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The evolution of design patterns in joint decision-making spaces

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Abstract

This paper outlines the evolution of decision-making spaces through selected instantiations, analyzing the role of design in their utility and identifying preliminary patterns in spatial layout. It builds on the combination of two research fields: A) Decision support systems and B) Creative Spaces. The paper aims to take a first step towards combining these two existing research fields by focusing on the spatial design aspects that foster the convergent aspect of creativity and to provide guidance for further research on the design of decision-making spaces.

Keywords: decision-making, user experience, creative spaces, complex systems, boundary objects

1. Introduction

The aim of this paper is to identify patterns of spatial design in the evolution of joint decision-making spaces, possibly providing initial guidance on design patterns for future instantiations of such spaces. It aims to provide initial guidance for further research on how these patterns might influence both the experience and efficacy of joint-decisions making spaces. The field of future-oriented joint decision-making spaces might well prove relevant, as the addressing of the 21st century's wicked problems demands for detailed cross-stakeholder analysis and well elaborated decisions with both factual and emotional buy-in across epistemic communities (Dentoni et al., 2018). Furthermore, emerging technologies, especially artificial intelligence (AI) and Extended Realities (XR) provide new resources, with their impact on decision-making spaces to be researched. While the role of both the spatial arrangement and the design of the boundary objects representing decision-alternatives themselves need further research, this paper focuses on the evolution of the spatial arrangements being made, especially through their evolution. The analysis in this paper follows a timeline of selected practical instantiations of decision-making spaces through the last 100 years and tries to preliminarily identify the evolution of design patterns and their possible impact on the decision-making processes. The patterns being found and documented shall be evaluated for their potential experience impact in further studies comparing different spatial layouts. As such, decision-making spaces, often termed 'war rooms' have historically played a critical role in shaping geopolitical, economic, and corporate outcomes. Starting at ancient fireplaces to discuss community affairs via the Greek polis (Zanakis et al., 2003), to the 20th century "control rooms", Gui Bonsiepe's cybernetic 'Opsroom' well analysed by Dubberly (2022), and to 21st century digitally supported meeting spaces – an important, but little researched factor of their utility appears to be their spatial design. The research question posed here is: *'How to use historical cases to scope further research on the impact of decision-making space's design on decision-making experiences?'* The research question's relevance gains additional importance with the need for design guidelines for decision-making spaces of the near future hosting the addressing of wicked problems in a cross-stakeholder manner and with the extensive support of technologies including AI and XR.

2. Theoretical foundations

Decision-making spaces are physical, virtual, or hybrid spaces designed to host and drive decision-making experiences, frequently across stakeholders from different epistemic communities. In the practical field, Sibbet (2012) describes the arrangement of what he calls 'big pictures' displaying options/scenarios in decision-making spaces. However, to the best of the author's knowledge, little is known about the effects of the design of decision-making rooms in the scientific communities. For instance, Padilla et al. (2018) fundamentally describe the cognitive effects of the decision-alternative representation by visualizations and their impact on the experience and outcome of the decision-making process. However, interestingly, the spatial framing and layout harboring these decision-alternative representations as boundary objects seem less investigated in the scientific communities. Jungmeier (2009) investigates war-rooms evolution in terms of media philosophy and proves insightful in terms of historical context and media theory. While extensive in the description and the concept of the 'Feldherr' (commander) stakeholder figure, it does, however, not go into the specifics of the 'boundary object', joint analysis / decision-making, and the underlying spatial design patterns of 'war rooms' as decision-making spaces. We are using 'boundary objects' in the sense introduced by Star and Griesemer (1989). These entities are, in the case of decision-making spaces, often found to be instantiated as tangible artifacts like maps or digital displays and serve as intermediaries representing system status and decision alternatives, bridging the knowledge gaps among diverse stakeholders. Their design and arrangement in space are essential for facilitating decision-making by embodying shared understandings while retaining flexibility across various interpretive contexts (Mark et al., 2007). Existing research in decision-support systems themselves (DSS) is well established. Sharda et al. (1988) provided a good overview, which was later updated by Newman et al. (2017) on the example of dealing with natural disasters and cross-stakeholder decision-making. Arnott and Pervan (2014) established a differentiated connection between the fields of DSS and Design Science Research. Morelli et al. (2022) recently described the field from the stance of integrative psychological and behavioral science, adding to the theoretical underpinning of the discipline in terms of cognition. However, until today, little is known about the impact of DSS's spatial representation on the decision-making experience and efficacy. On the other hand, existing research on 'creative spaces' (Thoring et al., 2021, 2019, 2018) largely focuses on creating ideas (***divergent*** thinking and acting) and little is known on the impact of spatial design on decision-making (***convergent*** thinking and acting). According to Guilford (1961) divergent thinking refers to the generation of ideas and choices, while convergent thinking refers to the selection of ideas and decision-making. The focus of current creativity research on divergent thinking, which goes along with a neglect of convergent thinking, is stressed, e.g., by Cropley (2006). Vischer (2008) laid the general foundation for the understanding of how people are affected by the design of environments for work; however, the author does not focus on decision-making spaces specifically.

3. Method

This paper builds on the combination of two so far relatively disjunct research fields: (A) Decision-Support-Systems (DSS) and (B) Creative Spaces. While (A) largely focuses on the DSS themselves and the complex impact introduced by their design, (B) so far largely focuses on the effect of spatial design on the ***divergent*** aspect of creativity (creation of decision-variations) and less on the ***convergent*** (decision-making / obliteration of variations). While the relation of divergence and convergence has been well researched by Müller-Wienbergen et al. (2011) in creative space research, convergence has played a comparatively smaller role, and decision-making within creative spaces is so far largely unknown. Thus, it seemed advised to look at the connection between the fields. To initially investigate these connections, we looked at a selection of practical, but impactful use-cases. We explored a range of stereotypical examples from the beginning of World War II to the present day, found in existing literature, documentaries, and popular film culture. We shift from early military and Science-Fiction cases to their design pattern's and technologic adaption in a 'swords-into-plowshares' motion into approachable modern business set-ups. The resulting selection of exemplary decision rooms were analysed according to their spatial setup, involved furniture and technological equipment, and relation of stakeholders. For each example, we included corresponding literature, where available. Based on a manual coding and conceptual mapping of these examples, several

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patterns of different types of decision rooms were extracted. In the following subsections, we present selected images, in which we highlighted the relevant aspects in yellow outlines.

4. Results: the evolution of decision rooms

In this section, we briefly outline the historical evolution of decision room design over the last 100 years through practical and fictional, but influential instantiations. We examined how shifting global contexts, advancing technology, and the increasing relevance of rich-in-information boundary objects have pushed the layout design and functionalities of these spaces.

4.1. World war era decision-spaces

Jungmeier (2009) suggests the British 'Cabinet War Rooms' (CWR) from 1939 as one of the first actual war room(s), also specifically using the term. The design choices made for these war rooms of the World Wars served from the beginning on both functional and psychological purposes. Centralized 'single source of truth' command and control were critical, and the space's design layout was integral to facilitating this centralized approach (Hart, 2014). Spatial layouts facilitate a typical NtoN arrangement with a characteristical map in the middle. The RAF's operations room shown in Figure 1 works with physical elements, which were still manually animated. Large tables were the focal points of these kind of rooms, promoting collaborative deliberation. Walls or tables covered with detailed maps enabled planners to visualize strategic situations rapidly. The design emphasized clear lines of sight and minimally obstructive furniture to ensure quick data accessibility and group communication (Moran, 2012). While in military setups, the hierarchy in the organization was clear, the room layout suggests the establishment and discussion of a common shared understanding NtoN before the actual hierarchical decision-making.

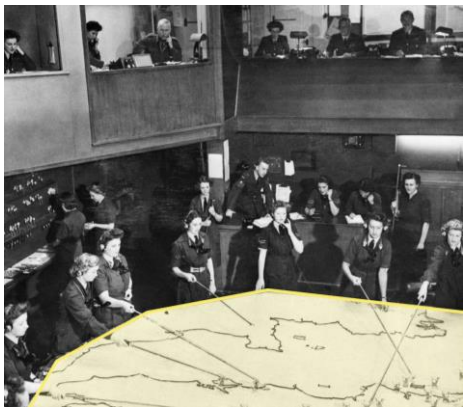

Figure 1. Operations Room at RAF Fighter Command's No. 10 Group Headquarters, Rudloe Manor (RAF Box), Wiltshire, showing WAAF plotters and duty officers at work, 1943. General view of the Operations Room at No. 10 Group Headquarters, Rudloe Manor (RAF Box), Wiltshire, showing WAAF plotters and duty officers at work (Source: Imperial War Museum)

4.2. Cold war era: merging physical space and advanced technology

With the advent of modern electronics, displays and animated data visualizations became common. An early example has been NORAD (Figure 2) Pragmatical reasons, it seems, shifted the spatial layout: As these displays were delicate and susceptible to destruction by touch, liquids and dust, and the manual actuation of elements (and thus physical reachability) was no longer needed, vertical space layouts as shown in Figure 2 became commonplace. This also enabled large-scale projections. While maintaining an NtoN approach to keep all stakeholders equally informed, they did imply a direction to the space. Largely change the room's atmosphere. This shift eliminated the 'round table' perception of the space. It is yet to be investigated how this fundamental change from the predominantly horizontal, multidirectional maps influenced the decision-making experience and efficacy (see 'Conclusions'). Potential studies might involve, recreation of such spatial layouts, e.g., in Virtual Reality for A-B Tests. It might seem that this shift might have initiated a precedence for modern meeting room layouts with screens for PowerPoint presentations and their even more directed, hierarchical presenter-based spatial 1toN designs.

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Figure 2. Illustration of North American Aerospace Defence Command (NORAD) 1961 (Source: Radio Cooperation of America RCA, 1961) (left) and Interactive data visualization map and circular seating arrangement in the 'War Room', Dr. Strangelove, Set Design by Sir Ken Adam (1964) (right) (fair use)

Sir Ken Adam has been a key figure in Cold War cinematic design. Not just through the James Bond movies, he had a fundamental impact on reality itself. While Sir Ken Adam's designs, notably for 'Dr. Strangelove' were cinematic in nature, they resonated deeply, encapsulating the dramatic essence of these strategic environments. His tiered designs and vast, open spaces amplified a room's gravitas, creating an atmosphere of high-stakes decision-making (Frayling, 2006). Despite being conceptualized for film, Adam's vision captured the essence of tension, urgency and hierarchy – factors central to real-world decision rooms. His designs have occasionally been referenced in broader discussions on strategic space aesthetics, exemplifying the convergence of art and real-world functionality (Schnoor and Wilson, 2016). While Adam was influenced by NORAD (Figure 2) via Stanley Kubrick (Hars-Tschachotin, 2014), he interestingly decided to add a round table to the otherwise directional NtoN-layout, enabling the dramatic discussion in the film about the imminent atomic threat. The geopolitical tensions of the Cold War necessitated decision rooms that seamlessly integrated evolving technology, ensuring swift, secure, and effective decision-making (Gaddis, 1998). Security became a pivotal design element. Rooms were frequently constructed underground, merging security with technology. The integration of early computers, communication consoles, and electronic display systems influenced room layouts and furniture design. Design choices had to accommodate technological advancements while ensuring human operators remained efficient and comfortable (Shaker, 2002). The Cold War era also pushed the need for decision rooms that were adaptive, integrating advancing technology while remaining rooted in the primary goal of facilitating critical decisions under intense pressure (Edwards, 1996). This is also tangible in NASA's Mission Control Center (MCC-H).

4.3. Gui Bonsipe and cybernetics: complex systems

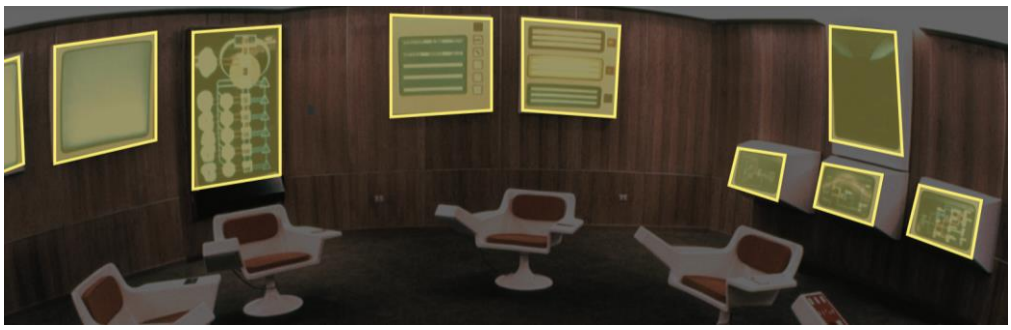

Figure 3. Opsroom within Project Cybersyn from 1972 following a multilateral NtoN approach with decision alternatives spread across the room and voting controls individually accessible to stakeholders (Photo: Copyright © Gui Bonsiepe)

The 'Opsroom' within 'Project Cybersyn' is widely seen as the first decision-space embracing Cybernetics. Designed by Gui Bonsipe based on the underpinning by Stafford Beer, it had systemic thinking and multi-stakeholder dialogues at its core. This is reflected in the omnidirectional NtoN-arrangement with decision alternatives being represented on displays arranged on the surrounding walls, making it multi-directional. Gui Bonsipe followed the 'Gestalt'- Rules for design here to make complex scenarios understandable and democratic (Vehlken, 2022; Meyer, 2019). Even though the room only reached the state of a mock-up, it is widely considered as an important milestone in decision-room design (Penin, 2021).

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4.4. Corporate decision-rooms in the 20th century

As the 20th century progressed, there was a shift in decision-room design, integrating traditional elements with new technologies (Steele, 1986). These rooms began to incorporate both physical and electronic tools, reflecting a world that was becoming more interconnected. Furthermore, their application has rolled out from military uses to cooperate applications, e.g. stock trading or dynamic performance monitoring. The latter half of the 20th century brought the widespread application of semiconductors, enabling electronic tools to be integrated into decision-making spaces. While rudimentary by today's standards, tools such as cathode projectors, complex switchboards and early computers empowered a new era of data processing and presentation (Nelson, 1990). This technological evolution also enabled a faster pace of decision-making. With electronic tools, data could be computed rapidly, allowing for real-time adjustments and quicker responses to changing scenarios (Laudon and Laudon, 1997). Recognizing the importance of collective intelligence and teamwork, the design of decision-rooms began to prioritize configurations that also fostered collaboration. Round table setups, modular furniture, and spaces for breakout discussions became more commonplace (Brill et al., 2001). The move towards collaborative spaces probably also influenced group dynamics amongst stakeholders: There was a push towards collective problem-solving, leveraging diverse skill sets and promoting open dialogue (Johnson and Johnson, 1994). The late 20th century introduced multimedia systems to decision rooms. The incorporation of dynamic video, audio, and graphical data presented in tandem provided a richer, more holistic data representation aimed both at intuition and cognition. This aided in more comprehensive analysis and catered to varied information processing styles of decision-makers (Paivio, 1986).

4.5. The digital age and modern decision rooms

With the advent of the digital era, decision rooms have undergone a transformative shift, transitioning from purely physical spaces to more dynamic, technologically integrated environments (Gray, 1987). The digital age also brought the integration of collaborative tools designed to facilitate real-time information sharing and remote collaborative decision-making. Systems such as video conferencing, digital whiteboards, and cloud-based collaboration platforms have become integral components of modern decision rooms. While these tools significantly enhanced communication and collaboration, they also introduced challenges, notably cybersecurity concerns and the need for technological fluency among decision-makers (Whitman and Mattord, 2011). In an age where data is abundant, the ability to visualize complex information has become crucial. This is well described in the visual analytics community (Fisher et al., 2011). Decision rooms are now often equipped with large interactive displays and advanced data visualization software, enabling decision-makers to analyze intricate datasets in a visually intuitive manner (Few, 2009).

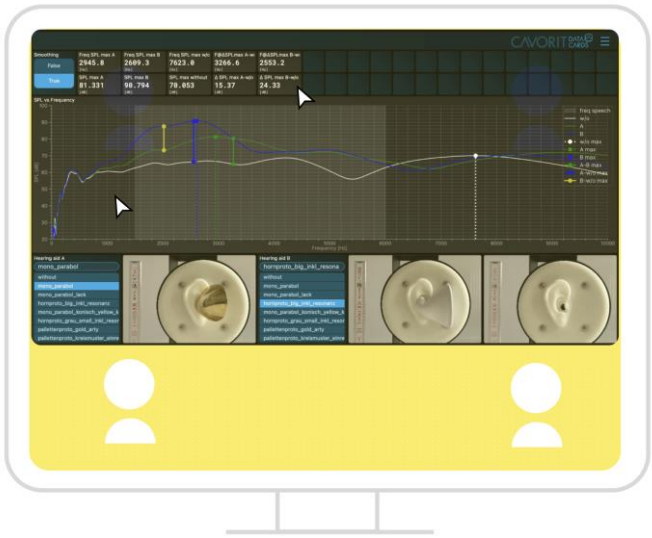

Figure 4. Data Science-based decision-making platform DataCards applied in the research team at analogue hearing aids development (Klöckner and Wiesner, 2023)

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Research by Ware (2020) underscores that effective data visualization can lead to faster, more informed decision-making, but it also mandates a need for interpretative skills among users, e.g. Data- and Systems-Literacy. The proliferation of virtual collaboration tools means that decision rooms no longer need to be confined to a single physical location. Virtual decision rooms, hybrid 'huddle spaces' and emergent formats yet to be invented facilitated by tools like VR and AR, are on the horizon, offering the potential for even more informed hybrid decision-making processes (Bailenson et al., 2008). Modern collaboration tools like Miro, Mural, Jupyter Notebooks and DataCards (Figure 4) push to a roll-out of virtual/hybrid joint-decision-rooms, empowering decision-experiences with smart algorithms at the core. In the artistic and exhibition design field, but less in professional decision-making rooms, Data-Physicalisations became popular to make data-representation both ‘graspable’ in the literal sense and multi-perspective by the object nature of the ‘boundary object’ (Dumičić et al., 2022). This might hold potential, especially for future hybrid-by-infrastructure decision-making spaces containing real, augmented and fully virtual 3D-objects as ‘boundary objects’.

4.6. Current trends and the 21st century

Extended Reality (XR) might well be seen as a potential major influence in the future landscape of decision-making rooms, transcending traditional spatial limitations and offering immersive experiences. According to Slater and Sanchez-Vive (2016), VR/XR has the potential to create shared virtual environments where users, irrespective of their geographical location, can collaboratively engage in decision-making processes, essentially redefining the notion of a 'room'. Studies by Bailenson et al. (2008) highlight that XR can facilitate cognitive immersion, enabling decision-makers to engage deeply with complex data or scenarios and envisage outcomes with enhanced clarity. Figure 5 taken from the introduction of Apple VisionPro provides an idea of the possibilities in spatial arrangement. Apple refers to this as ‘spatial computing’, potentially providing for a free arrangement of two-and three-dimensional decision-alternative representations in space.

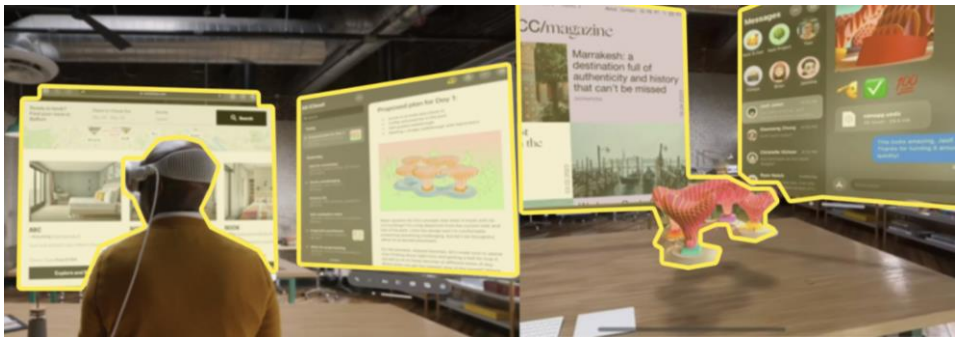

Figure 5. Recent XR developments like Apple Vision Pro or Meta Quest III might empower the design of hybrid-by wearable spaces for joint decision-making. While 1to1 for now, this might nudge designs towards NtoN hybrid arrangements (Source: Apple Inc.)

Beyond conventional artificial intelligence, future decision-making spaces will likely see the rise of augmented intelligence, where algorithms don't just process data but synergize with human intellect to drive decision-making collaboratively. Russell and Norvig (2016) posit that the future of AI is not just about autonomous decisions but rather assisting human decision-making, ensuring that outcomes are both data-informed and human-centered. Zhicheng Liu et al. (2008) outline the potential of systems that provide real-time feedback during decision-making processes, dynamically adapting to the inputs from human users and optimizing outcomes based on combined human-machine insights.

5. Discussion

The examples presented in the previous section provide some insight into the evolution of high-level design patterns in decision-making spaces over the past 100 years in military and business. When looking at the found room layouts, equipment and furniture, involved technologies, relation of stakeholders in the room, and other design specifics, several patterns were identified: Initial findings

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achieved in the preparatory research done for this paper suggest an outlined preliminary chart (Table 1) as follows: The typology of the design of decision-making spaces could preliminarily be clustered into a 2 x 4 matrix defining eight different formats according to their 'digitality' and the typical main flow of information: 1toN = presenter type flow of information, NtoN = no specific hierarchy among stakeholders of decision-making session. 1toN spatial arrangements focus on a presenter who utilizes the boundary object to convey possible choices. The presenter's role might shift from one stakeholder to another; however, at least a temporary hierarchy is being induced. NtoN arrangements typically induce a more 'democratic' flow of information during the consideration phase of the decision-making processes, even when the final decision is being made hierarchically. Notably, an asymmetry appears in the chart as current decision-making spaces typically tend to typically cover 1toN (Screen-based presentation) but much less NtoN ('round table') arrangements, especially in hybrid by infrastructure setups. Interactive tables for democratic decision-alternatives evaluations appear to be still rare today. Thus, conducting further research in the fields of A) NtoN hybrid-by-infrastructure decision-making spatial layouts (e.g. interactive tables) and (B) 1toN and (C) NtoN arrangements in hybrid-by-wearable space layouts appear needed. As the geopolitical and technological fields evolved, so did the design of these spaces. However, certain patterns remain in the layout: Round table-like arrangements (see Ken Adams, Figure 2 for instance) were already found at the ancient fireplaces and even found their way into the English language: initiating a 'round table' proposes a rather flat hierarchy of discussion, often spanning stakeholders from different epistemic communities. The 'round table' might be a literal artifact forming a boundary object for decision-making or might be metaphorical (Cresswell et al., 2013). It might or might not contain or carry decision alternatives representations. The round table has recently even been suggested as a metaphor to be applied to AI agents (LLMs) to improve reasoning via consensus (Chen et al., 2023). In summary of the selected examples, decision-making spaces are consistently driven by function and urgency, leading to designs that emphasized clarity, accessibility, and communication (Alexander, 1964). The Cold War era underscored the need for fortified spaces while introducing more sophisticated technological systems for data analysis and representation. The Digital Age empowered a transformation towards the integration of collaborative tools, (though not so much in hybrid applications) and a shift towards dynamic and interactive data visualization as a core component. With the beginning integration of Virtual Reality (VR) and Augmented Intelligence, the contours of immersive and interactive decision-making are being redrawn (Slater and Sanchez-Vives, 2016). Future development might lead towards a synthesis of intensively technologically augmented spaces and human-centric designs (Hedge, 2019). A compelling proposition is also in the decentralization of decision rooms, leveraging virtual environments to bridge geographical distances, empowering global collaborations (Bailenson et al., 2008) and largely pushed by remote work schemes introduced during the Covid-19 Pandemic. In the young field of cognitive ergonomics, it seems plausible to assume that future decision-rooms will prioritize design elements suited to augment cognitive throughput, shape narration, and enhance decision-making efficiency (Vischer, 2008). Additionally, as described by Seeber et al. (2020), the evolution of generative AI, including NLP, suggests a transition from a pure analytical AI focus to a more collaborative paradigm (AI as a team member). In such a scenario, AI systems might morph into integral 'contributors' within decision-support systems, providing real-time insights and potentially challenging human perspectives. The literature discovered in the creation of this paper interestingly mainly covered **convergent** (decision-making) activities, while **divergent** (option/scenario-creation) activities have hardly been described in the decision-making rooms literature. Remarkably, hardly any literature has been found, that connects decision-making space's design and the experience potentially influenced by it. Thus, the research question can partially be answered by the following suggestions on the scope of research investigating the relation between design and experience of decision-making spaces: A) Identification of process logs of historical decision-making sessions in war rooms and an analysis on hints for relations between design and experience / efficacy using LLMs. Additionally evaluating the patterns found in this paper. B) Scoping further deductive empirical studies in existing and/or experimental decision-making spaces with options for triangulation. These studies might include qualitative and quantitative aspects to shed light on the relation between design, experience, and efficacy. Biases introduced by gender, ethnicity and social status would be very relevant to investigate in terms of inclusive design. It is striking that the historical

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examples appear mainly male coded. Moreover, biases introduced by algorithms/AI in the creation and representation of decision-alternatives before decision-making would be very relevant to investigate.

Table 1. Overview of findings

	Analogue	Digital	Hybrid by Infrastructure	Hybrid by Wearable
1toN	Speech, Analogue Presentations	PowerPoint etc. via Screensharing	PowerPoint digital Presentation	Apple Vision (Fig. 5)
NtoN	Fireplace, Greek Polis, Round-Table, NORAD (Fig. 1 left), Ken Adam War-Room (Fig. 2 right), RAF (Fig1)	Miro, Mural, DataCards (Fig. 4), Jupyter Notebooks, Zoom etc.	Cybersyn (Fig.3), [Potential hybrid round-tables]	[Potential NtoN arrangements]

6. Conclusions

With this paper, we aim to present an overview of design patterns in the history of decision-making rooms. Based on selected instantiations from literature, documentaries, and popular film culture, we were able to extract some first spatial patterns, that will be the foundation for further investigations in this topic. Further studies seem needed especially in three fields, (A) the evaluation of the impact of spatial layouts on the collective decision-making experience, (B) the creation of a framework for spatial patterns in designs of decision-making rooms, and (C) prototyping and evaluation of alternate layouts for decision-making spaces involving both infrastructural and wearable XR technologies and design for augmented intelligence AI-based decision-making support. (A) The evaluation of the impact of spatial layout seems a promising path for future research but will be challenged by budgetary constraints in both rebuilding actual decision-making rooms (possibly by VR) and sufficient user sample size for A-B tests. (B) needs further research in the literature about both decision-making spaces and creative spaces to increase theoretical underpinning and provide additional data. (C) might be possible based on this paper and further research in the fields of (A) and (B) while gathering empirical data potentially covering UX (User experience), psychometrics, and KPIs from the DSS-field. Additional research investigating the impact of the different spatial layouts outlined in this preliminary framework on the experiences and outcomes of decision-making processes will also have to be made. Especially, the rather unexplored field of design of hybrid-decision-making spaces appears promising to understand designs that foster the balancing of stakeholder needs in decision-making processes (Hettinga et al., 2018). In conclusion, we argue that the work presented in this paper provides an initial foundation for future research in the field of design of decision-rooms, potentially providing support in the addressing of wicked problems across stakeholders from various epistemic communities.

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