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Kinds of 'moving' in designing with sticky notes

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We explore why and how designers move sticky notes by conducting a visuospatial analysis of sticky note moves as they unfold across time in design practice. We find that individual sticky note moves have a relatively stable sequential order containing strategies for directing and maintaining shared attention. Further, three kinds of sticky note movements are found pertaining to the formation of associations, categories, and partial solution structures. Moving sticky notes provides support for conceptual design centrally through attending to the proximity between notes across time in gesture and placement. Proximity serves as a marker of associative strength and category centrality, and also plays a key role in the structural build-up of relationships between objects.

Keywords: design moves, design practice, design cognition, collaborative design, ethnomethodology

The type of design situation that occupies us in the present paper is commonplace and mundane: A group of designers is positioned in front of a whiteboard already populated with filled-in sticky notes, engaged in a creative process to advance a design project. A designer grabs one of the notes, removes it, and re-affixes it in another location on the board.

Below we explore how and why designers move sticky notes. Specifically, our interest hones in on trying to understand the peculiar and perhaps puzzling practice where the designer uses the sticky note's flexible repositionability by moving an already filled-in note (typically containing a couple of words) to another spatial location on the board. When viewed in isolation, sticky note moves may seem like a puzzling design practice— what could be the purpose of moving that note a few inches?

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The study of how specific forms of representation or materials support design have been important to design researchers in advancing our understanding of design practice and cognition (Cash & Maier, 2021; Ball, Christensen, & Halskov, 2021). Several studies have explored visualization and prototyping

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(Chafi, 2014; Pei et al., 2011) in order to understand how representations may provide external support for design cognition (Scaife & Rogers, 1996; Tversky & Suwa, 2009), for example, to resolve uncertainty (Cash & Kreye, 2017; Christensen & Ball, 2019). The ubiquitous sticky note represents one of the most commonly deployed ways of visually supporting design yet remains one of the least studied and understood (Ball et al., 2021). Currently, we do not have an empirically qualified understanding of how sticky notes facilitate design processes. We know that sketching supports design cognition through the visual reinterpretation of ambiguous forms (e.g., Goel, 1995; Tversky & Suwa, 2009), and prototypes allow for processes of detailing, collaboration, and filtering the design space (Lim et al., 2008). However, it remains theoretically unclear what sticky notes offer, and we know little about how the proximate and relational repositioning of objects and words over time facilitates design progression. With this study, we aim to help further theoretically explicate *how* visualization plays important roles in designing with sticky notes.

By honing in on the trademark quality of sticky notes—the flexible repositionability offered by the strip of adhesive on the rear side—we ask what the relative repositioning of words and sketches on paper offers to a design process.

Analysing sticky note moves poses a challenge to the standard research methods used in design cognition. Often, no new information is explicitly added by moving a note, and the nature of such moves renders the activity short on verbalization that might explicate their purpose. Consequently, it is necessary to draw into the analysis the visuospatial layout and content of the rest of the board along with the situated and embodied interaction of the design team to understand the sequential order and kinds of sticky note moves. This aligns well with a new and growing body of practice-based design research which focusses on the study of embodied, situated, and multimodal design practices often conducted in natural settings (Ball & Christensen, 2018; Comi et al., 2019; Lloyd, 2019; Luck, 2012; Matthews & Heinemann, 2012). A few recent papers have focused on social practices in using sticky notes as design artifacts (Due, 2018; Matthews, 2009; Matthews et al., 2021; Nielsen, 2012), and others have focused on mundane kinds of cognition and reasoning (Livingston, 2008; Luck, 2012).

This paper deploys a multimodal methodological approach to analyse sticky notes moves as a type of design activity. We aim to empirically explore and theoretically advance knowledge of *kinds of design moves* by giving primacy to a *visuospatial analysis* of observable design moves using sticky notes. First, we aim to uncover the situated sequential order of sticky note moves. Second, we will explore the different *kinds of sticky note moves* that help create new connections, combinations, and relations amongst sticky notes, and the visual strategies and processes used for their explication.

1 Theoretical background

1.1 Sticky notes as design material

Visual design materials are central to architects 'and designers' professional vision, as these materials help the formation and articulation of their design intentions (Comi & Whyte, 2018; Luck, 2007, 2012) and coordinate design activities (Luck, 2010; Rakova & Fedorenko, 2021). Sticky notes are a particular type of design material, and how they feature in the course of design activities is underexplored within design research. The past decades have seen the emergence and popularization of the sticky note as a material to support a host of—mainly collaborative—design processes (Christensen et al., 2020). Unlike classical design materials mastered only over years of training in the studio, sticky notes are intuitive and require little training. As a medium, they are representationally flexible (allowing, e.g., for sketches and words), with words as the most common entry. Their small size and flexible repositioning invite wasteful, divergent productions of many disconnected concepts that are later moved around and brought together to create new, meaningful, structural wholes.

The most common use of sticky notes as a design material involves relatively short-term situational collaborative design processes where the group is positioned in front of a whiteboard, with each participant armed with a block of sticky notes. Over time, the board becomes populated with aspects and ideas (each written on a different note) related to the problem at hand, and with each note placed visibly in a non-layered manner on the board for all to see. The specific design method employed varies (e.g., mind-map, brainstorm, empathy map). Given the popularity and relative homogeneity of such collaborative sticky-notes-on-board design activities, it seems likely that they are experienced as supporting design progression in essential ways, where both novice and expert designers finding design value in their application (Ball et al., 2021).

As a visual support tool for design, sticky note techniques deploy the graphical mapping of concepts represented as text or visual elements in order to organize information visually (Bresciani, 2019). Using sticky notes inherits some of the advantages of using other types of visuospatial displays, including how they provide the ability to use Gestalt principles to support cognition (Hegarty, 2011). Gestalt psychologists emphasized that organisms perceive entire patterns or configurations (gestalts), not merely their individual elements. In perception, elements tend to be grouped together if they are part of a pattern which is a 'good gestalt' ('prägnanz'), for example, in their simplicity, order, balance, symmetry, or coherence, also known as the *principle of perceptual organization* (Kosslyn, 2006). Good gestalts are aesthetically pleasing, as also found by theories of perceptual fluency (Alter & Oppenheimer, 2009; Reber et al., 2004). The Gestalt 'Law of Proximity' states that spatial proximity may be used to group and organize conceptually related information, even

for abstract information. Similarly, the utilization of colour or graphical devices (such as lines and circles) may also serve to illustrate proximity (Wickens & Carswell, 1995).

In sticky note sessions, the principles of perceptual organization may serve an essential function in allowing a vast number of initially disconnected elements (visual disorder) to be dynamically moved into emergent clusters and groups (creating visual gestalts and order).

1.2 Design making and thinking

Designing may be described as a process that transforms initially disparate elements (*parts*) into new, aesthetic, and relationally structured configurations (*wholes*) through the coevolution of problem and solution (Dorst & Cross, 2001; Wiltschnig et al., 2013). In this process, designers effectively move around in two spaces. One is an embodied, materially messy space of making things, populated with objects and parts that are seen by eyes and are combined, built up, and broken apart by hands (Luck, 2018). The other is a cognitive space, where possibilities are explored and created through framing, constraining, and restructuring (Cross, 2011; Newell & Simon, 1972; Simon, 1969).

In design practice, designers seem surprisingly capable of merging these two spaces by *thinking-in-the-middle-of-making-things* (Livingston, 2008), as illustrated in practice-based studies (Luck, 2012) and the literature on situated cognition (Ball & Christensen, 2018; Hutchins, 1995). *Thinking* and *making* approaches tend to study design moves in somewhat different ways, as will be reviewed below.

1.3 Design thinking moves

In the early days of design research, design was conceived as a cognitive search in a space of possibilities (Newell & Simon, 1972), bounded by cognitive capacity limitations (Simon, 1969). A 'move' was considered the change between two states in the problem space through the application of an operator. Moves were considered to be hypothetical cognitive steps taken by the problem solver in a space of possibilities, with linear progress prohibited notably by cognitive capacity limitations and the nature of the problem. Following in this tradition, Goldschmidt (1995, p. 195, 1997) characterized design moves as 'a step, an act, an operation, which transforms the design situation relative to the state in which it was before the "move"'.

Aligning with the definition of a design move as the application of an operator that changes the current state, a critical class of design moves pertains to the combination, building of a structural relation, or association of objects (e.g., sticky notes) in the design space. Such moves (operations) may be considered

a low-level kind of cognitive activity (often occurring outside cognitive awareness), which may be studied by exploring the shifting spatial relations among elements. The type of design moves occupying us here considers a design move to be perceptible through a study of design behaviour (Chiu, 2003) instead of being constituted solely as a discursive move that may not produce any physical change (Trousse & Christiaans, 1996). Thus, we focus on the micro-operations connecting visual objects instead of studying design moves involving mainly higher-order cognitive functions such as framing (Paton & Dorst, 2011) or reinterpretation (Stones & Cassidy, 2010). Through the study of situated object interaction, we will observe the role of sticky note moves that combine notes and build up structure, as well as moves that relate notes to other notes through mere association. We build on the approach of Dove et al. (2018), who investigated how sticky notes support categorization qualities associated with semantic long-term memory and showed how sticky notes may be considered nodes in an emerging semantic network.

In design cognition research, the theoretical distinction between associations and structural relations has been investigated and related to expert behaviour. Thinking in terms of structural relations between parts and elements constitutes a central component of how expert reasoning differs from novice reasoning, whether in design (Cross, 2011), chess (Chase & Simon, 1973), or the categorization of physics problems (Chi et al., 1981). Thinking about structural relations is a deliberate and controlled type of cognitive activity, drawing heavily on the capacity of attention span, executive functions, and working memory (WM), that is sometimes tied to expert reasoning. Conversely, novice reasoning has been described as relying on superficial similarity or the mere associations between elements, drawing centrally on associative memory through automated processes undemanding of WM resources. The current understanding in cognitive psychology is, however, that the two forms of similarity are mutually dependent. Associative memory (Anderson & Bower, 1973) and superficial resemblance can play an essential part in supporting the build-up of relational structure. For example, analogical reasoning implies a conceptual mapping and transfer of structural relations whereby knowledge from a base domain is mapped onto an objective from another (target) domain (Gentner, 1989; Gentner & Markman, 1997). It has been shown that the process of retrieving analogies relies heavily on quick, parallel, and automated associative similarity (Forbus et al., 1995; Holyoak & Koh, 1987) before a subsequent WM-taxing process of mapping and transfer may take place (Markman & Gentner, 2005). Therefore, associations may play key roles in forming new structural relations and are important for novices and experts alike. A current example of the close interplay between association and creating structural relations comes from dual-process theory. Dual-process theory's premise is that there are at least two types of cognitive processes: Type 1 is intuitive, associative, and fast, and Type 2 is analytical, deliberate, and slow (Evans & Stanovich, 2013). Designers typically move between such

associative and analytical periods as they explore and refine their concepts (Steinert & Leifer, 2012; Wiltschnig et al., 2013), and most design tasks appear to involve some interaction between these two types of processes (Badke-Schaub & Eris, 2014). Ideation is often characterized by rapid bursts of associative idea generation (Type 1), interspersed with deliberate, reflective periods of interpretation and structural build-up of design elements (Type 2) (Ball et al., 1994; Cash & Maier, 2021; Gonçalves et al., 2016). While we do not usually refer to associations as 'design moves', we here draw attention to associations as an ordinary and meaningful way to connect and relate objects that help establish associative networks of potential importance as a foundation for building up structure.

1.4 Design making moves

A different approach to design moves is attributable to Donald Schön (1983; Schön & Wiggins, 1992), who famously described how designing involved repeated micro-episodes he labelled move 'experiments', wherein the designer engages in a conversation with the material. Schön described in detail the 'kinds of seeing' involved in the designers' professional 'vision' (Goodwin, 1994) in these sequences, where the consequences of a move would be explored. Schön and Wiggins (1992) distinguish several kinds of seeing that perform distinct functions in design but all draw on visual apprehension. They may involve seeing spatial gestalts that may guide their thinking in terms of object relations. Episodes of seeing-moving-seeing often entail perceptually discovering emergent but unintended and unexpected consequences of design moves.

Much of practice-based research builds on the concept of 'professional vision' (Goodwin, 1994), whereby professionals 'see' and 'articulate' events and visual objects in their perceptual field. Through video analysis of professionals in action, Goodwin studied socially situated activity, including interactions with visual objects, and identified three practices of 'seeing' and 'articulating': coding, highlighting, and producing visual representations. In this tradition, it is notable that a 'move' is a process involving the perceptual act of 'seeing' by applying professional vision to the design situation through 'seeing-moving-seeing' sequences. With Schön, we thus gain a language for the process of 'design moves' where designers engage in material-making. We note that not all visually available objects can be attended to at any one time. In this respect, Whyte et al. (2007) made the distinction between 'fluid' (open and unfolding) vs. 'frozen' (unavailable for change) visual objects. While fluid visuals seemed to support activities relating to collective sense-making and exploration, frozen visuals mainly enable keeping records of design decisions and mobilizing consensus. In the design process, objects, however, do not become frozen or fluid in any absolute sense, but, dependent on the situation and the task at hand, may become unfrozen or refrozen, with the specific

pattern playing essential roles in setting the tempo and direction of design activities. In offering primacy to movement and change, the concepts of freezing and unfreezing may be used to describe and understand how the complex set of visually available objects in sticky note sessions may iterate between stable and active positions.

2 Methods

2.1 Data

We analysed three select episodes of naturally occurring collaborative sticky note interaction from datasets previously collected. Example 1 stems from a study of sticky note interaction in student design teams with facilitated brainstorming and clustering activities (Abildgaard, 2020; Christensen & Friis-Olivarius, 2020). Examples 2 and 3 stem from a dataset of a professional design team working for a European car manufacturer, which has previously served as a shared dataset for the Design Thinking Research Symposium 11 (Abildgaard & Christensen, 2017; Christensen et al., 2017).[1] Example 2 has been partially analysed for how sticky notes support semantic memory in a previous study (Dove et al., 2018), and we extend the analysis here to focus on the kinds and structure of design moves in a more fine-grained analysis. We refer the reader to descriptions of the datasets and methods in the previous publications. Each example is selected based on a thorough screening and initial coding of the two datasets, where interaction with sticky notes occurs. The first dataset (from which example 1 is drawn) consists of moves with 867 sticky notes. The second dataset (from which examples 2 and 3 are drawn) consists of moves with 160 sticky notes in the two design sessions. To give an idea of the frequency and commonness of sticky note moves in our data, the design team, in example 1, moves 15 sticky notes a total of 40 times during a 6 min-and-30-s-long convergent episode. Our analytical interests extend to the visual relatability of individual notes through their movements to other notes on the board. We focus our selection of examples on convergent processes such as categorization and clustering activities, and ignore for the present purposes the divergent or ideation phases where the sticky notes were first filled in.

2.2 Analytical approach

Given that we will be zooming in on the situated practice of designing (Nicolini, 2009) and focusing on micro-episodes of individual sticky note moves, we are operating at very short-term timescales in design (Shroyer et al., 2017). To analyse the kinds of sticky note moving and their sequential order in design, we draw on the methodologies of ethnomethodology (EM) (Garfinkel, 1967) and conversation analysis (CA) (Sacks & Garfinkel, 1970) (henceforth EMCA) and combine this inductive approach with the methodological flexibility of cognitive psychology (de Ruiter & Albert, 2017; Gylfe,

Franck, Lebaron, & Mantere, 2016) and an ethnographic approach to design research (Ball & Christensen, 2018; Button & Sharrock, 2000; Matthews & Heinemann, 2012). We rest our analysis on video recordings of naturally occurring interaction (Heath et al., 2010).

One of CA's basic analytical strategies is to locate the problem that certain observable talk and doing might be a solution to (ten Have, 2007, p. 16) by attending to the action's sequential order on a turn-by-turn basis. Our theoretical assumption is that designers working with sticky notes, more specifically *moving* sticky notes, seek to create order and connect parts into wholes by organizing and associating sticky notes. In this case, we are zooming in on what designers are doing, saying, and not-saying at a particular moment, and analysing how and in what ways these practices are the solution to the problem of creating an order. The sequential order of the social practice of moving is analysed in each example and illustrated with visual and verbal transcriptions inspired by the Jeffersonian system (Jefferson, 1984). We aim to describe the overall interactional order of design moves with sensitivity for the situated—embodied interaction and the material-semiotic environment.

Our microanalytic concerns begin with the transcription of the video recordings informed by video ethnography (Heath et al., 2010) and the branch of EMCA that focusses on multimodal interaction (Deppermann, 2013; Goodwin, 2013; J. J. Streeck et al., 2011). Our approach is inspired by similar approaches within EMCA studies of the here-and-now details of situated social interaction (Heinemann et al., 2012; Luck, 2010; Matthews & Heinemann, 2012). Since our primary focus of the analysis is not verbal utterances but the moving activity itself, our analysis takes its beginning at the moving of a sticky note from one place to another. This entails that moves, like turns at talk and actions, are regarded as projectable, in that designers, given their professional vision (Goodwin, 1994), can see trajectories of moves as they unfold (Hindmarsh & Pilnick, 2007). The move of a sticky note may initiate a line of moves, which reconfigures the sticky notes and their relations and makes the designers able to recognize the current design/problem as being closer to a new coherent configuration. Thus, the organizing principle of the analysis and the transcription rests on the embodied actions of the participants and the objects in use, an approach similar to the study by Comi et al. (2019, p.102), which concentrates its analysis on the visual objects in use and not the verbal utterances. The transcription is centred on the timing of each move of a sticky note as the organizing principle. To make the visualizations of each move in the analysis as accessible as possible for the reader, we use still frames from the video data and draw simplified illustrations thereof. The illustrations show the organization of the sticky notes on boards and visualize the moving of each sticky note illustrated with a number for the order of each move. We show the time it takes from moment the sticky note is lifted from the board, moved, and placed again with time measured in seconds (e.g.,

[2.9]). Each illustrated frame has a timestamp (hh:mm:ss.s). Alongside the visual illustration of the moving sequences, we transcribe parts of the verbal actions where they are sequentially connected to the embodied actions of the moves. Acknowledging the challenges for multimodal transcription exceeding talk, body, and gaze (Mondada, 2018), we aim at a precise transcription of the details relevant for this study, in particular touch, moves, and talk, and their sequential order. In some cases, we have also included animated images from the video data in a simple form (GIF) to illustrate certain moves or gestures in detail.[2] We aim to design a visual and verbal transcription of the here-and-now details of the moving activity with sufficient details for the readers to grasp the process of the interaction.

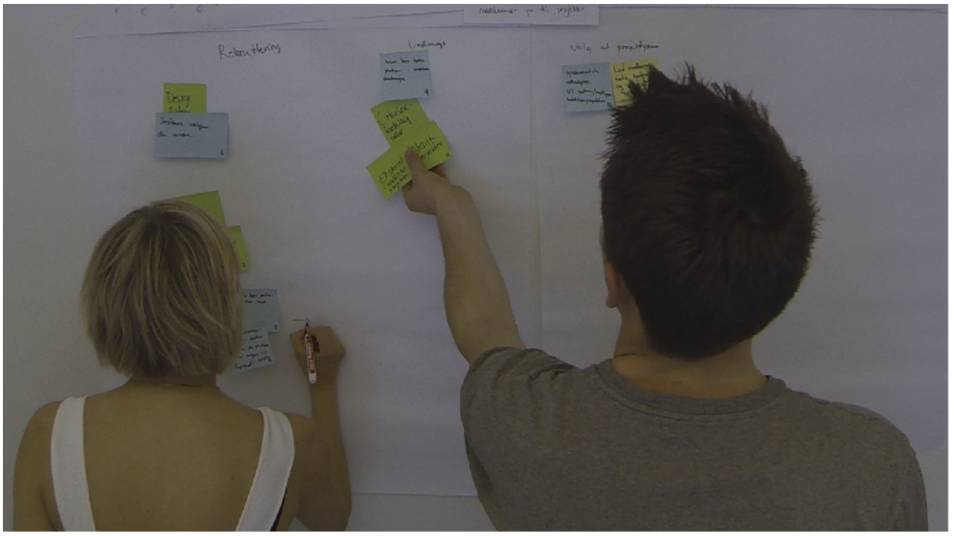
3 *Analysis*

We have chosen three examples derived from the abovementioned datasets to illustrate how design teams collaboratively move sticky notes and why these moves make sense in their particular design processes. The three examples have been chosen in an abductive analytical process where we have screened the datasets for sticky note moves and interesting empirical findings, discovered blended and distinctive types of moves, and after detailed microanalysis of candidate extracts, selected and examined the three examples below in a theoretical context, where the observed design activity is accounted for rather than predicted (Svennevig, 2001). The three examples which we analyse below are not an exhaustive list of 'kinds of moving' but are the most prevalent, repetitive, and legible examples in our datasets of design activities with sticky notes.

3.1 *Example 1*

We begin our analysis of kinds of moves by looking at a student design team of three working in a convergent design phase after a facilitated brainstorming session on developing a strategic design proposal on recruitment of clients for a credit card company (see Picture 1). The design team had selected several sticky notes from a previous brainstorming session, which have been placed in categories below three headlines (see frame 1, Figure 1).

We enter the data when the design team begins to move the sticky notes from the headlines downwards on the whiteboard. The moves result in a flowchart representing the necessary steps and decisions in a process (frame 4, Figure 1). Creating the flowchart is not something the team has discussed prior to the moving of the sticky notes. It is something that happens during the process of moving and is never verbalized as a specific goal. As we see in the first frame in Figure 1, sticky notes A1 and A2 are moved to the bottom of the whiteboard (move 1, [2.6]). The person moving the sticky notes, Karen, draws an arrow after placing the note to mark something to follow. In this excerpt, the trajectory of the move becomes immediately apparent to the co-participants as the



Picture 1 Two of the team members at the whiteboard moving sticky notes

first pair of sticky notes are moved and now visually represent a sequence of steps in the flowchart that is beginning to take shape. The moving of sticky notes from a categorical representation to the developing flowchart continues in the following turns and comes to an end when all the sticky notes have been reorganized to visually represent a flowchart (see Figure 1). We notice a longer pause between the moves in frame 3 (move 7, [3.0] and move 8, [9.0]), where the flowchart at this point consists of four steps/sequences. The design team takes some time to move and place the sticky notes following an organizing principle where all parts must fit into the flowchart. However, some sticky notes (F1, F2, G1, G2, G3, and H) are still left below the headline categories. Next, the team moves the last notes from the remaining categories to fit into the flowchart at the bottom of the whiteboard. They move one cluster of notes to the front of the flowchart (i.e., move 8) and cluster the leftovers (G1, G2, G3, and H) as if to fit them into a final sequence of the chart (See move 9 and 10, frame 4, Figure 1). The notes G1, G2, G3, and H did not belong together when they were placed below the headlines, and none of the team members explicitly argues for a connection between the notes, nor does the content of the notes directly interrelate. However, H is stuck onto the G cluster in the final move, and now all sticky notes fit into the flowchart representation.

When we turn to the linguistic form of the utterances accompanying the moves, we notice how the turns are formatted around each move in a way that displays attention to an expected course of action. First, we focus on how Karen begins to move the first pair of sticky notes while also reading aloud the content of each note, enabling the two other members to locate 1) which note is being moved and 2) what the written content on the note is

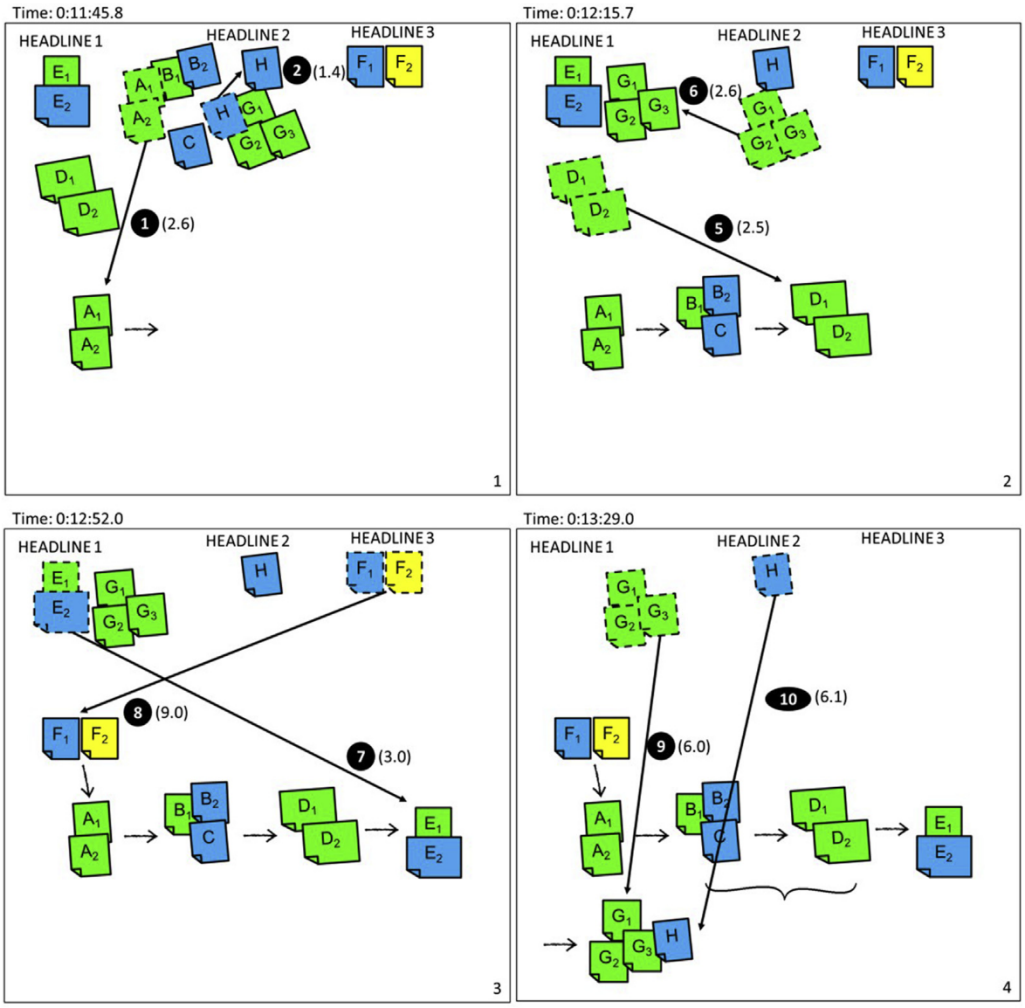
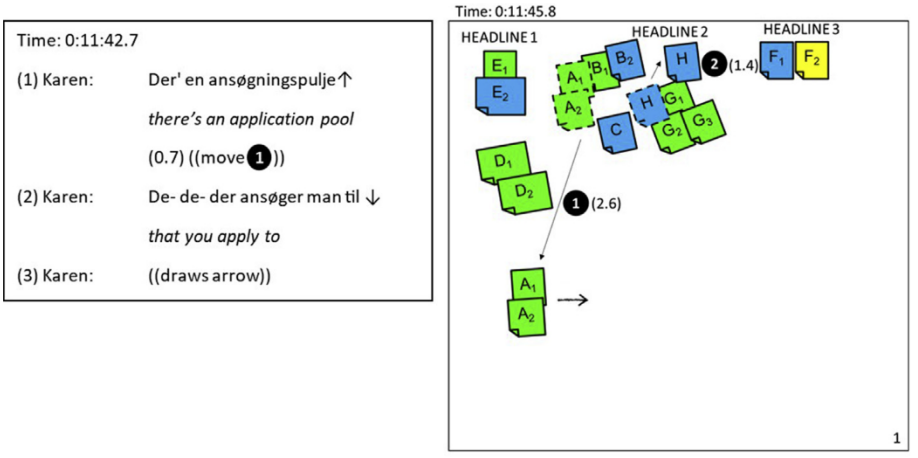


Figure 1 Moving sticky notes from categories with headlines to flowcharts

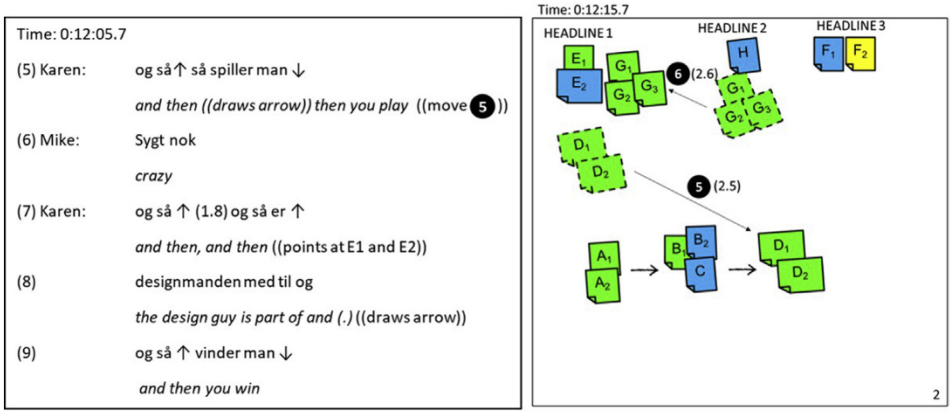
(Excerpt 1). As we observe in the following examples, the reading aloud of the sticky note prior to the move or parallel to the move is part of the sequential order of sticky note moves.

The first part (line 1) of the turn is produced with a rising intonation (indicated in the transcription by the upward facing arrow) and the second part (line 2) ends with a falling intonation (indicated by the downward facing arrow). This format indicates something similar to what Jefferson (1990) names as 'lists' in natural conversations, where the variation in intonation arouses the expectation of a listing of sorts (rising intonation) and eventually the ending thereof (falling intonation). In this example, the prosodic practice of 'listing' follows

Kinds of 'moving' with sticky notes



Excerpt 1 Reading aloud and moving sticky notes



Excerpt 2 Listing sequences in flowchart and moving sticky notes

the moving and drawing in the interaction. At move 5 (Excerpt 2), the sequential order becomes more established.

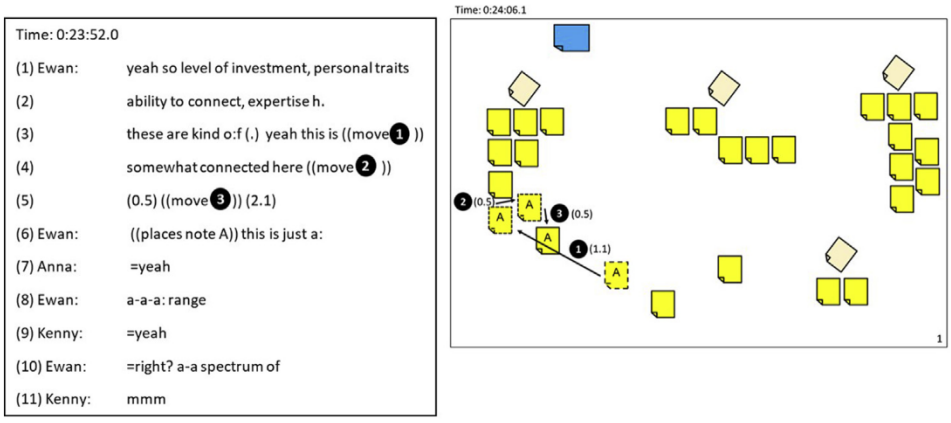
Karen uses a '*and then*' with rising intonation to display to her co-participants that something is next up, a listing of sorts, after which the move is made. Karen then draws an arrow (line 8), and a falling intonation indicates the end of the move (line 9) and the new placement of the sticky notes. The order of moving in this example is as follows: 1) localization of note move by reading aloud, 2) moving note, 3) drawing of arrow, 4) localization of next move by reading aloud, 5) moving note, and so on until all sticky notes have been reorganized. In this example, the speech produced by Karen creates expectations for what comes next; another set of sticky notes will be moved from the categories at the top of the whiteboard and reorganized as a part of a sequence in

the flowchart at the bottom. This example illustrates how the team moves notes in clusters and visually establishes and maintains an inter-note connection while reorganizing the notes. As we will return to in the discussion, this example shows how markings in the form of arrows between the notes being moved serve as a strategy to visualize causality and direction in a new emerging whole.

3.2 Example 2

This example is drawn from a dataset of a team of professional designers developing a concept for a workshop with lead users of specific car accessories. The notes on the board illustrate different elements of the workshop design, such as user personality traits, values, and habits, which have been developed during a brainstorming session and placed on the whiteboard in emerging categories. We enter the data when the design team is rearranging the sticky notes after the initial placement. In this example, we see how the design team is figuring out how to move and place two sticky notes in relation to the existing sticky note categories that have just been formed. Four categories have already been formed on the board, but some sticky notes are yet to be placed in their 'correct' location. In the example, we see the design team discussing the association between the sticky notes and the existing categories, which results in a row of moves relevant to 1) how one sticky note is associated to, but not part of, one category and 2) how another sticky note is not associated to the other categories (dissociation) and is thus placed in a new emergent category. The analysis begins with 1) moving to associate to a category.

The move follows an order consisting of several elements. Before moving sticky note A, Ewan, the project leader, reads the headlines of the four existing categories aloud to the rest of the team (Excerpt 3). While reading each headline, Ewan gestures by pointing at the corresponding sticky notes 'level of investment', 'personal traits', 'ability to connect', and 'expertise'. The three moves before the sticky note A is placed happen in parallel with Ewan stating that the note 'is somewhat connected here' (line 4, Excerpt 3). The note is moved closer to the left-hand category of notes, as illustrated in Figure 2. After three moves slightly varying the spatial proximity to the category, taking less than 3 s in total, the sticky note is placed relatively close to the category to the left, but not symmetrically aligned with or close enough to visually represent being a member of the category (See Figure 2 or GIF 1 for visualization). This example illustrates how the moving of the note is sensitive to proximity to other notes. The (correct) distance between the note and the category is the driver behind the move; if the note stayed at the original placement, it would be too far away from any categories to indicate category membership or association. However, if the note is moved too close to the category to the left, it would be wrongly placed since it is not a member of the category entirely but only 'connected'—proximity matters in this case (Dove et al.,



Excerpt 3 Moving sticky note A closer to the left-hand side category

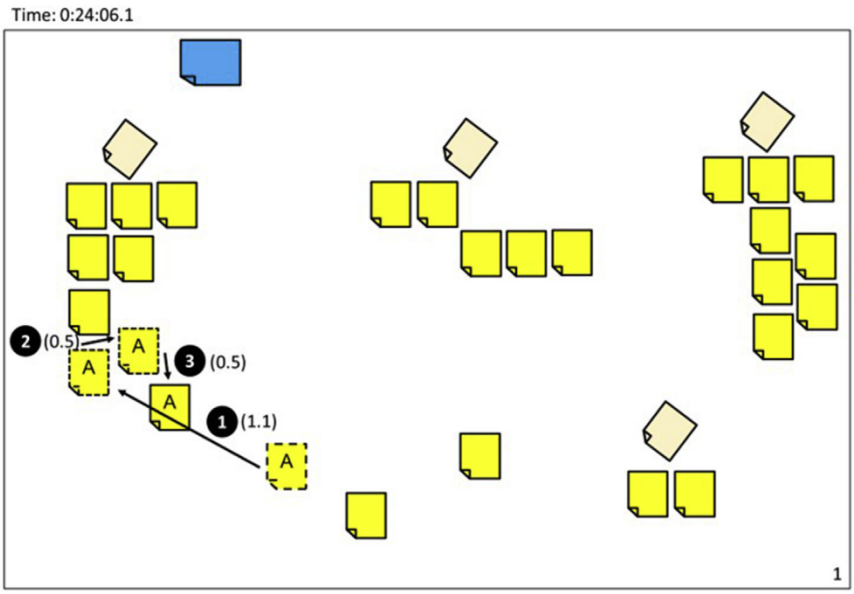


Figure 2 Moving sticky note A closer to the left-hand side category

2018). Thus, the new placement of sticky note A indicates an association (not membership) to the left-hand category.

Moving a sticky note from place to place by holding it without placing it finally on the board can be a way for the design team to examine or test whether the note belongs to a category or not (i.e., membership categorization). In the next excerpt from the same session, we see how a sticky note is being moved from place to place many times as a way to collaboratively examine its membership

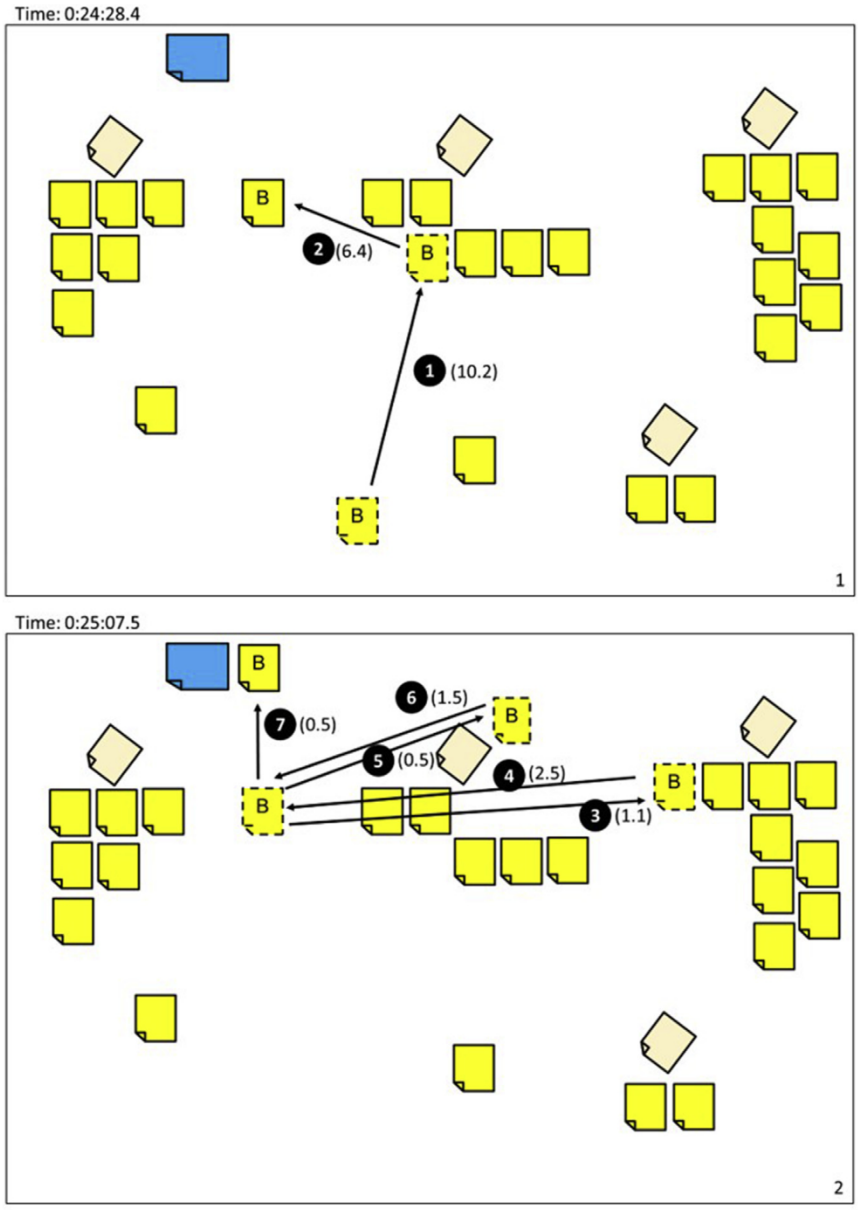


Figure 3 Moving sticky note B to the top of the whiteboard

to each category and reach an agreement on the final placement of the sticky note.

This example continues where the last move ended; after moving sticky note A closer to the left-hand category, Ewan turns to move sticky note B to figure out where it can be placed. As illustrated in Figure 3, sticky note B is moved while

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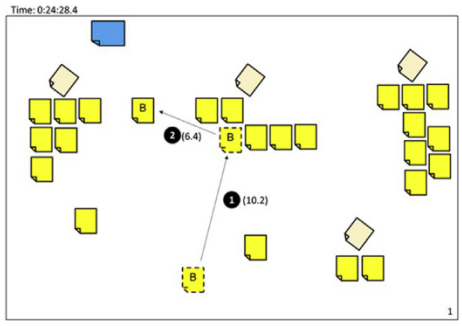
Time: 0:24:09.2	
(1) Ewan:	profession (.) profession: and prototypi:ng ((reads aloud from sticky note B))
(2)	(1.0) or or >what< did you mean with this one again?
(3) David:	kind of alignment with eh: (0.5) the
(4) Abby:	>=they told us that we<
(5)Ewan:	((move ❶))
(6) David:	it's the it's the in- >the kind of like< extending expertise maybe?
(7) Ewan:	yeah
(8) David:	or in between the whole thing there ((points towards whiteboard))
(9) Ewan:	somewhere in between here? ((move ❷))



Excerpt 4 Moving sticky note B between two categories

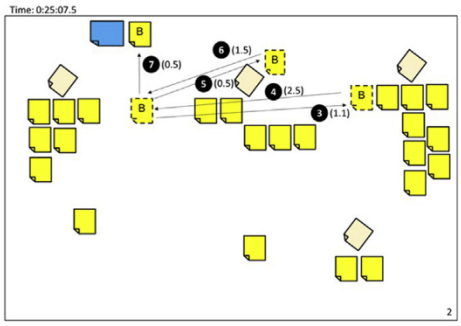
in hand a total of 7 times before it is placed conclusively on the board. However, the moving of the note occurs in two parts with a reaffixing pause in between. In the following, we will analyse the first part of the move, the pause, and the last part of the move to show the details relevant for understanding how the note is moved and what order the move follows.

First, the note is moved twice before being placed between the two categories, 'ability to connect' and 'expertise' (see Figure 3 or GIF 2 for visualization). The move is initiated with Ewan reading the content on the note aloud, 'profession and prototyping' (line 1, Excerpt 4), and then asking David, who wrote the note, what the note means (line 2, Excerpt 4). Ewan begins to move the note before David replies to the question (move 1), and Abby, another team member, also formulates an (incomplete) reply to the question. David formulates a reply with hesitation and a question-format proposal, 'kind of like extending expertise maybe?' (line 6–8, Excerpt 4), referring to the note as being a possible extension of the left-hand category 'expertise'. Immediately after, David adds an alternative placement 'in between' the two categories. Ewan asks David for confirmation 'somewhere in between here?' (line 9, Excerpt 4). The note is moved closer to the left-hand category 'expertise' and placed between this and the category to the right, 'ability to connect' (move 2, frame 1).

After placing the note between the two categories (frame 1, Figure 3), Ewan returns to the note, points to it, and holds on to it while discussing the meaning of the content with David (see GIF 3 for visualization). Ewan touches and rubs the note with his thumb and index finger as a kind of prolongation of his turn, indicating a doubtfulness of the placement between the two categories. In the production of this gesture of touching and holding, we observe how Ewan in a verbal pause directs visual attention to the (mis)placement of the note and how the other team members orient to this particular note as Ewan holds on to it. This practice of physically holding on to the note and fiddling with it for 12 s appears to display how the placement of the note is not yet final; the note is still

Time: 0:24:51.0

(1) Ewan:	it's kind of also a little bit between this and this ((move 3))
(2)	the personal trait ((move 4)) (2.3).
(3)	it's more a h. ((move 5)) (.)
(4)	yeah maybe ((move 6)) maybe there:
(5) Abby:	but it's it's not anything that we:
(6) David:	=no no
(7) Abby:	=we need for the screening
(8) David:	=no no
(9) Abby:	>but it's something< to keep in mind
(10) David:	yeah
(11) Abby:	I mean [the: I mean] if we are:
(12) Ewan:	[you mean the tools]
(13) David:	=it's more yeah
(14) Ewan:	((move 7))
(15) Abby:	for example focusing [on people]
(13) David:	[yeah exactly]



Excerpt 5 Moving sticky note B between three categories

in the process of being moved. This sequence of actions displays orientation to the note as a misplaced element on the board and an unfinished move in the process of categorizing the notes.

The second part of the move of sticky note B occurs in five moves before it is finally placed on top of the board (see GIF 4). The moving begins with Ewan proposing a new potential placement in the category 'personal traits' to the farthest right (line 1–2, Excerpt 5). In the first move (move 3, frame 2, Figure 3) to the potential category, the note is moved in line with the other notes at the top row of the cluster formation. Ewan moves the note back to its original placement (move 4) but expresses hesitation 'maybe there' and moves the note to the level of the headline of the category 'ability to connect' marked by a yellow rotated sticky note (move 5, frame 2, Figure 3). As Ewan moves the note between the categories as if to decide their membership, he verbalizes his thoughts to the other team members. After Ewan has tested if the note belongs to two other categories, Abby objects, 'but it's not anything we need for the screening' (line 5–7, Excerpt 5). Abby and David arrive at the agreement that the note is something 'to keep in mind' (lines 6–10). Ewan displays an understanding of Abby's objection by saying 'you mean the tools' and makes the final move (move 7) where he places the note at the top of the board next to a blue sticky note (move 7, frame 2, Figure 3).

The order of the move in this example is somewhat complex since it consists of several moves in the search for a fitting category with a long pause in between. However, the order of the move can be described as follows: 1) localization of

Kinds of 'moving' with sticky notes

note to move by pointing and reading aloud, 2) move to test membership of category, 3) discussion with the team about the meaning of the note, 4) move to test membership category, 5) collaborative reinterpretation of the meaning of the note, 6) final placement of note. Interestingly, this example tells us something about how the design team collaboratively constructs the meaning of the note while examining where the note belongs by moving it back and forth between categories to find association or dissociation.

3.3 Example 3

Moving can also indicate the centrality of certain notes in a design process, which may lead to the development of new solution structures. In this example, we shall look at how moving three sticky notes results in the build-up of a new subcomponent and how additional content is added. The example is drawn from the data from the same professional team of designers as in the previous example, but this example is from further into their design process. The designers have conducted the workshop with the lead users, which has led to many new insights and ideas which have been documented on various boards with sticky notes (Picture 2) that they are using to develop and refine their final deliveries.

The design team is revisiting two boards of sticky notes. The board to the left consists of three categories arranged in horizontal rows, which maintains a structure where the leftmost note of each row represents a headline for a different subcomponent. The board to the right consists of quotes and notes from the workshop with lead users central to the design concept they are working on (Picture 3). We enter a conversation about concept development where

Picture 2 Design workshop setting

Picture 3 The two boards with sticky notes

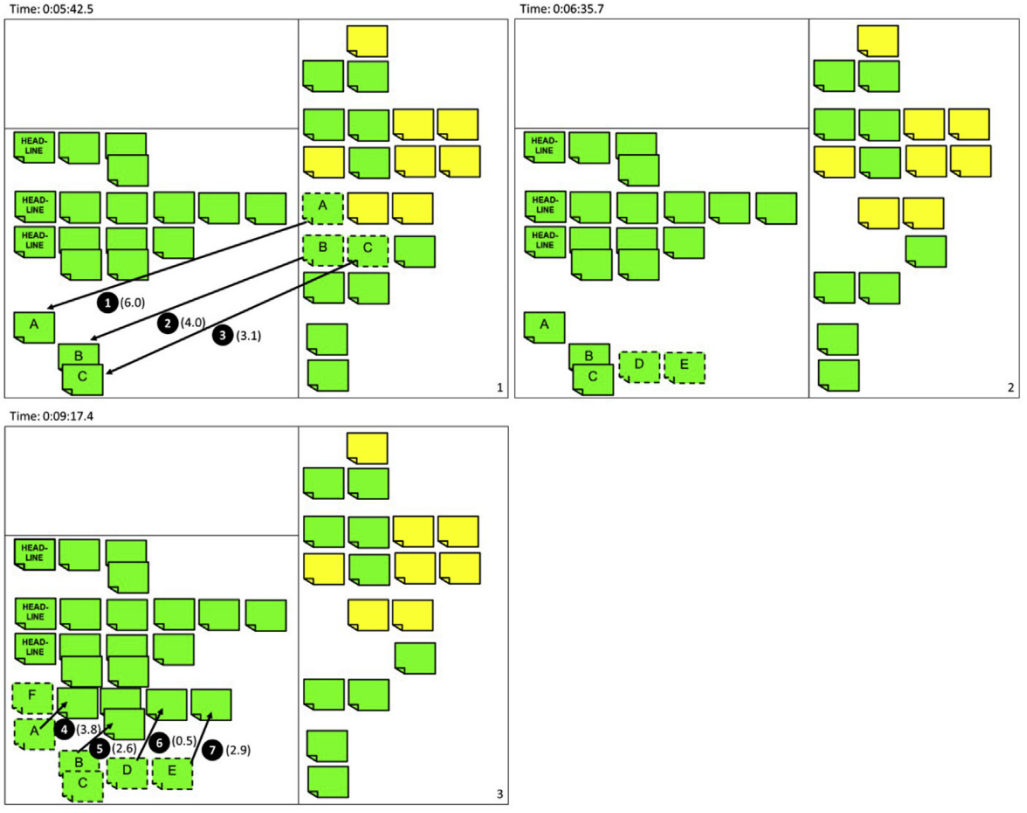


Figure 4 Moving sticky notes and creating a new category

Kinds of 'moving' with sticky notes

the design team, led by Rose, discusses how sticky notes A, B, and C may be part of the 'opportunities areas' central to the design concept they are working on (frame 1, Figure 4). Rose initiates the move by pointing to the note, which she refers to as a potential area in the developing concept. One of the team members, Kenny, agrees with her, adding that 'this could be an area' while pointing towards the board with the notes in a similar way to Rose (line 1–2, Excerpt 6). As they agree, Rose moves sticky note A, followed by note B and C, while Kenny states that 'we have several examples of it' (line 3–6, Excerpt 6) to support the decision to move the notes. We observe how note A is placed in a position to the farthest left to indicate a headline similar to the above rows of existing categories with note B and C placed on top of each other to indicate content in the category (frame 1, Figure 4). Additionally, Rose draws two quotation marks on the top of note B and the bottom of note C to indicate the two notes' merger into one. The following interaction is now centred on the board to the left where the sticky notes have been moved.

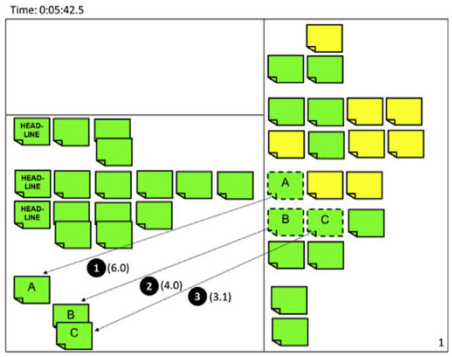
The conversation continues, and while Kenny, Rose, and Ewan are talking about details concerned with the concept development, Rose writes two new notes (D and E, frame 2, Figure 4). Rose asks Kenny if the notes are 'on the same or a different level', and Kenny replies 'the same level', after which Rose places the notes on the same level as notes B and C (see frame 2, Figure 4). On one level, the new notes serve cognitive functions by facilitating the record-keeping of what is being discussed (Dove et al., 2018). At another level, the particular way these new notes are made serves interactional functions in relation to the design's progression; they mark the formation of a new category and its added content.

The design team goes on to discuss details around the concept to arrive at a mutual understanding. Rose removes sticky note A from the board during the talk, leaving a blank spot at the 'headline' position. While keeping note A in her hand, she places a new sticky note on the board, note F, as a new headline to the category being formed. Then sticky note A is moved to the right to indicate content in the new category formation, and the rest of the notes (B, C, D, E) are also moved one by one to the right to indicate content belonging to the category (move 5–7, frame 3, Figure 4).

4 *Discussion*

We aimed to answer the research question of how and why designers move sticky notes around on boards through a visuospatial study of the temporal dynamics in 'sticky note sessions', supported by an analysis of team verbalization. Our EMCA-inspired analysis focused on understanding how individual moves are ordered and what kinds of moves are used.

Time: 0:05:38.6	
(1) Rose:	so this ((points at sticky note A, nods)) could potentially be: an
(2) Kenny:	=I think this could be an area ((points towards sticky notes))
(3) Rose:	okay
(4) Kenny:	yeah
(5) Rose:	((move 1))
(6) Kenny:	and I think we have (0.8) I think we have several examples of it
(7) Rose:	yeah but
(8) Kenny:	also:
(9) Rose:	((move 2))
(10) Kenny:	we have this Tesla buying guy he wou:ld (.) only by (.) organic (.) food.
(11) Rose:	((move 3))
(12) Kenny:	I think (0.9) it's hard to remember.
(13) Rose:	((ads quotation marks on sticky note B and C))



Excerpt 6 Moving three sticky notes from one board to another

Across episodes, we note that sticky notes are most frequently moved a single note (or one group of notes) at a time, as opposed to the movement of several notes in parallel. The visual orderliness ('prägnanz') of the board layout (Kosslyn, 2006) seems to serve as a way for the group to easily assess the progression of its chosen task. Initially, the notes will usually be placed in a disorderly array scattered throughout the board, but upon the sequential movements of notes one at a time, the board ends up in a visually more orderly state, with clear sets of visual gestalts (groups of notes placed in order/symmetrically in visually distinguishable categories). The attendance to the degree of visual orderliness as an indicator of task progression is evident even when only a few notes placed in a disorderly manner are left. We see that the group will try to order these last remaining disorderly notes in alignment with the developing representation, even when these last notes do not fit well into the developing structure (see examples 1 and 2). Only upon having completed the reorganization of the visual board by moving all notes into organized visual gestalts does the group tend to halt its work on the subtask.

Our analysis of three episodes of sticky note movements reveals the internal order of each move and samples the kinds of movements that are at play.

4.1 The sequential order of individual sticky note movements

Moving sticky notes is a dynamic process intertwined in the material environment and social interaction. In these examples, we observe how the primary social action and the shared point of attention are oriented to the material environment, the sticky notes as design materials, and the embodied interaction, not the speech system per se. The design materials and the embodied interaction with them are strong resources for the progressivity in the design

Kinds of 'moving' with sticky notes

process. For individual sticky notes moves, we notice they can be described as maintaining a sequential order.

Pointing to or touching a sticky note is used as a specific interactional resource that frames the imminent moving of a note and projects the next relevant actions (e.g., moving more notes, adding content, or reorganizing notes). To establish shared attention, pointing and touching is used as a main resource for 'unfreezing' (Whyte et al., 2007) and initiating the move of a sticky note. In some cases, we also see how the reading aloud of a sticky note may be used to initiate the move. Pointing, touching, or reading aloud functions as 1) resources in the conversation for framing and initiating the move, and 2) an invitation for the other team members to take part in the moving of the sticky note with next actions relevant for proposing an appropriate reorganization by association, dissociation, reinterpretation, category formation and so on.

When the sticky note in focus has been established, one team member takes the note from the whiteboard, and the process of moving the note to its final location begins. The person making the first move projects the next actions, whether this is 1) establishing agreement about the content by asking the other team members what the meaning is, 2) moving the note directly to potential placements, and determining the connection by asking the team members about the fit (connected, related, different from, something else, etc.) or, 3) moving the note without verbalizing the reason, but through the material structure and embodied action, displaying the trajectory of next actions. The movements vary considerably in terms of their duration, extending from less than 1 s to minutes. During the moving, the design team members may display agreement or disagreement with the positioning of the note with arguments related to the interpretation of the note's content or with minimal responses. These actions are sequentially produced in a way that emphasizes how specific places on the board represent features of the design or concept and how specific notes are essential parts of the developing orderly visual structures in the layout of the board. The sticky note structure on the whiteboard and the accompanying gestures, as opposed to the speech system, most often become resources in the co-construction of how to move a sticky note and where exactly to place it. We observe how minute moves to one side or the other relating to the already placed sticky notes are central to the final placement of the note 'on the move,' and in some cases, the members display high sensitivity to the precise placement of the note in the structure already created. However, we also observe how the established structure can be fragile if one note is taken away, resulting in a complete reorganization of all notes (example 1). Several gestural indicators (e.g., holding and continued touching of the note; pointing; the group facilitator physically placing him-/herself next to a specific note) serve to illustrate that a move is still 'in process' and that the note has not yet reached its final destination.

Placing the sticky note involves touching its top with adhesive to secure attachment, but this gesture also functions as a resource to display the finalization and 'refreezing' of the move to the other members. At this time, the individual sticky note movement seems to be considered final by the group, allowing it to progress to the moving of the next note.

4.2 Kinds of sticky note moves

The analysis illustrated that individual sticky note moves involve a rich set of inter-note relations being both explored, established, connected, and built up, as well as dissociated, discarded, and broken apart when traced as they unfold across time. We explore here the kinds of inter-note relations, as well as the situational strategies deployed for their visual establishment, with particular attention to the role of visuospatial and temporal proximity. The relations between sticky notes that are traceable when viewed across time may take several forms, three important ones being of associating, categorizing, and structurally relating.

4.2.1 Association

One recurring kind of sticky note movement pertains to the holding of a note while moving it towards and away from other notes, with a short or long pause at each explored associative position. Such movements seem to explore inter-note associations, often as a way to link the note to a group of similar notes. We noticed how the associative explorations made use of spatial proximity between notes to illustrate seeming associative strength between concepts, and it sometimes required several incremental adjustments to positioning before a final position was settled on, and the note reaffixed to the board, indicating that precision in the spatial distance to other individual notes was considered important. Importantly, when viewed across time, it is apparent that indicating associative strength is not just carried out by positively finding one good association, but also of positively exploring, but discarding, other potential connections, thereby creating active *dissociations*. However, when repositioning notes, it is mainly positive associations (not dissociations) that are displayed through visuospatial proximity. The moving strategies used to visually indicate association include holding a note while moving it towards other notes, but may also deploy pointing, the direction of gaze, or verbalization as communicative resources.

4.2.2 Categorization

Once reaffixed in a new position, several strategies pertain to visually establishing and maintaining an inter-note connection, in connection to forming a new category or cluster of notes. Group membership is illustrated through the primary strategy of visually ordering notes symmetrically and/or with close proximate distance ('prägnanz'). Between-category discriminability is illustrated by placing note groups at a greater spatial distance from each other (Dove et al.,

2018). Other strategies to illustrate grouping are also evident and pertain to the use of category headlines (e.g., using a different colour/different positioning/bold font sticky note to indicate a category headline), encircling a group of notes, or positioning notes on hierarchical levels.

A notable strategy pertains to placing notes on top of each other in chunks. In this note-on-note strategy, we saw how the notes become so tightly interlinked as to be moved in conjunction with each other, even across shifts in the kind of visual representation (see example 1). In this way, chunks of notes may inherit their internal coherence and structure across visual representations, even while the rest of the board changes visual structure entirely. Thus, grouping appears to serve the main function of allowing the chunk to be used subsequently as a 'building block' (Christensen & Friis-Olivarius, 2020). But it should be noted that for nonlayered categories, the internal category structure is usually not maintained if the entire category is repositioned. This may indicate that, upon establishing a category, the relative spatial proximity within groups no longer serves a main purpose. This is not to say that all category members are equal, as indicated by category headlines pointing to select notes, central positioning of select notes, the rereferral to some notes in a category more than others across time, or the order of selecting notes as category members (first members appear more central).

4.2.3 Structural relations

Establishing relations between notes does not only pertain to establishing associations and categorizing notes. In working towards more complex concept build-up, the relations between notes often involve illustrations of causal relations. Here, inter-note marking in the form of arrows, lines, or brackets on the whiteboard (e.g., example 1) serves as a strategy to visualize causality, direction, or hierarchical relations in an emerging whole. Sometimes, a partial structure is established before fitting it into the overall solution under development. In example 3, we noticed how a sticky note was singled out as a potentially interesting novel subcomponent, which was elaborated upon by grouping it with both existing notes and newly written ones. The sticky note group was finally given a new headline that aligned with the pre-existing solution structure, making it a subcomponent.

The examples serve to illustrate how sticky note moves may be of several different kinds and may involve both, the establishment of associations and dissociations, the grouping of notes into clusters and categories, and the establishment of inter-note relations between notes in the structural build-up of organized wholes. Each of these kinds of moves deploys a relatively distinct set of resources and strategies to move from unrelated and disconnected elements to partially structured wholes.

4.3 The role of proximity in relating sticky notes

While spatial proximity is not the only strategy identified in the relating of sticky notes, proximity often seemed in our examples to take primacy over the speech system and is likely a main reason why visuospatial support systems (sticky notes on whiteboards) are used to support collaborative design processes. In architecture, the capacity for making spatially proximate arrangement of elements is amongst the most central of skills. While the importance of visual proximity is thus well known in design, our findings are surprising in a number of respects:

While exact spatial proximity is of crucial importance in architectural design, it is not at all obvious that exact spatial distance should matter in relating words and concepts. Why should increasing or decreasing the *spacing* between two words carry relevant information to the perceiver? Nonetheless, these minute relative movements of sticky notes seemed important and meaningful to the designers, thereby allowing proximity to serve as information in conceptual design processes.

Further, relative proximity between design objects seemed to have similar roles across modalities in the design process. Spatial proximity seemed to be used as an indicator of certainty, associative strength, or category centrality. Similarly, temporal proximity (the length of time a note-to-note relation took to explore or establish) also seemed to function as a way of indicating associative strength, category centrality, or certainty.

Importantly, proximity seems to play different roles across distinct kinds of sticky note moves. Whereas inter-note proximity preoccupied the designers when they were making associations and categorizing, proximity seemed to play a different role when building structural relations amongst sticky notes.

This finding may be explained through the dual-process theory of design cognition (Gonçalves & Cash, 2021). Relating dual-process theory to our findings, it seems that associating and categorizing sticky note moves are closely related to Type 1 associative processes, which may explain their reliance on proximity as a primary indicator of associative strength. Conversely, more deliberate and reflective Type 2 processes are involved in trying to connect parts and categories into newly organized wholes. Indeed, in reasoning about structural relations, exact note-to-note proximity no longer seems to serve as a main source of information, with effortful reasoning instead directed towards the *content* of relations: causality, directionality, hierarchy, sequence, and so on.

Type 2 design processes are characterized by demanding a high degree of cognitive load of WM. The capacity limitations of human WM make it

extremely taxing to mentally combine, organize and structurally relate more than a few elements at a time. This makes cognitive offloading important by visualizing elements and moving them around for visual processing support. This mental work pertains less to associations of elements, and more to the structure amongst these elements. This may be the reason why the moving of sticky notes for establishing structural relations does not seem to rely on proximity in the same way: the type of reasoning conducted perhaps focusses less on the degree of association and more on establishing the content and organization of relations. Here exact note-to-note proximity plays a lesser role, being replaced by a focus on the *relative* positioning and proximity between all the notes in a structure (e.g., their relative positioning in a causal sequence or hierarchy).

This means that proximity has several roles to play in design cognition. As indicated through our examples, it may be argued that Type 1 reasoning with associating and categorizing moves effectively helps establish the chunks, or building blocks, that are subsequently organized and related structurally using Type 2 reasoning. Types 1 and 2 are thus not just two distinct types of processes. Their interplay may also partly help explain design progression from a multitude of disjointed elements to newly organized wholes.

5 *Future research*

Our findings suggest that proximity plays distinct roles in different kinds of design moving. Future research should investigate the role of team alignment on the meaning of the—often silent—sticky note moves in order to clarify whether aligning on the interpretation of the meaning of sticky note moves impacts design progression. Further, in so far as kinds of sticky note movements differentially relate to Type 1 and 2 processes, it may be possible that aligning team task instruction to their dual-process type in sticky note ideation, rather than to the standard 'brainstorming rules' (Matthews, 2009), may enable better visuospatial process support.

Our studies examined design sticky note sessions where the team initiated the process with the generation of parts before moving to inductive grouping and structuring. More research is needed on the kinds of sticky note moves at play in sessions initiating with a preimposed visuospatial category structure for notes to fit into (e.g., Business Model Canvas). Our studies only looked at brief episodes of sticky note moves – more research is needed to capture structural build-up across longer stretches of time in the life of ideas (Gonçalves & Cash, 2021).

We believe our analytical approach focusing on visuospatial design moves may further inform theories of design, beyond sticky notes. Design often takes place in rich visual environments (e.g., design studios) with a multitude of

objects, and here it may be possible to trace objects as they become related across time, insofar as it is possible to parse the environment into distinct visual objects as was enabled here through the analytical focus on sticky notes. We anticipate that such types of analysis may help explicate further the process of how products *are made* and *take shape* through associative and relational processes that are not always explicated in talk.

6 Conclusion

With our visuospatial analysis of sticky note movements across time, we aimed to uncover the situated sequential order of sticky note movements and explore the different kinds of sticky note moves. We explored how these moves help create new connections, combinations, and relations to other sticky notes and the—mainly visual—strategies used to their explication. With our findings, we hope to have pointed out new directions for research on visual support in design, and design moves, by exploring how and why designers move sticky notes.

By tracing sticky notes movements across time, we show that individual moves seem to have a relatively stable sequential order. We identified several kinds of sticky note movements pertaining to the formation of associations, the creation of categories, and the building up of partial solution structures. For associations, we found that inter-note spatial proximity serves as a visual proxy for associative conceptual strength, and we note that both associations and dissociations are visually presented when viewed across time. Viewed across many moves, inter-note relatability seems to create a semantic network of note associations that may underpin the formation of categories, with some of these categories and chunks maintaining their internal structures across shifts of representation. In turn, the clusters and categories may be used as components in solution build-up. In this way, sticky note moves serve to support the cognitive and social processes involved in collaborative design. Our findings lead to the contribution that a main reason sticky note moves support conceptual design seems to be due to the changing visuospatial proximity between notes across time in gesture and note placement. Proximity, however, does not play the same role across distinct kinds of moving. Inter-note proximity seems to serve as information on associative strength and category centrality in Type 1 reasoning. However, in the structural build-up of relations between categories or objects (i.e., Type 2 reasoning), proximity seems to play another role in the mentally taxing clarification of the content of note relations.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.destud.2021.101036.

Notes

1. We are grateful to the designers in the DTRS11 dataset for allowing us to re-analyze the dataset for the present purposes.
2. Since the print version of this manuscript cannot display animated images (GIF), the print version contains images to illustrate the moves and gestures.

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