most complex CRSs. The designers defined the lighting for the animation in the first week of February 2014. The following week they worked on the lighting before a Skype meeting they had with the production studio in Moscow. The day before the Skype meeting, the team of designers had an internal meeting

in which they collaborated to remember the features of the lighting. As the figure shows, the CRS taking place during the internal meeting (here and now) linked the time in which the lighting was defined and done (past) as well as what the team should have prepared by the Skype meeting (future).

The second illustrative example (see Figure 11) was taken from an occurrence of the most recurrent t-pattern amongst the 158 CRSs that we analyzed. In these CRSs, A checked on work-progression with D, the operational designer with whom he participated in most CRSs. The CRS between A and D referred to a similar time scale to that of the previous example, taken from the most complex t-pattern. This time scale concerned the period in the design project dedicated to working together on the animations, which corresponded to the week we spent at the design studio. The difference between this example and the previous relates to the future-oriented nature of the case. In this example, the future-oriented features of the CRS referred to a deadline set at the beginning of the project, whereas in the previous case the future oriented aspect of the CRS was linked to the week in which the design team had to reach consensus about the general structure of the commercial and the animations and define their specific features.

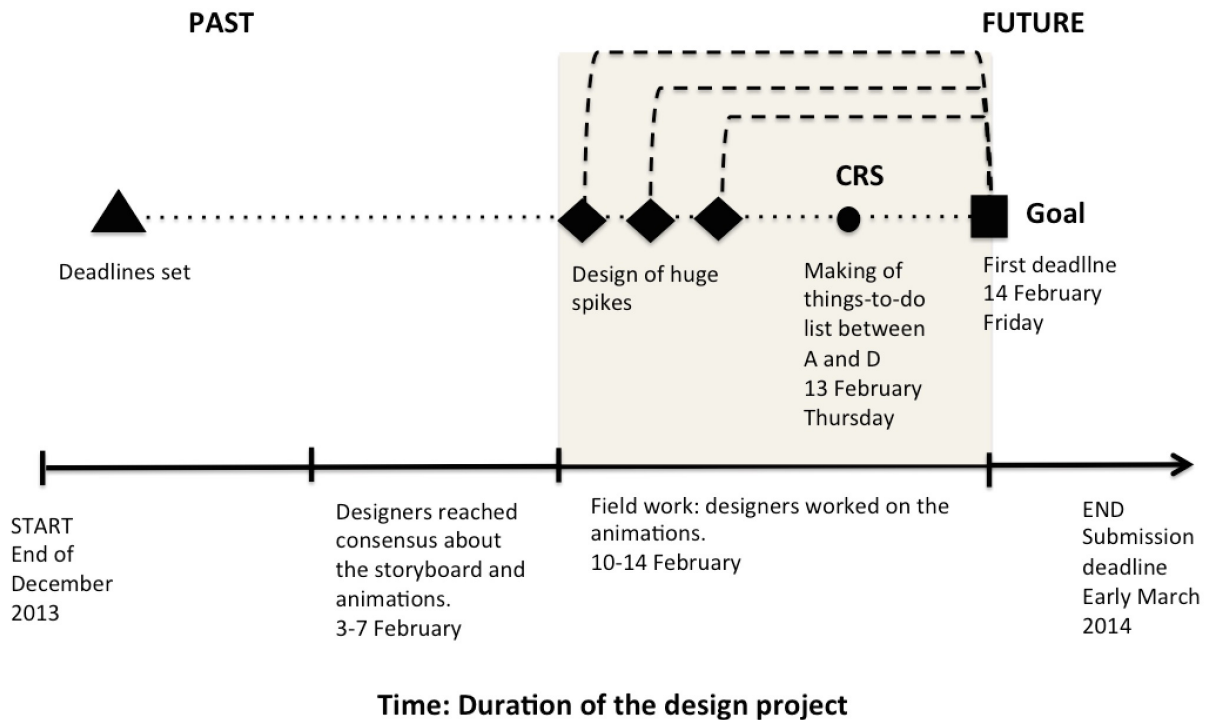


Figure 11: Time scale of the selected occurrence of the most recurrent CRSs. The different stakeholders involved in the making of the advertisement set the deadlines for the design project at the end of December 2013. The preliminary deadline for submitting the first version of the commercial to the production studio in Moscow was February 14th, 2014. The CRS between the project leader, A, and operational designer, D, referred to a particular aspect of the design project (e.g. the design of huge spikes) that had to be improved before the deadline. Thus, the CRS linked different time-scales of the design project (in the here and now).

4. Discussion

We have presented a multimodal approach to the study of collaborative remembering in work environments. The kind of collaborative work activity we investigated was a team of professional designers who were working together on an advertisement for Russian television. Our study has focused on specific types of interactional sequences in which members of the team of designers had to collaborate to remember relevant information about the design project. Such collaboration manifested itself in two ways: (i) members of the team of designers co-constructing a shared memory of the design project cooperatively (e.g. A and B collaborating to remember); and (ii) members of the team of designers (e.g. designer A)

requesting information about past design projects from other designer(s) (e.g. designer D or designers D and M jointly) that led them to remembering individually or collaboratively in a cooperative fashion. We termed these sequences “collaborative remembering sequences” (CRSs). CRSs were initiated by three different types of questions acting as reminders (polar questions; content Q-word questions; and alternative questions) which were employed by the designers to bring a shared past into the present, in relation to a specific goal (e.g. checking work-progression).

We looked at whether it would be possible to find behavioural patterns over time, whilst members of the team of designers were engaged in memory collaboration. In order to do so we explored the formation of temporal patterns in the 158 CRSs we analysed. Here we found that a large number of the behaviours originally coded were part of some type of temporal pattern. We observed that A and D were the combination of designers that recalled collaboratively in a patterned fashion for the longest time. The most complex temporal pattern that we found in CRSs, taking into account the number of designers (A, B, D and M) and the number of behaviours involved (N=936), showed that operational designers D and M were responsible for verbal recall whereas A and B were responsible for gazing at artefacts in the design studio ((M)S+(M)GPA+(D)S+(B)GM+(A)GM). The material environment seemed to have also externally grounded collaborative remembering at the design studio in a patterned fashion over time. When looking at the longest behavioural pattern during CRSs (A) S+ (D) S+ (A) GM+ (D) GM), we found that there was a key role played by artefacts during memory collaboration as well as the leading role played by designer A, whose behaviours are followed by those of operational designer D.

Our qualitative microanalyses of two CRSs, one taken from the most complex pattern and another taken from the longest t-pattern, enabled us to link these significant temporal patterns in CRSs to their actual realisations during collaborative design. Here we observed the ways in

which sequentially coordinated changes in gaze direction temporally synchronized with speech (including questions acting as reminders) and scaffolded collaborative remembering in the design studio. In line with previous results, polar questions were the type of questions used to initiate CRSs in both cases. The function of both occurrences presented as illustrative examples was checking work-progression. The project manager, B, and the project leader, A, each initiated one CRS, which fits in with the distribution of roles in the team (leader and manager vs. operational designer) and the structure of the sequences. That is, in both CRSs designers A and B collaborated with D and M in their individual and collaborative remembering. Finally, we linked both occurrences in the time-scales involved in CRSs during collaborative design. Here we found that the examples taken from the most complex as well as the longest temporal patterns were associated to future-oriented features of memory collaboration. Even though each CRS referred to different events, actions and time-frames in the past (e.g. deadlines set at the beginning of the project and the general structure of the commercial and animations defined a bit more than a month after deadlines were set), both sequences connected past, present and future collaborative design from the *here and now*. The results obtained from the analyses we conducted showed that: (i) the project leader, designer A, and operational designer D were the combination of team members that participated in more CRSs in a patterned-fashion; (ii) changes in gaze direction towards artefacts in combination with speech structured CRSs; (iii); (iv) the distribution of roles led to the collaboration of individual and collaborative remembering structures of CRS; and (v) CRSs were future-oriented even though the past they referred to may be located at different temporalities throughout the design project.

Collaborative remembering in the design studio is a multimodal and distributed joint activity, in which social and spatial factors such as distribution of work roles and spatial proximity among team members is crucial. Collaborative remembering in the design studio is a

complex cooperative activity that is highly dependent on work roles and how they complement each other (leader vs. subordinate), on the coordination of verbal and non-verbal behaviours over time, the material environments, design plans and goals.

The results of this case study would need to be validated on a broader corpus, including multiple types of teams of designers working on different projects over longer periods of time. Although basic turn-taking and interactional mechanisms in conversation may seem to rely on universal rules that are valid across languages and cultures (Stivers et al., 2009), further research would need to include teams of designers coming from different cultural backgrounds, since one could expect that mnemonic techniques may differ across cultures (e.g. Alea & Wang, 2015). Multiple mnemonic techniques in combination with differences in human-computer interaction (e.g. Vatrapu & Suthers, 2007) and distinct design cultures (e.g. Vanhille, Detienne, Baker & Mougenot, 2015) may influence the structure, organization and temporal patterns of collaborative remembering in interaction with external resources in the design studio. A broader corpus should include both face-to-face interactions in the design studio but also in distant computer mediated interactions at multiple locations in which tele-presence videoconferencing may play an important role.

A better understanding of the web of mutual dependencies animating collaborative remembering at the workplace will enable us to design ecologically valid experiments to test how and in what capacity each of the factors explained above influence collaborative remembering at work. This will be crucial for practical interventions to improve social (e.g. team composition), cognitive (e.g. who remembers what) and material (e.g. artefacts, technology and spatial design) ecologies for collaborative remembering at the workplace.

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