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Decisive design: how spatial arrangements shape group decision-making

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ABSTRACT: This paper examines how spatial arrangements affect digitally supported individual and group decision-making. In a controlled within-subjects study, 24 participants completed the NASA Moon Survival Task across three spatial conditions: standing at an interactive table, sitting at the same table with personal zones, and using laptops. By analysing decision quality, speed, and perceived collaboration, the study shows that spatial design meaningfully shapes decision performance, interaction dynamics, and user experience.

KEYWORDS: decision-making, spatial design, interaction design, user experience

1. Introduction

Making decisions is part of human nature. It lies at the heart of our free will and shapes the futures we create together. Besides the task itself, context matters: framing and priming (Kahneman, 2024), our individual and shared experiences (Mollick, 2024), our intuition (Gigerenzer, 2023), the design of the systems that support us in the process (DeSanctis & Gallupe, 1987), and even the graphical arrangement of decision alternatives themselves (Thaler & Sunstein, 2022): they are all known to have an impact on decision speed, quality and process. Today, a substantial amount of group tasks are conducted on displays placed in meeting rooms. Whether on individual laptops or large interactive screens, those screens have been shown to have a substantial impact on the group's performance (Mateescu et al., 2021). Spatial design seems to be a decisive factor in decision-making. Surprisingly, little empirical evidence has been collected on the influence of the spatial arrangements of displays in meeting rooms on group decision-making. This publication aims to address that research gap through investigating the following research question: *What are the impacts of spatial screen arrangements on individual and group decision-making quality, speed, and processes?*

2. Theoretical background

In this section, we aim to provide an overview of relevant research on design factors that influence group decision-making processes and outcomes. We build on findings in one systematic literature review by Mateescu et al. (2021), publications mentioned in this review and several other publications in the fields of Human-Computer Interaction (HCI), decision-making, and psychology.

2.1. Design as a decisive factor in group decision-making

Group decision-making is a well-researched field of science. Within that field, several publications elaborate on the influence of software-based decision-support systems on empowering processes, results, and the speed of group decision-making tasks (Gray, 1987; Hamada et al., 2020a). The focus of these publications is usually on the systemic conception and or the graphical user interface (GUI) of those systems as independent variables. Additionally, the use of large interactive screens as a medium for

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group activities has been explored in a systematic literature review, revealing several relevant and mostly desirable effects of such devices (Mateescu et al., 2021). Another relevant factor is the spatial design and arrangement of elements in group decision-making spaces. This has been investigated by Klöckner & Thoring (2024), but only theoretically and historically, focusing on the evolution of such spaces and lacking empirical evidence. The current research lacks a rigorous investigation into the influence of spatial arrangements on group decision-making. This publication aims to shed light on the influences of spatial design arrangements on digitally supported group decision-making. Specifically, it inquires about the quality and speed of decision-making under varying spatial conditions through an empirical, exploratory laboratory study.

2.2. Human factors

Context matters in decision-making: A wide range of factors is known to influence individuals conducting these types of tasks. For example, the psychological effects observable when merely varying the descriptive framing of a decision-making task are substantial (Tversky & Kahneman, 1981) – fundamentally altering decision-making processes and outcomes. As the authors point out, this challenges the theory of pure rational human choice. As Gigerenzer (2023) highlights, decision-makers' level of experience in the field of the task at hand also has substantial impact on their capability to rely on personal intuition, in return driving decision quality and speed: Pilots collect flight hours for good reason, being able to tap into their fast and, most of the time, reliable intuition when the time comes to make crucial decisions under time pressure. Additionally, the personality characteristics of decision-makers play a significant role in this process. As Weller (2018) inquired, individual decision-making competence (DMC) can be related to personality dimensions, as measured by HEXACO (Ashton & Lee, 2007). Urieta (2021) notes how the 'Alternative Five Factor Personality Model' (AFFPM) characteristics, in addition to age, sex, and social position, influence what the authors refer to as an individual's 'decision-making style'. In addition to personality, emotion plays a relevant role in decision-making results and processes. As noted by Zeelenberg et al. (2008), daily emotions drive decision-making motivation, which, in turn, influences both the processes and outcomes. Seo & Barret (2007) found a strong connection between affective experience and decision-making performance. Interestingly, the authors also found that emotional self-awareness correlates positively with decision quality. Investigating the human influence becomes even more interesting when examining multiple decision-makers acting in concert: Research on group decision-making reveals that factors such as group size (Laughlin et al., 2006), setup, epistemic community representation, hierarchy, and a wide range of other variables significantly influence group decision-making: The seminal framework introduced by Chahine et al. (2017) outlines how small groups make decisions – and which factors influence them in the process. In Bessey's (2023) publication, the hierarchical structure of groups' impact on decision-making quality has been shown experimentally.

2.3. Decision-support systems

In addition to the complex factors of individual humans and groups in decision-making processes and outcomes, the systems used also introduce sources of variance. Those systems, called Decision Support Systems (DSS), usually provide context for the task at hand and represent alternative decisions. The way in which their design influences decision-making has been well investigated (Affisco & Chanin, 1990; Moore & Chang, 1980). Critically, research on Decision-Support Systems, in general, and specifically on their efficacy, has shifted from statistical hypothesis testing to the Design-Science Research (DSR) methodology, as Arnott & Pervan (2016) point out in their publication review. This leads to a different lens on DSSs' design as artifacts influencing decision-makers. Their conception, User Experience, decision-alternative representation, data visualisation patterns, and recently AI support implementation (Rudzinska, Klöckner et al., 2026) are well researched in the transdisciplinary connection of Decision Science and Human-Computer Interaction (HCI) (Eberhard, 2023; Hinrichs et al., 2024; Jasna Kuljis, 1995; Neri et al., 2025; Norman, 1999). For group DSSs, the design of so called boundary objects (Caccamo et al., 2023; Mark et al., 2007; Star & Griesemer, 1989) is crucial for successful joint decision-making processes (Klöckner et al., 2025) – they serve as shared, flexible artifacts that different group members can interpret in their own ways while enabling coordination and collaboration across their divergent perspectives.

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2.4. The role of spatial design

The built environment in which groups are making decisions is assumed to play a key role. This is investigated in the research on spatial design on team performance (de Korte et al., 2011; Rashid et al., 2006; Thoring et al., 2020). The evolution of design patterns in decision-making spaces has been examined by Klöckner & Thoring (2024), shedding light on the spatial arrangements of media that contain group DSS as boundary objects for group decision-making. As this publication was based on historical material, the effects of the spaces' design on the group decisions made therein could, unfortunately, not be directly observed, leaving relevant questions about the relations between the decision-supporting spaces' design patterns and the influenced decision-making processes at least partially unanswered. However, the impact of hybrid (physical and digital) spaces on social processes in general is well captured in Hornecker & Buur (2006). The authors do not specifically focus on group decision-making but frame what Star & Griesemer call boundary objects in a relevant way by introducing a theme for 'externalization' of human thinking for 'shared reference' and as 'common ground' for group processes. They refer to this as 'expressive representation,' building on Ullmer & Ishii's (2000) concept of 'representational significance' for tangible user interfaces. While it is a very relevant framework built on three case studies, Hornecker & Buur's (2006) work did not focus specifically on collecting data and insights into group decision-making. Tang et al. (2006) investigated, in two studies, how groups can 'couple' their work when working on interactive tables. The authors did not specifically examine group decision-making; however, valuable guidance for scoping this publication has been derived from their work. Specifically, insights from participants' positional arrangements around interactive tables have been valuable. The authors suggest 'high resolution personal territories' for further research – a concept that has been implemented in the study underlying the publication at hand. Tang's work is also based on Gutwin & Greenberg's (2002) seminal framework, 'Workspace Awareness for Real-Time Groupware', which structures the available knowledge about the design of collective software to unleash the potential of collective intelligence (Lévy, 1994). Gutwin's framework proves helpful today, especially when exploring collective hybrid intelligence (Cui & Yasseri, 2024; Rudzinska, Klöckner et al., 2026).

The systematic review by Mateescu, Pimmer, et al. (2021) examined relevant publications on the impact of large interactive displays on group processes. Their review of 41 studies highlights the benefits of introducing group-work dynamics, specifically through large, horizontal interactive displays or interactive tables. Mateescu et al. also view the primary benefit of large interactive displays as not in task-related outcomes, but rather in group dynamics, knowledge gains, or the speed of task completion. The overview provided by their review, along with other sources (Schulz-Hardt et al., 2006; van Ginkel & van Knippenberg, 2012), helped identify the research gap for this publication. In summary, the contextual variables mentioned above have been well researched and are well reflected in the literature from decision science, psychology, management, and HCI. However, to the author's knowledge, little direct evidence has been collected about the impact of the spatial arrangement of digital elements placed in decision-making rooms on the efficacy (speed, quality, process) of group decision-making. Obtaining this knowledge is important for both further research on group Decision-Support Systems and for practitioners seeking guidance in designing novel decision-making spaces optimized for decision efficacy and group dynamics. The publication at hand aims to address the outlined research gap by analyzing the results of an empirical, randomized study.

3. Methodology

To investigate the identified research gap (the influence of display spatial arrangements on group decision-making), we conducted an empirical study. It is based on the well-investigated NASA Moon Survival Challenge (Hall & Watson, 1970), which serves as a standardized decision-making task. Participants are tasked with prioritizing recovered items after a lunar crash landing to determine which supplies are most critical for survival. Designed as an exploratory study, we employed an inductive approach, triangulating data from multiple sources (outlined in the Measures section) aligned around a protocol. The dependent variables were (1) decision-making quality, (2) decision-making speed (both split up by individuals and groups), and (3) the assumed influences of the spatial conditions as attributed by the participants. To avoid cross-factor influences (conjoint effects), the study's independent variable was three distinct spatial conditions, designed based on the literature on Group DSSs and HCI (see Theory section).

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3.1. Research design

The study employs a controlled within-subjects design to investigate how spatial configurations impact group decision-making processes and outcomes. 24 architecture master's students work in groups of four each and complete the standardized NASA Exercise: Survival on the Moon under three spatial conditions in randomized order: standing at a shared interactive tabletop, seated at the same table with individual digital work areas, and seated with individual laptops. The groups experienced the conditions in randomized order to minimize sequence effects and inter-individual variability. The standard NASA exercise has been adapted by splitting the 15 items into three groups of 5 items each – balanced by level of difficulty. The NASA score calculation was adapted coherently. Data collection involved combining system interaction logs with protocol analysis and post-condition questionnaires to capture perceived collaboration, communication quality, and decision-making processes, using Likert and qualitative methods. This multi-layered study design enabled a comparative assessment of how spatial arrangements might influence decision quality and speed plus perceived group dynamics.

3.2. Participants

We recruited six groups of four participants each, stemming from the same community of architectural engineering master classes. Using a pre-study questionnaire, we assessed participants' self-reported technological knowledge for homogeneity and excluded those who had previously completed the NASA task. The groups were randomly assembled and checked for background and sex diversity (F=18, M=6) as well as age, and epistemic background homogeneity. The number of groups has been defined by randomizing across all possible permutations of spatial conditions (3 Factorial = 6). The group size (n=4) has been defined by the literature on group dynamics in decision-making (Laughlin et al., 2006), resulting in a total of (n=24).

3.3. Materials

To avoid any cross-factor influences (conjoint effects), the study's only independent variable was three distinct spatial conditions (Figure 1). (1): Standing at an interactive table with a one-sided interface ("Standing Condition") (2): Sitting at the interactive table with individual zones and a central interaction element ("Placemats Condition") (3): Sitting at a table with individual laptops. ("Laptop Condition")

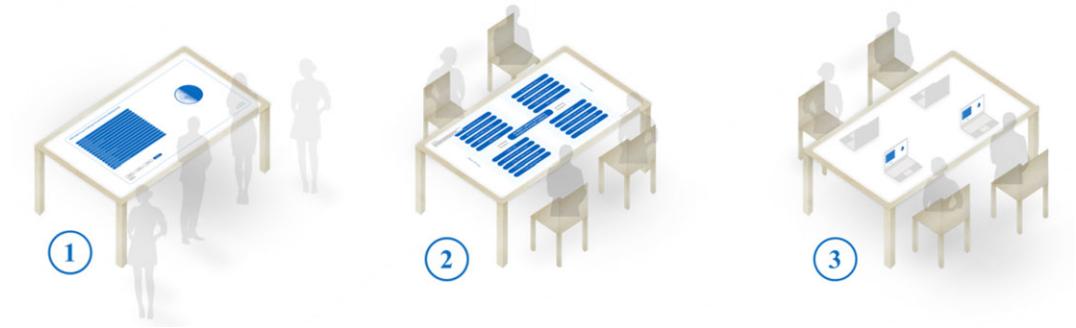


Figure 1. Spatial arrangements' designs: (1) "Standing" (2) "Placemats" (3) "Laptops"

Conditions (1) and (2) have been designed to investigate the potential of interactive tables in group decision-making processes. As outlined by Bluedorn et al. (1999), better decision results and speed were expected for the standing condition, while preferable group dynamics and buy-in were expected for the sitting conditions, with comparable decision-making speed and quality. Condition (3) was used as a baseline for the standard decision-making spaces. Following the insights of Mateescu et al. (2021), who suggested that horizontal displays provide better group dynamics and task outcomes, we decided against A) a contemporary standard setup of laptops on a table plus a vertical display, and B) an interactive vertical display in the style of a digital whiteboard. We utilized accessible, contemporary educational whiteboard hardware for the interactive table to evaluate potential spatial design patterns with high practical applicability and potential for further research, thanks to their affordability. To reduce sources of variance and biases, we standardized the following effects: General Spatial Design: All three spatial conditions were set up in the same standardized laboratory setup. It featured standard white walls, warm

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white LED lighting, standard office chairs, and subtle green sound-damping wall elements. Ambient Conditions: Room temperature and humidity have been continuously monitored. Standardized Decision-Making Task: To minimize the effect of the decision-making task itself and its framing (Tversky & Kahneman, 1981), we used the well-studied NASA Lunar Survival Challenge (Hall & Watson, 1970, Hamada et al., 2020), a fictional space travel task where participants are asked to rank items under time pressure according to their importance for survival. We used NASA's original wording and items. The original 15 items were split into three equal groups of 5 using two principles: (A) maintaining as much as possible of NASA's original order, and (B) balancing the difficulty of the item groups based on the estimated difficulty for participants' technological skill level and epistemic community. Although prior research on the NASA Task does not provide formal item-difficulty parameters, several studies examine item-by-item disagreement, variance, and misranking patterns (Hall & Watson, 1970; Laughlin et al., 2006). Taken together, these findings indicate that the 15 items vary in difficulty and, hence, were distributed across the list in a manner that yields a balanced pattern when grouped into 3 clusters of 5. In each spatial condition, participants completed the task individually first and then as a group, following the original task. A drag-and-drop interface succeeded the original pen-and-paper procedure. Observer Distanciation: To minimize influence on results, the study's conductors left the laboratory during the decision-making tasks. Task description and instructions were provided in a standardized manner through our software without conductors' intervention. Participants received a pseudonymization ID. These measures were designed to minimize sources of variance and achieve an acceptable signal-to-noise ratio.

3.4. Procedure

Before conducting the study, we obtained ethical approval for the study's goals, concept, data collection and analysis procedures, GDPR compliance, and the ethical and safe treatment of participants. Participants were recruited from the architecture master's program and provided informed consent without being informed of the study's spatial design focus. They also did not receive prior information about the decision-making task itself or the broader research agenda on spatial influences. Each group of four completed the NASA Moon Survival Challenge under all three spatial conditions in randomized order. In each condition, participants first completed an individual ranking, followed by a group discussion leading to a shared ranking using the respective interface.

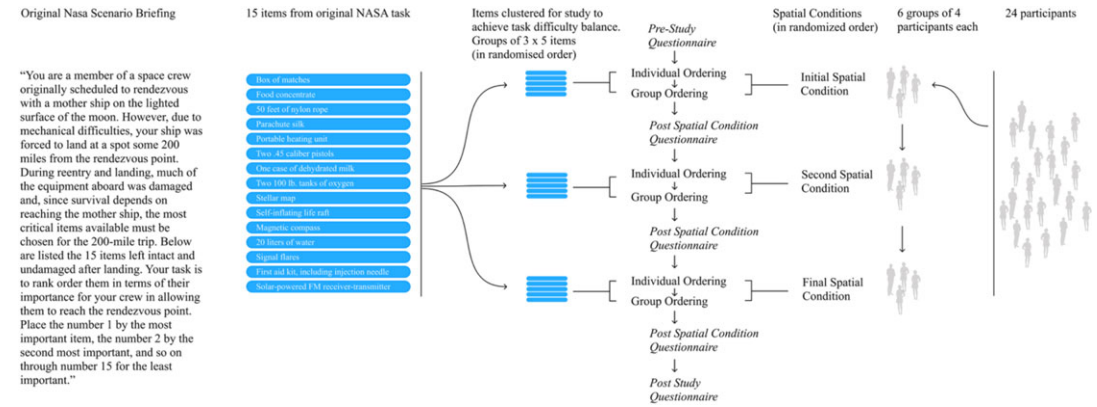


Figure 2. NASA Moon Survival Task with item list grouping for study, procedure of tasks and questionnaires and participant grouping

After each Spatial Condition, the group completed a questionnaire capturing their immediate impressions of collaboration and communication. The procedure is shown in Figure 2. The session lasted approximately three hours per group, and all participants received a €50 voucher as compensation.

3.5. Measures

To obtain a more nuanced understanding of potential observable effects and for triangulation, we used the following data sources, linked by pseudonymized participant IDs and millisecond-level timestamping. Log Files: The custom server-side software was developed to facilitate the decision-

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making process. Logging the individual participants' IDs, group IDs, individual and group phases, and spatial condition IDs, the following events were recorded: phase beginnings and endings; completed and aborted changes to item orders by individuals and groups; result submissions by individuals and groups; and, ultimately, individual and group scores. Scores and timestamps served as direct indicators for decision quality and speed. Questionnaires: (1) Pre-Study questionnaire for participant selection and assessment of prior knowledge, as well as for group assembly according to the criteria mentioned above. (2) Post-condition questionnaires (Likert scales + qualitative reasoning) after each stimulus (spatial condition), assessing group dynamics. (3) Post-study questionnaire comparing participants' impressions throughout the spatial conditions and obtaining perceived influence of the spatial conditions on decision-making speed and quality, as well as critical incidents in group dynamics (comparative; Likert scales + qualitative reasoning).

3.6. Data collection and analysis

For this publication, data from two sources have been analysed: (A) Server-side log files of the custom-made decision-making software, containing scores and timestamps for individual and group submissions; (B) Questionnaires obtained pre- and post-study, as well as post each stimulus (spatial conditions in randomized order). For (A), the data were analyzed using score distributions as standardized indicators of decision quality, utilizing histograms and time distributions until submissions as standardized indicators of decision speed, and employing Kernel Density Estimators (KDE) both for individuals and groups (Figure 3). For (B), Likert Scales, ranging from 1 to 5 in terms of agreement with statements about decision quality and speed, were analyzed (Figure 4, Charts A and B), as well as the preference for spatial conditions in percentage (Figure 4, Chart C).

4. Results

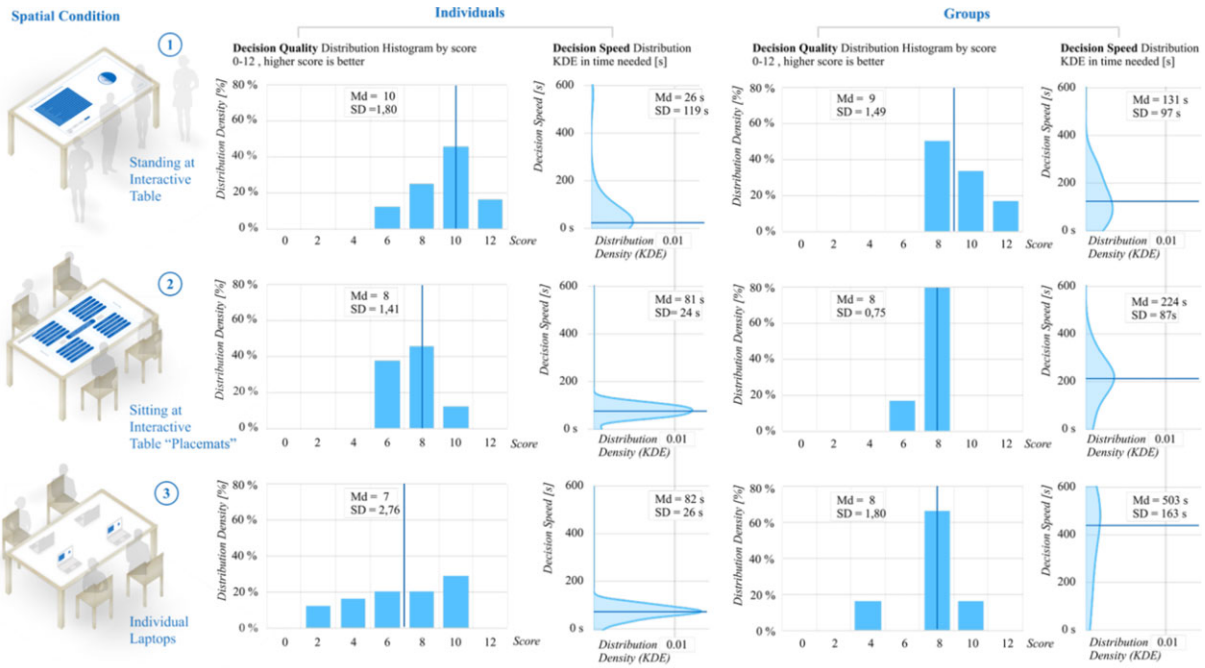


Figure 3. Decision quality and speed in dependence on the spatial conditions 1-3. Individual participants' and groups' results by scores and temporal distributions

Insight 1: Groups and individuals make the fastest and highest quality decisions in the Standing Condition. (Figure 3, First Row). The median score here is Md = 10 for individuals, and interestingly, it is only Md = 9 for groups. The median decision speed is 26 seconds for individuals and 131 seconds for groups. This effect was expected but is remarkably strong.
Insight 2: When seated at the interactive table, individual decisions are slightly better (Md = 8) than on laptops (Md = 7), and comparable for groups (Md = 7) (Figure 3, Second Row). Interestingly, Groups at

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laptops took more than twice the time (Md = 503 s) to obtain the same decision quality as those sitting at the interactive Table (Md = 224 s) (Figure 3, Second and Third Row)

Insight 3: Participants perceived that the "Placemat" Condition improved the group decision-making results the most (MPlacemats = 3,88 vs. MStanding = 3,79; Agreements on a 1-5 Likert Scale; Figure 4, Chart A) – however, decision quality is noticeably lower than while standing (see Insight 1)

Insight 4: Participants clearly preferred the "Placemats" Condition for group decision-making tasks (45,8%), followed by the Standing Condition (33,3 %) and the Laptop Conditon (20,8%) (Figure 5)

Insight 5: Decision speed is best for the Standing Condition with (Md = 26 s) for individuals and groups (Md=131s) (Figure 3, First Row).

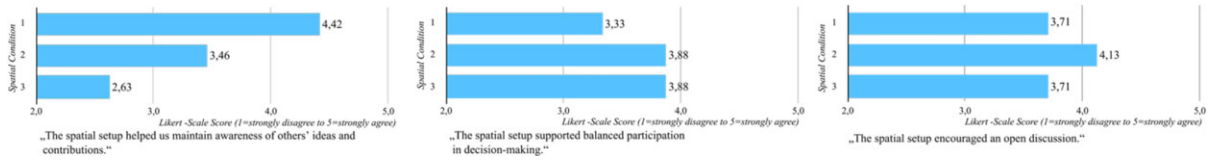


Figure 4. Participants' perception of the impact of spatial arrangements on decision quality and speed (charts A & B – Likert scale 1-5), preference on spatial setup (chart C – % of participants)

Insight 6: The Standing Spatial Condition clearly leads in terms of the perception of the spatial setup supporting awareness of other participants' ideas and contributions (Figure 5). Lower values were archived by the "Placemat" Condition, and by far the lowest for Sitting with Laptops.

Insight 7: In all other aspects of the spatial setup's perceived contribution to the group decision-making process, the "Placemats" Spatial Condition outperformed or at least matched the other spatial setups. Except for perceived balance, Sitting with Laptops consistently performed worse or equally to the other spatial setups in terms of supporting the group decision-making process (Figure 5).

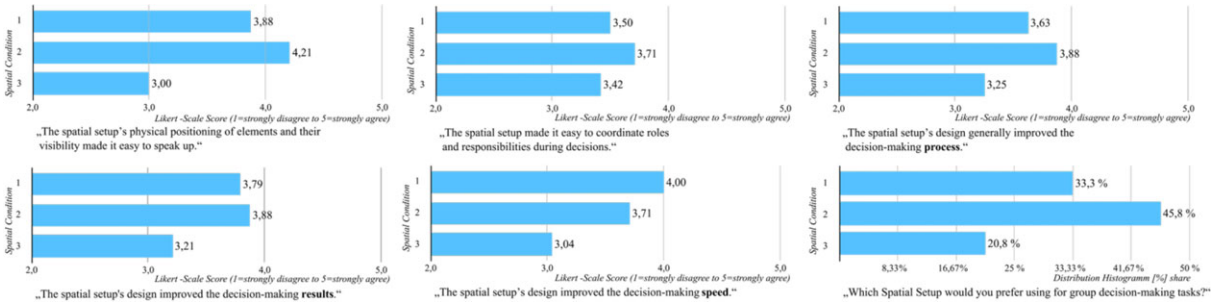


Figure 5. Perception of the impact of spatial arrangements on the decision-making process

5. Discussion

Several insights found are remarkable: the finding that the Standing at Interactive Table Spatial Conditon performs best in terms of individual and group decision-making speed and quality (Insight 1, confirming Bluedorn's (1999) work on standup meetings), but ranks lower in the decision-making process reveals an interesting trade-off: good process versus good results (in terms of quality and speed). Standing at an interactive table also gave the participants the best feeling of being aware of other participants' ideas and contributions. This effect might be attributed to the directional nature of this setup: Practically, better visibility by avoiding upside-down typography and emotionally by participants facing in the same direction in the notion of 'us against the problem'. As a participant said: 'We were standing next to each other and I felt much more engaged to think about the task.' However, on average, the process with the standing setup was perceived as less balanced, less coordinated, and less supportive for speaking than sitting at the interactive table. Participants reported that other participants might have been able to take a more dominant (less balanced) role due to the positions not being fixed and bodily appearance mattering more as a factor than sitting, which presents an interesting area for further research in group dynamics. Let us compare and examine the trade-offs: at first glance, practitioners may tend to prioritize better results over better processes. However, research by Korsgaard et al. (1995) demonstrates that decisions made in a more transparent process (especially one that involves balance) consistently receive stronger

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buy-in and decision follow-up, thereby strengthening their strategic impact. So, depending on the task at hand, practitioners may consider spatial layouts like the digital "Placemats" on an interactive table, occasionally even accepting slightly lower decision quality and speed as trade-offs for strategic stakeholder buy-in. Our study empirically confirms the dilemma 'quality and speed vs. process and buy-in' outlined by Mateescu (2021) and van Ginkel (2012). Insight 2 suggests that groups may achieve only slightly better decisions when sitting at a shared digital surface ("Placemats") than with laptops; however, they are twice as fast in our study and are much more pleased with the process (Figure 4 and Insight 3), which might again lead to better follow-up. As one participant puts it: "2 had a good balance of individuality and collective decision making. We had no barriers in between, but our own corners in a common space." Overall, sitting at a shared space with a central group element (in this case, the submit button) and an individual space seemed to support the process and might offer a spatial design pattern that balances well between decision results, speed, and process quality: a well-placed boundary object might support balanced group decisions. We can empirically confirm that, in group decision-making, Hornecker and Buur's (2006) notion of shared reference points indeed supports the group process. We can thus transfer a crucial aspect of Ullmer and Ishii's (2000) underlying 'emerging frameworks for tangible user interfaces' from tangible interfaces to more affordable standard touch interfaces in decision-making rooms, offering an accessible design pattern for both practitioners and further research. Shared 'common ground', mixed with personal zones, preferably laid out horizontally, is indicated to support group decision-making. This questions the way we make group decisions today. Referring to the spatial condition facilitating individual laptops, one participant notes: "[. . .] the screens were a literal barrier. They separated us, leading to more hesitation. The first setup [In this case, "Standing at Interactive Table"] felt more like a dynamic group activity, the second [Laptops] like a negotiation, and the third ["Digital Placemats"] like a mix." The Spatial Condition "Laptops", although commonly used in group decision-making tasks today, consistently performed the worst in all categories: decision quality, decision speed, and process. However, we all use it nearly every day. Time for a design change?

6. Conclusion

The insights gained may help in understanding the connection between spatial arrangements, decision quality, speed, and process. Further inquiry into the group dynamics is planned based on the sensory equipment and AI-based research methods. The research question highlighted relevant patterns, narrowing the identified research gap and leaving more to be explored in the study at hand and in further research. Limitations arise from the constraint on the number of spatial conditions investigated, and possibly from the association of our item groups with Spatial Conditions. Additional insights will be obtained through the future AI-based analysis of the recorded sensor data and further statistical analysis. Additional spatial conditions, the combination with Augmented Reality and spatial computing, and shared Human-AI integration, appear as promising fields for further research. In summary, we identified interesting connections between spatial layouts and group decision-making quality, speed, and process that may guide practitioners and further research. Especially shared interactive tables with individual and common zones seem promising.

What we can state today: *Different spatial designs are suited to different group decision-making tasks. And the difference between them is decisive.*

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