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Co-Located Team Designing: the oscillation between individual and social processes

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Contemporary approaches to the study of design teams tend to assume that teamwork is entirely social, thereby failing to examine the extent to which design team processes involve the assumed joint attention and social collaboration. Nowadays mobile devices enable a situation where almost the entire design process is carried out in a team co-located setting, which allows for both individual and social creative processes during teamwork. In this perspective, this article explores the oscillation between co-located individual and social design activity. To study the shift from individual to social activity *within* design teamwork, we surveyed 23 hours of team activity amongst 25 high-school students by coding and analyzing captured video of their teamwork while working in a self-imposed manner on a design task. We found that different creative sub-processes, such as information search, problem defining, idea generation, decision-making, and feedback, foster different degrees of joint attention, and that the joint attention may be established more successfully through analogue and shared digital communicative resources.

team designing; individual creativity; social creativity; joint attention; co-located teamwork

1 Introduction

Theoretical models of designing differ in whether they conceptualize design as an individual activity, or a social endeavour. Early theoretical models of design and creativity processes tended to rely on conceptualizations of individual expert designers as creators working in isolation, i.e., the lone stoic thinker (Fischer, Giaccardi, Eden, Sugimoto & Ye, 2005; Sawyer, 2007; Cross, 2011). As design theory and practice has evolved into collaborative forms, such an individual conception was supplemented (some would say replaced) by the idea that design was first and foremost a social team endeavour (Cross & Cross, 1995; Kleinsmann, Valkenburg & Buijs, 2007). The current theoretical mainstream on team designing and creativity, tend to fall into one of three distinct approaches. (1) Team efforts are compared to individual efforts in order to establish which is superior. For divergent production specifically, the creativity literature has debated whether individual vs. social production is more efficient, with some evidence that individual ideation (Diehl & Stroebe, 1987) or a hybrid of individual and social activity leads to more ideas (Korde & Paulus, 2017). (2) Team activity is viewed

as a form of input-process-output model (Reiter-Palmon, Wigert, & Vreede, 2012). (3) Team social micro-processes are studied (e.g., Cross, Christiaans & Dorst, 1996; Christensen, Ball & Halskov, 2017). These recent approaches tend to assume that teamwork is entirely social, and hence fail to examine the extent to which team processes actually involve the assumed joint attention and collaboration. While the third – process based - approach to the study of designing is well suited to address fluctuating levels of social collaboration over time, in effect such studies typically involve only observations containing team-dialogue, thereby failing to explore flipside of the coin: individual team-related activity. Current design team research thus ignores the fact that a large part of collaborative design sub-activities are done by lone individuals (both inside and outside social meetings), albeit in some form of prior or concurrent coordination with the other team-members.

The present paper attempts to address this research gap by offering a first analysis of oscillations between individual and social activity over time *within* team designing. Coming from the field of cognitive and social psychology within design research, we take an integrated approach to examine real-life team interactions across different design episodes and sub-activities with both quantitative analysis of interaction patterns and types of design activity, and qualitative microanalysis of team member interactions.

Specifically, this paper explores how individual and social dimensions of design team activity shifts across different sub-activities. The empirical study involve 25 high-school students and their teamwork, which entails sub-activities such as idea generation, information search or decision-making, where technology and physical materials feature in their ongoing work. This also makes it relevant to examine how the individual team members use digital and analogue communicative resources to attract and establish joint attention.

When the design research literature shifted from the study of individuals to teams, it may in part have been fuelled by shifting design practices into ever more open, complex, dynamic and networked forms of organizing (Dorst, 2015). Similarly, the present paper also finds inspiration in ongoing changes in design team practices, in the form of increasing team co-located activity due to new ways of working, partly driven by new mobile technologies. Twenty years ago, digital tools for collaboration were located in complex stationary setups, tying them to specific locales, unsuitable for mobile collaboration (Heath & Luff, 1998). Ubiquitous mobile digital design tools are, however, changing the nature of organizing for designing, allowing for the full range of design team activities to be carried out on brought-along mobile devices. Consequently, design team members need no longer change location back to their desk after a meeting in order to continue individual work, allowing for a co-located design process oscillating between individual work and social dialogue.

Theoretically, we seek to inform descriptive models of design team processes on the issue of self-selected oscillation between individual and social team activity over time. While joint attention (Harvey, 2014), shared representations, and team mental models have been deemed important process characteristics for design (Kleinsmann et. al., 2007), it is not clear how joint attention may fluctuate across design sub-activity types or over the course of designing. Further, while joint attention may be mediated through shared analogue media (co-sketching, collaborative prototyping) or gesturing, it is unclear whether and how joint attention may be established in the context of ubiquitous personal mobile computing. We sought to explore the effectiveness of the communicative resources deployed in attempts at establishing joint attention.

1.1 Design Team Processes

A team process is defined as “members’ interdependent acts that convert inputs to outcomes through cognitive, verbal, and behavioral activities directed toward organizing taskwork to achieve collective goals” (Marks, Mathieu & Zaccaro, 2001), and centrally involves member interaction. The state-of-the-art temporally based *recurring phase model* of team processes (ibid.) is based on the idea that teams perform in temporal cycles of goal-directed activity, called episodes (Bush, LePine & Newton, 2017). Episodes are sequenced distinguishable temporal units which teams perform on

their path to goal accomplishment. Centrally, they are iteratively structured by identifiable periods of action and transition periods between actions. Action phases are periods of time when teams are engaged in acts that contribute directly to goal accomplishment, while transition phases are periods of time when teams focus primarily on evaluation and/or planning activities (Marks et. al. 2001).

The special nature of designing, devising courses of action aimed at changing existing situations into preferred ones (Simon, 1969), shifts much of team activity towards transition phases (involving, for example, goal specification, problem definition, strategy formulation, and planning for design). In such transition phases, the team needs to reach a shared understanding of their goals and processes, before commencing with action phases. Fundamental to collaborative design activity is the sharing of representations, which serve as the basis of subsequent sub-goaling, and individual design activity. Shared understanding may be defined as a similarity in individual perception of actors about either how the design content is conceptualized or regarding team transitive memory (i.e., 'who knows what'; Kleinsmann et. al., 2007). Reaching a team shared understanding in the context of creating novel design is tricky (Cross, 2011). Even when information is apparently shared, misunderstanding and misinterpretations are evident which means that common, shared understanding cannot always be assumed in team work (ibid; Kleinsmann et. al., 2007). It has been shown that analogizing (Christensen & Schunn, 2007) and mental simulation (Casakin, Ball, Christensen & Badke-Shaub, 2015) in teams can play an important part in reaching shared team understanding and support team mental models.

Descriptive studies of design activity place centrally activities related to problem clarifying, planning, gathering and sharing information, and generating and adopting concepts (Cross & Cross, 1995; Cross, 2011). The experimental setup in these studies involved short time-frames and depriving the participants of their usual tools and working environments. Such conditions may have shielded the above studies from finding design activities stretching over longer durations, or involving activities crossing organizational or physical boundaries. Consequently, longitudinal descriptive models from engineering design often entails a descriptive separation between conceptual design (early) and detailed design (later) (Cross, 2008). Further, the design sub-activities identified by Cross (2011) need not be thought of as constituting a normative linear progression, given the iterative nature of design, with co-evolution of problem and solution, that has been stressed as fundamental to design (Dorst & Cross, 2001; Wiltschnig, Christensen & Ball, 2013). Lawson (2006), in his descriptive model similarly argued for four types of design sub-activities: Assimilation, general study, development, and communication.

For the present purposes, of examining oscillations between individual and social activities, we examined episodes of transitions from individual to social activity for their design sub-activity content. In principle, the opposite oscillation (social to individual) is equally theoretically interesting, but they do not easily lend themselves to analyses of design sub-activity due to the lack of verbalizations. Hence, we restrict our analysis to examine the oscillations from individual to social team activity.

We hypothesized that these sub-processes fall into the categories of either transitory or action phases, with differing in needed levels of joint attention for their completion: sub-activites involving transitory phases (problem definition, planning, and concept development) should contain more and longer episodes of switching from individual to social activity. The action phases would more frequently involve individual sub-goaling, and information search should thus less frequently entail such social episodes, while the action phase of detailed design should be constituted by a number of short team monitoring checks, with the purpose of quickly checking for whether individual work was on track with the shared understanding in the team (i.e., faster oscillations over time).

1.2 Communicative Resources and Joint Attention

A second research question regards the contextual factors and communicative resources influencing whether attempts at attaining social dialogue actually succeeds. A prerequisite of reaching a shared

team understanding is to attain joint attention in the team to initiate a dialogue (Harvey, 2014). Joint attention may be defined as participant's being mutually oriented to a common part of their visible environment, and are aware that their conversational partners are also looking at it (Whittaker & O'Conaill, 1997; Zhang et al., 2017).

In a co-located setting, any diversion away from individual work activity will involve a team member intruding or interrupting other member's individual attention. In a work context, interruptions are usually thought to be negative as they hamper individual productivity, but they may equally have beneficial effects (Jett & George, 2003) such as causing minor conflict, which can foster creativity (de Dreu, 2006). An individual being interrupted may feel counter-productive in the moment, but the presence of communicative resources establishing that the cause of the intrusion has a team benefit, may help make the attempt to attract attention successful. Communicative resources can involve analogue (e.g., sketches) or digital (e.g., screen content) media, and visual or not currently visible referents to team generative materials, as well as gesturing. Intruding work using analogue media may help communicate shared understandings, since the referent would usually have been pre-generated collaboratively, while digital referents change visual content rapidly, and hence needs further individual examinations before social meaning may be extracted. A consistent issue in co-located team work, observed in our data, was how the screen of a laptop, tablet or smartphone was oftentimes shielding the individual member from the others, making it difficult for all members to keep track of each other's work. Visibility of the actions of others has been argued to be of central importance in co-present collaboration (Cole & Stanton, 2003). Visual referents should be more effective at attaining joint attention, but in the case of referring analogue media (which carries a consistent visual meaning across situations), referring to both visible and hidden (i.e., not currently visible) analogue media may both be effective in attaining joint attention. For digital shielded content, intrusions might be less likely to lead to joint attention as the potential team benefit from the intrusion would be harder to assess.

2 Methodology

We apply a video ethnographic approach (Heath, Hindmarsh & Luff, 2010, Heath & Hindmarsh, 2002) to collect data of naturally occurring group activity, recording the design teams' processes in-situ.

2.1 Participants and Case Description

We recorded twenty-five Danish high-school students working in seven self-selected groups of three or four people. The students were aged between fifteen and eighteen years, with fifteen female and ten male. The school is one of Denmark's leading IT and media high schools, and their teaching is 100% digital, meaning the students only need their laptop or tablet during class. We followed a 2nd year class during a week-long interdisciplinary project aiming to train creativity and innovation competences. To facilitate the course, the teachers employed a process tool designed to encourage creativity and innovative thinking. The students were assigned the task to design an innovative solution with multimedia to "brand Danish contemporary art for a foreign audience". The design brief focussed on a specific Danish artist who experiences difficulties reaching an American audience. The students were to make a mind map, a mood board, personas, and a prototype, visualization, or sketch of their final solution.

2.2 Video observation

We recorded a total of 39 sessions of group activity, capturing each group with a 2-GoPro dual-audio camera set-up. This setup enabled the capture of all group members face-on along with their use of analogue and digital materials. All groups were recorded in several iterations, and at each time point 3 out of the 7 different groups would be recorded simultaneously in a counterbalanced collection design. Each group was recorded in 5-8 sessions throughout their design process, and the dataset involved data from all groups the first two days, and from 5 groups the third day. The students were not asked to organize or locate themselves in any particular way. Instead, we sought out the groups

wherever they themselves chose to sit in the open class environment and working on whatever they found relevant.

2.3 Analytical approach

We approach interaction analysis from a multimodal perspective, a broad interdisciplinary approach, which analyses communication as more than speech and text (e.g. Streeck, Goodwin & LeBaron, 2011, Heath et. al., 2010, Goffman, 1964). When communicating, we use language, gestures, gaze, our bodily position in a particular environment, and materials in our surroundings, which we in this article refer to as communicative resources. Communicative resources, like multimodal utterances (Goodwin, 2006), contains both verbal and non-verbal elements that we employ, when communicating with each other when trying to make sense and establishing a shared understanding of what is going on.

Since we have an interest in addressing the material and digital aspects of the social organization of collaborative work, our focus is not just *which* materials and technologies are in use during group activity, but for which purpose and *how* they are activated during interaction. When applying a multimodal approach to interaction analysis, communicative resources like pointing, gaze direction, and the material that the pointing is directed towards, becomes important features as they are used to establish when a particular space becomes a shared focus for the organization of cognition and action (Goodwin, 2003: 219; Goodwin, 1994).

The typical analytical strategy deployed in multimodal analysis is qualitative in-depth analysis of micro-events. Here, we supplement this approach with a protocol-analysis (Ericsson & Simon, 1999) inspired approach to quantifying and understanding interactional patterns.

A typical protocol analysis approach would involve transcribing, segmenting, and coding verbal data, for example in the study of 'think aloud' protocols (Ibid.) or naturalistic creative (Dunbar, 1995) or design team meetings (Christensen & Ball, 2014). However, for the present purposes of understanding shifts from individual to social activity, we diverged from transcribing and segmenting verbal data by dialogue turn-taking, and instead segmented data by shifts in activity coded directly from the video.

2.4 Coding

To make data available for quantitative analysis, three independent coders assessed the videos. All transitions and time spent on social activity in each group was marked with timestamps.

Attention was coded in three categories: 1) *Individual activity* was coded in case the group members focused their attention on distinct tools or objects (typically mobile devices), but did not interact verbally or non-verbally. 2) *Attempt to attract attention* was coded when a member tries to draw attention from one or more members to initiate social activity, either verbally (e.g. calling a name or asking a question) or non-verbally (e.g. gestures). Finally, 3) *joint attention* was coded when two or more group members interact, maintaining a shared focus (e.g., on a prototype or a screen). The activity is coded for the duration of the shared focus, leading to *episodes of joint attention*. An episode is started by a shift from individual activity to joint attention, typically initiated by an attempt to attract attention, and ends when the group reverts to individual activity. Episodes of joint attention constituted our main unit of analysis.

Episode topic was coded as on- or off-task, where off-task was coded if the dialogue revolved around personal talk or was unclear. For all episodes containing verbalizations, we utilized a coding scheme for design sub-activity drawing on the works of Cross (1995) and Lawson (2006), containing seven distinct categories: Problem definition, searching for information, planning (decision making, delegation of tasks), concept development (idea generation, feedback), and detailing. We narrowed our analytical focus by concentrating on communicative resources as both verbal and non-verbal markers, which were actively involved during interaction. Episodes involving joint attention were coded for types of communicative resources in use. For the quantitative coding, the communicative

resources could be digital (e.g., laptop), analogue (e.g. cut-outs, magazines, prototypes), and could be either 'visible' or 'not visible' to the intended receiver. Finally, it was noted whether the participant attempting to attract attention used gesturing.

2.5 Inter-rater reliability

Two independent coders coded 17.5 minutes of the video data for attempt to attract attention, and for joint attention. Reliability of episodes was calculated by segmenting according to each video second, for a total of 1046 segments. A Cohen's kappa coefficient of inter-coder reliability was calculated for each code. Attempt to attract attention Kappa= .65; Joint attention Kappa= .75. Further, two independent coders assessed on-task behaviour on 14% of the episode data displaying satisfactory reliability, Kappa=.62.

3 Results

The dataset contained a total of 23:30 hours of design team activity, 10:41 hours of which was coded as involving joint attention, and 12:49 hours was spent in the teams in individual activity. We identified 758 unique joint attention episodes in the dataset. Of these, 122 episodes were removed due to off-task dialogue, leaving a total of 636 episodes. The episodes ranged from 2 seconds and up to 13 minutes, with a mean length of 1:03 minutes, (standard deviation= 1:32 minutes). For 196 episodes a distinct attempt to attract attention was identified. Different communicative resources were used in the attempts to attract attention, with 52% of the episodes using digital and 23% using analogue references. Further, in 53% of the episodes communicative resources were visible, while in 24% of cases they were not visible (e.g., an unshared personal screen), and in the remaining 23% of episodes, no clear referent could be coded. Additionally, 17% of the episodes contained gesturing by the member attempting to attain dialogue.

Of the full set of episodes, 579 involved social dialogue. Based on the dialogue, the design sub-processes of the social engagement could be successfully coded in 505 cases, and of these 10% involved defining or framing the design problem; 14% involved searching for information; 48% involved concept development (idea generation: 24%, or request for feedback: 28%); 40% pertained to planning (decision making: 30%, or delegation of tasks: 15%); and finally 38% involved detailing the design.

3.1 Exploring Joint Attention Episodes by Design Sub-activity

A repeated measured GLM revealed that the prevalence of the seven distinct design sub-processes differed significantly from each other $F(6,3024)=26.42$, $p<.001$ (See table 1). The results revealed that from least to most prevalent design sub-activity: problem defining, searching for information, and delegation of tasks did not differ significantly from each other, but they were significantly less frequent than the remaining 4 sub activities. Idea generation did not differ from feedback, and decision making, but was significantly less prevalent than detailing. Finally, feedback also significantly differed from detailing.

In order to explore the length of each oscillation by design sub-activity, we compared the mean length of each episode containing a design sub-activity to a baseline of all other episodes not containing that design sub-activity. Two design sub-activities displayed significantly longer than baseline length while the remaining design sub-activities did not differ from baseline: Idea generation episodes (M=0 1:36, STD= 01:56), $F(1,504)=19.56$, $p<.001$, and problem defining episodes (M=02:25, STD=02:43), $F(2,504)=34.56$, $p<.001$.

Table 1. Mean, standard deviation, and parameter estimates for the prevalence of design sub-activities across episodes of joint attention.

				95% confidence interval	
Design sub-activity	Mean	Std. dev.	*t*	Lower bound	Upper bound

Problem definition	.10	.30	7.36	.07	.12
Information search	.13	.34	8.71	.10	.16
Delegation	.14	.35	9.20	.11	.17
Idea generation	.23	.42	12.33	.19	.27
Feedback	.28	.45	13.84	.24	.31
Decision making	.29	.45	14.39	.25	.33
Detailing	.36	.48	16.78	.32	.40

The major observations appear in alignment with oscillation expectations: frequency and length of episodes of joint attention fluctuate across the type of design-sub activity. Especially activities associated with transition phases appeared longer and/or more frequent, while action phases appeared shorter and/or less frequent. As a notable exception, there were only few (yet lengthy) problem defining episodes.

3.2 Exploring temporal development in joint attention episodes

Across the three consecutive days of observing, all design sub-activity except for delegation (F=1.78) displayed significant distinct differences between the days (F's ranging from 6.33 to 19.27). Linear decreasing patterns over time were found for information search, idea generation, and problem definition. Conversely, linear increasing trends were found for feedback and detailing. And finally decision making displayed an inverted-U shape relation to time (see figure 1). To examine the length of episodes across time, we compared the mean episode length across days of design activity. The mean episode length differed significantly across days (M Day 1=01:22, M Day 2=01:05, M Day 3= 00:45), $F(2,504)=5.69$, $p<.004$. Follow-up t-tests revealed that compared to Day 3, Day 1 $t(275)=3.91$, $p<.001$ and Day 2, $t(373)=2.09$, $p<.04$ were significantly longer, while Day 1 and 2 did not differ. The analysis illustrated that across the design process, the speed of oscillation between individual work and team activity increased.

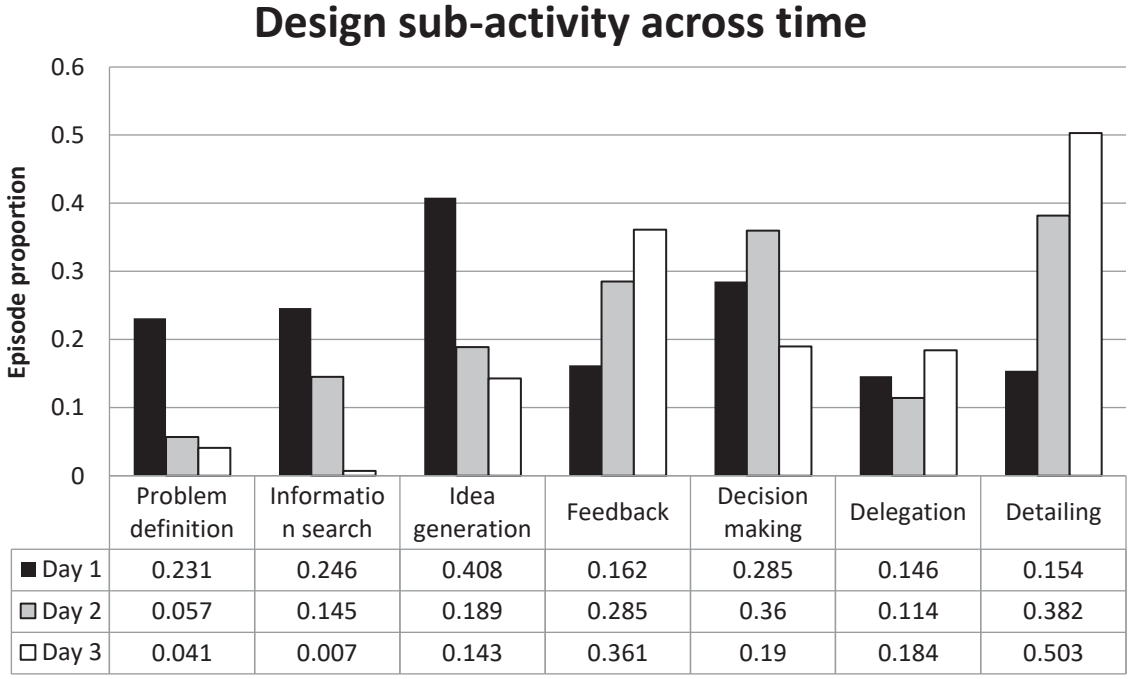


Figure 1. Proportion episodes with joint attention by design sub-activity across three time points.

The major observations of episodes of design sub-activity across time seem mainly in alignment with normative design models. Planning activities appeared at a constant high throughout the process,

displaying an elevated level of decision making mid-way. At the later part of designing, a frequent (but short) set of episodes involved checking with the team for being on track.

3.3 Modelling successful and unsuccessful attempts to attract joint attention based on usage of communicative resources

The number of successful to unsuccessful attempts to attract joint attention did not vary significantly over the course of days, χ^2 (2, N = 196) = 1.99, p=.37. For the successful and unsuccessful attempts to attract joint attention, we carried out a logistic regression for the involvement of communicative resources. An evaluation of the final model versus a model with intercept only was statistically significant, χ^2 (4, N = 196) = 52.32, p < .001. The model was able to classify correctly, with an overall success rate of 75%. Table 2 shows the logistic regression coefficient, Wald test, and odds ratio for each of the predictors. The odds ratio indicates that successful compared to an unsuccessful attempt to attract social attention is more likely to be drawing on the communicative resources of visible and not visible analogue media, or visible digital media. Successful switches to social dialogue were also more likely to involve gesturing (as opposed to verbal only) attempts to attract attention.

Table 2 Logistic regression predicting successful attempt to attract joint attention from usage of communicative resources.

	B	SE	Wald	df	Sig	Exp(B)
Digital Visible	1.64	.44	14.03	1	.001	5.16
Digital Not Visible	.47	.42	1.27	1	.26	1.60
Analogue Visible	2.06	.68	9.01	1	.003	7.81
Analogue Not Visible	2.44	1.09	5.01	1	.03	11.51
Gestures	2.39	.76	9.76	1	.002	10.87
Constant	-.45	.29	2.35	1	.13	.78

In general, the deployment of communicative resources was effective at turning an attempt to attract into joint attention and social dialogue. Analogue media displayed larger effect sizes compared to digital ones. Only digital media that was not visually available or shared with the team appeared ineffective at mediating the relation between attempt to attract and joint attention.

This initial analysis surfaced characteristics of the shifts between working individually and socially in the groups, which prompted subsequent questions about what motivated the shifts, how shifts were initiated, established, maintained, and interrupted? And which mediators enabled these shifts and stabilized or destabilized the given activity? In order to explore these questions, we conducted in-depth qualitative analyses of illustrative episodes.

4 Qualitative analysis

4.1 Transitions in interactions

We provide here detailed descriptions and analysis of three data extracts, which demonstrate the dynamic shift from working individual to working collectively, how certain types of sub-activity moderates' attempts to attract attention, and how digital and analogue recourses are used to mediate joint attention. As these examples illustrate, the actions occurring in the episodes are constructed and mutually elaborated through the simultaneous use of multiple communicative resources. Speech and action is transcribed following a CA-inspired multimodal transcription notation (Jefferson, 1984, Heath et. al., 2010, pp.70-83).

4.2 Concept development and decision making using analogue materials

Our first example is a 15.4s video clip. It demonstrates how social action in terms of *concept development* and *decision-making* is built by combining different communicative resources. In this transcript, we see Tara working on her laptop. Lilly and Vera, the other members, are also engaged

in individual activity, Lilly is cutting out images, Vera is flipping through a magazine. A poster with cutouts from magazines is placed in the middle of the table.

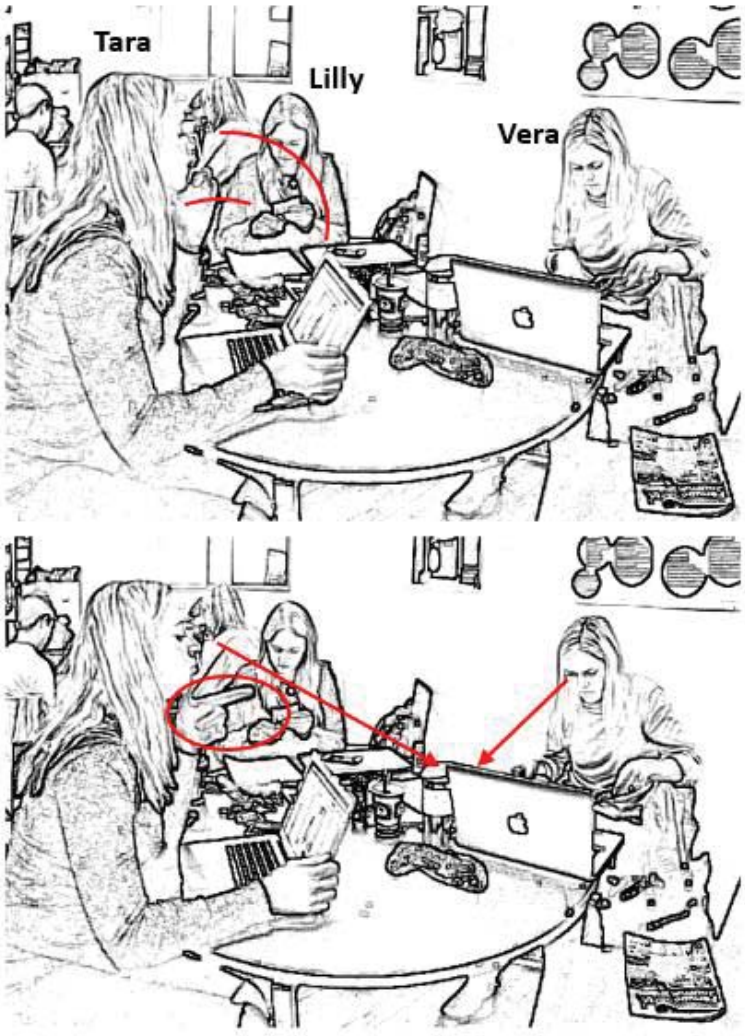
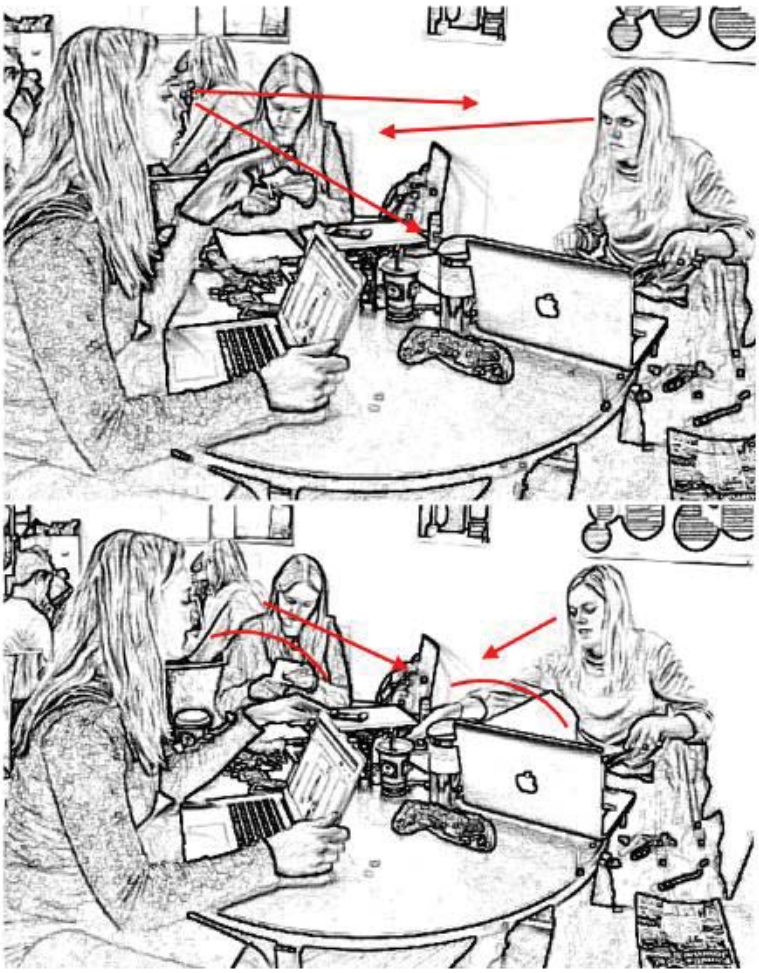


Figure 2 Attempt to attract attention. Video captured images have been manipulated in order to retain participant anonymity.

In frame 1 Tara looks up from her screen facing Vera saying "oka:y?", while moving her left hand to her chin in a chin-stroking gesture. With a rise in intonation, head (and gaze) movement and a chin-stroking gesture, she indicates an attempt to attract attention, where her talk, simultaneously with her bodily organization, displays a questioning and possibly evaluating attitude towards something they are working on. Neither Vera nor Lilly reacts immediately to Tara's attempt. In frame 2 Tara ask a question "why is there a plane (.) there?", while gazing and moving her hand from her chin to a pointing gesture towards the poster. In frame 2, Vera reacts to Tara's question by looking at the poster, when Tara says "there" with emphasis while pointing.



3

07.33.6
Tara: **Should** the plane not be down there?

>why did you put the plane up there<?

4

07.38.9
Vera: >because< I just began to **place::** it::: eh:

>what was it she said<?

Figure 3 Discussing the task.

In frame 3 Vera establishes eye contact with Tara, who continues her rhetorical questioning; “Should the plane not be down there?” while still pointing. Vera nods repeatedly while maintaining eye contact with Tara. Vera carry on nodding and smiling while Tara continues to question her directly in frame 3, where Tara rapidly says “>why did you put the plane up there<?”. In frame 4, Vera still smiles and looks down at the poster, and points, while explaining her reason “>because<…” for placing the plane this particular place. Vera’s pointing indicates to Tara a specific place on the poster, while visually searching for the argument, she uses the poster as reference point, while saying “>what was it she said<?”, not directed to Tara, but related to the topic of reference in the dialogue. In frame 5 Vera finds her argument on the poster; “likes to travel”, pointing with a tapping gesture at a particular place on the poster, displaying the argument for placing the plane here. Tara’s gaze follows Vera’s movement and she says “oh::” as she withdraws her hand to her chin, with her fingers in her mouth as if evaluating.

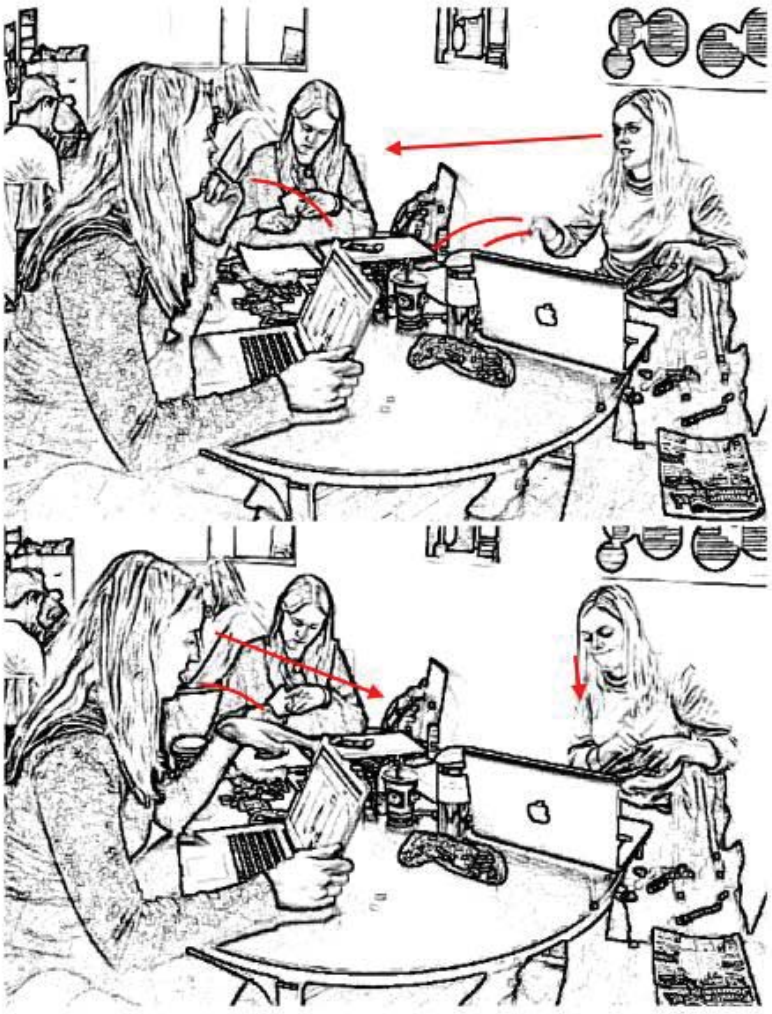


Figure 4 Reaching agreement.

Vera is building up her answer to Tara by combining communicative resources with different properties, which has advantages to the repertoire of possible action available to her in the situation (Streeck, Goodwin, & LeBaron, 2011, p. 2). In frame 5 Vera agrees with Tara's critique, saying "But it should be down there", while gesturing towards the place on the poster. In frame 6 Vera looks down, returns to flip through the magazine, she is holding, with a tight lipped smile as if demonstrating refusal to say no more (Ford, Thompson, & Drake, 2012). Tara takes a final look at the poster, while pointing, and then withdraws her proposal, accepting Vera's argument, while Vera confirms with a short "No".

In this excerpt, we see how Tara and Vera are drawing on a combination of communicative resources when negotiating the design and coming to a decision. The analogue material (the poster) is central for the course of action (the negotiation). The poster becomes a mediator for joint attention, and we see how they both actively are including the poster as a point of reference. What is interesting is how they continuously shift from working individually to addressing each other with questions or proposals to the task. It is also worth noting how the primary activity seems to be individual, and the social activity is only established shortly to align and decide details: Tara never loosen her grip around her laptop, and Vera never puts the magazine down.

4.3 Proposing an idea using digital resources

In the second excerpt, we show how joint attention is mediated by the use of a laptop during an *idea proposal*. The video clip is 9.6s in length. We enter into a group of three; Dan, Lea and Holly. Lea and Holly have just returned to the table and are talking about how to present their project. Dan, who

have been working individually at his laptop, looks up, turns his head and nods in an attempt to attract their attention. In frame 1, he establishes eye contact with Holly and immediately initiates his proposal "I was thinking", after which he turns to look at the screen of his laptop to show what he is "thinking". In frame 2, Dan moves back in his chair as if to make space for Lea and Holly to see his screen, while slightly turning the laptop in their direction. He utters the proposal "about an email to eh:: Julie Nord". This creates a focus for attention and locus for shared work (Goodwin, 2013) and the others display appropriate commitment to the joint activity (Bratman, 1992). Holly looks towards Dan, and in frame 3, she leans towards the screen.

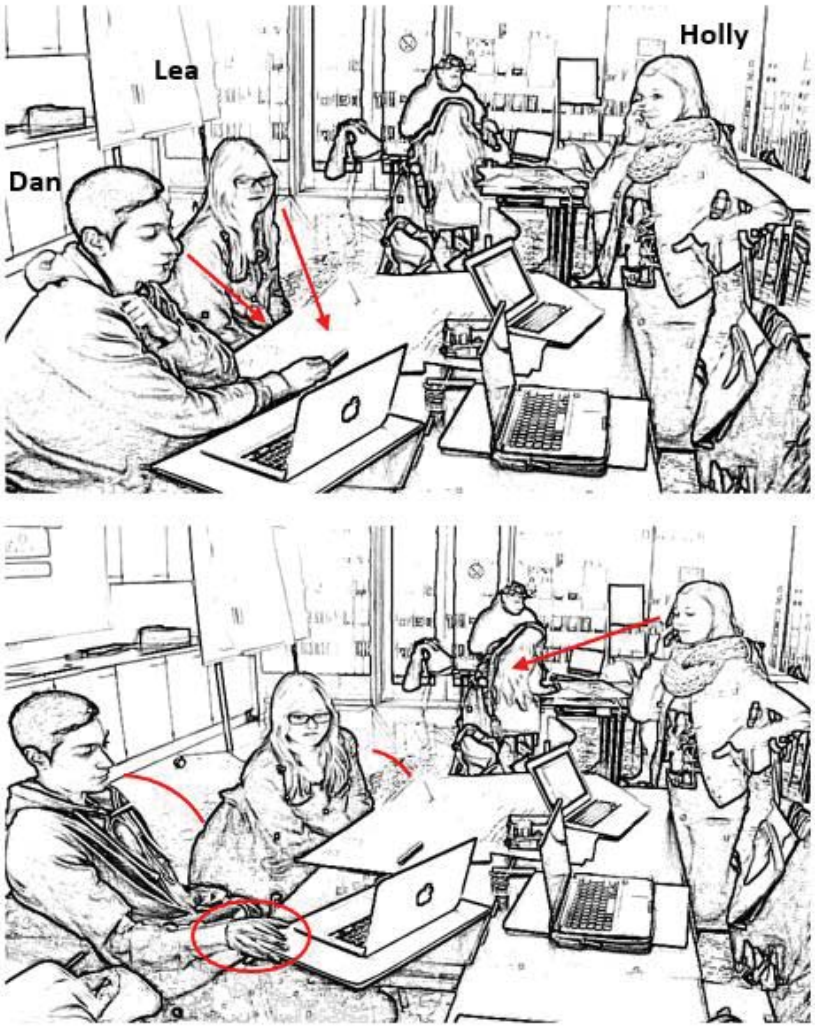
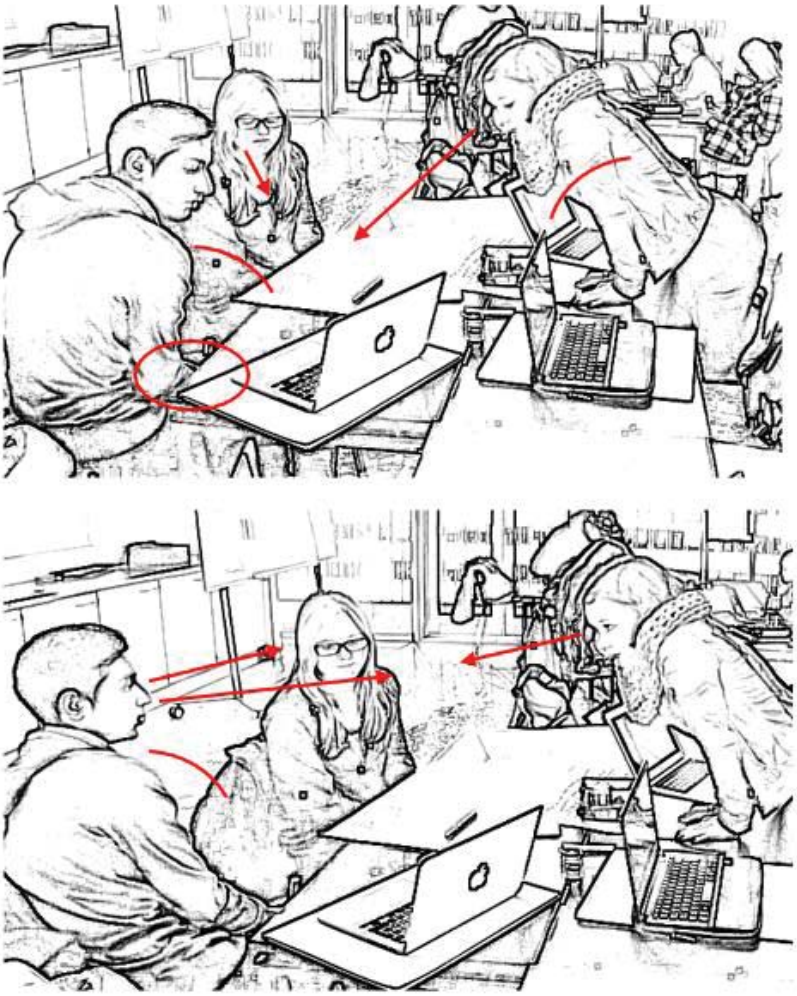


Figure 5 Establishing contact and focus for attention.

Dan elaborates the proposal in frame 3. He talks fast and hesitates ">then we could ask if< she wants eh:: to:: (.) eventually", while placing his hands between his legs and bending his body inwards, displaying a closed body language. He maintains his gaze towards the screen while uttering his proposal as if using what is displayed on the screen as verification in relation to the proposal. Lea interrupts with confirmative displays "it could be really cool [if we]", orientated towards the screen, while Dan adds details to his proposal "[make a short] interview on (.)".



3

10.36.2
Dan: >then we could ask if< she **wants** eh:: to:: (.) eventually

Lea: yeah it could be co- really cool [if we]

Dan: [make a short] interview on (.)

4

10.40.4
Dan: °the phone° **maybe**? >or something<

Holly: eh:: (0.5)

Figure 6 Rejection followed by withdrawal of proposal.

In frame 4, Dan lowers his voice "°the phone° maybe? >or something<", looks from Holly to Lea, while leaning slightly back, displaying uncertainty with a questioning and indefinite closing to his idea. Holly looks at him, while uttering a prolonged "eh::" followed by a pause. In the next frame she leans back, looks down and expresses a seemingly enthusiastic "Yes!" immediately followed by a "that might be" while lowering her gaze and wiping the table with her hands, which may indicate resistance rather that acceptance. Meanwhile Dan is already expressing a withdrawal of his idea with a whispering "°maybe°".

In frame 6 Lea is attempting to support Dan's idea, she lowers her voice, asking where the email is, seemingly ignoring Holly's hesitation. She refers to "the email" and gazes at Dan's screen as if to build up new action towards acceptance of the idea rather than dismissing it, by reusing resources provided by the prior action in frame 2 (Goodwin, 2013). Holly continues, saying they might "be lucky" and adds that they are "surely" not the first ones to come up with the idea, shaking her head slightly. A long silence follows (2.9 seconds), perhaps indicating disagreement or rejection (Pomerantz, 1984; Davidson, 1984). Lea then ads "but we can always try", glancing towards Holly. After this extract, Holly agrees to the idea and they decide to go with the idea of an interview.

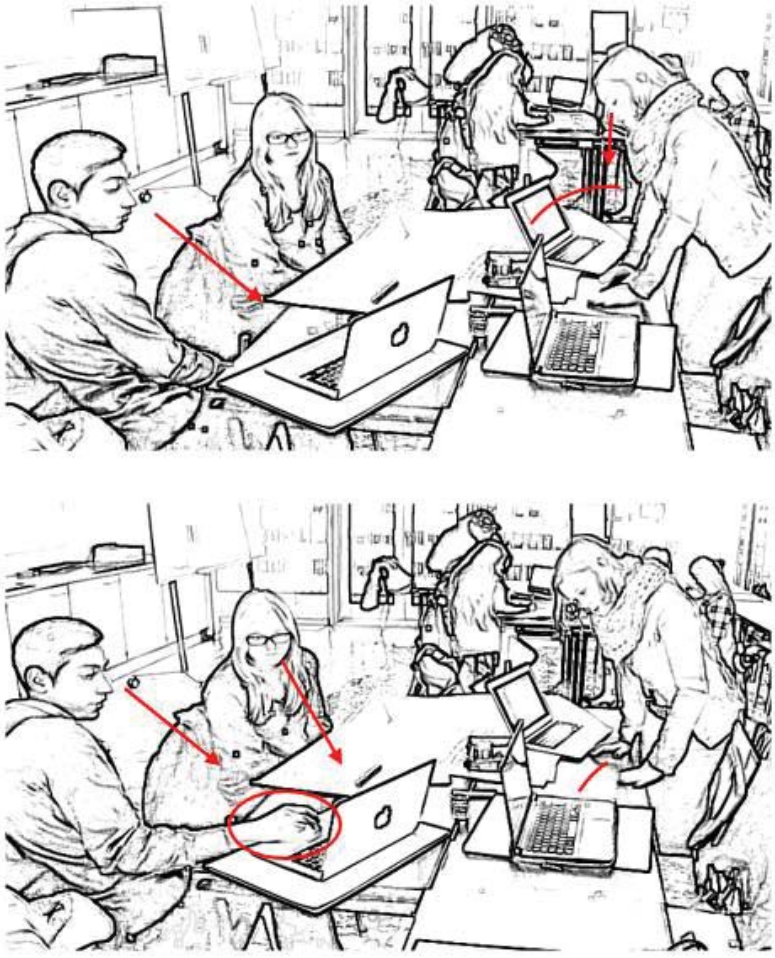


Figure 7 Reattempting to support idea.

What this excerpt exemplifies is how Dan is able to attain joint attention mediated by a personal laptop. The reason, we may assume, is that Dan actively draws on his laptop as a communicative resource during his idea proposal by organization his utterances around it (bodily orientation, gaze and verbal references). It is worth noting how he turns the screen towards the others. This seems like an effective way of establishing joint attention, making it possible for Dan to not only propose his idea, but also establish a common point of reference for decision-making when the need arises. In line with Goodwin's analysis on the discursive role of vision within different professions (1994), we argue that talk, gesturing, and image, mutually enhance each other in establishing joint attention.

5 Discussion

The present results contribute to procedural understandings of collaborative design practice, by honing in on oscillations between individual activity and joint attention in co-located design teams. By examining episodes of joint attention, we found that the frequency and duration of social episodes fluctuate over the course of designing in predictable patterns dependent on phases and activities involved. Descriptive models of design processes were informed by the theoretical separation of design sub-activities into transition and action processes, and the empirical evidence suggesting that many sub-activities carried out in transition phases seemed to contain more and longer periods of joint attention. We found that idea generation and problem defining activities were of longer duration, and the most frequent types of episodes related to concept development and planning. Conversely, action phases were mainly somewhat shorter and less frequent as

illustrated by the infrequent joint episodes on information search, with later design phases characterized by decreased shared attention duration, possibly due to numerous short touch-back episodes to check with shared team goals keeping individual design activity on track. The findings illustrate that the currently held general conception of team designing as entirely social in nature is overly simplistic: much of team designing entails individual activity, albeit delegated to individual sub-goals, and less than half of co-located team designing in our data contained joint attention. Future descriptive models of team designing should incorporate the understanding that only a subset of activities taking place in collaborative design involves social interaction.

Further, in the context of ubiquitous personal mobile computing, the present paper attempted to examine the role of communicative resources in attaining the sought after joint team attention. We found that both visual and hidden references to analogue media effectively mediated the relation between individual attempt to attract attention, and subsequent joint attention. Similarly, visible digital media (e.g., sharing a screen) was also effective, but references to invisible digital referents did not support shifts to shared focus. Follow up qualitative examples helped illustrate that the frequent and inadvertent shielding of personal screens in co-located designing was unhelpful in providing visual cues to quickly gain an understanding of the cause of interruption.

The realization that team design efforts do NOT always involve social activity attenuates the battle for individual attention taking place in co-located team designing. Thus, the present findings have implications for the organization of design, and for the design of design tools, in educational settings. For example, the frequent, but short, joint attention episodes during later design phases may imply the need for continuing brief social team engagement even when many design teams would have delegated that activity to an individual. Further, quick visual access to cues for what is causing attempts to attract attention is important for establishing dialogue, and design process tools might do well to further consider how to incorporate shared visual cues, and allow for quick episodes of team touch-back at later design stages.

Future research should further investigate the oscillating nature of team design activity in professional design teams. The present study made use of a co-located in-situ educational design setting with high-school students and it is unclear to which extend the present findings will generalize to professional contexts. It is for example noteworthy that the student designers in the present study spent limited time exploring the design problem, which is unlike known design expert behavior (Dorst & Cross, 2001). Furthermore, for the present purposes, we restricted our analysis to shifts from individual to social activity, ignoring the opposing directionality due to difficulties in coding non-verbal individual design activity. Individual activities may be examinable in other ways than through verbalizations (e.g., though observational estimates of their functions), and hence their future study could help explore further the nature of individual-social oscillations.

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