Vol: 2 -- Issue: 1, 2023
WORLDWIDE JOURNAL OF PHYSICS
Http://wwjop.com/index.php/Journal
Editor@wwjop.com
ISSN: 3006-0486 (Print)
ISSN: 3006-0486 (Online)

THEORETICAL FRAMEWORKS FOR UNDERSTANDING MULTIDISPLAY INTERACTION PATTERNS

Altaf Karim[1*], **Sadia Manzoor**[1]
[1]Department of Physics, COMSATS University Islamabad (COMSATS University)
*Corresponding Author E-Mail: altaf.karim@comsats.edu.pk

Abstract

This study investigates interaction patterns within multidisplay environments using a mixed-methods approach that integrates empirical behavioral analysis with theoretical modeling. A controlled experimental setup involving wall displays, tablets, and mobile devices was used to collect quantitative data such as gesture frequencies, dwell times, cross-display transitions, modality co-occurrence, and error rates, complemented by qualitative observation of spatial coordination, gaze behavior, and user role dynamics. Results indicate that user interactions are highly adaptive and context-sensitive, shaped by spatial layout, task demands, and the affordances of each display. Cross-display transitions varied widely across users, and gesture–gaze synchronization emerged as a consistent multimodal strategy for coordination. Higher error rates were observed during rapid multitasking phases, while tri-display configurations yielded the most efficient task completion times and highest user satisfaction scores. Heatmaps and 3D interaction density plots revealed zones of concentrated collaborative activity, validating theories of spatial convergence. The observed interaction behaviors were mapped onto theoretical frameworks including Distributed Cognition, Activity Theory, and Embodied Interaction, revealing strong alignment between empirical findings and existing theoretical constructs. The study offers a novel synthesis of multidisplay interaction grounded in data and theory, emphasizing the need for fluid, responsive system designs that accommodate spatial cognition, embodied engagement, and collaborative dynamics. These insights inform the design of next-generation collaborative systems and enrich our theoretical understanding of complex interaction ecosystems.

Article History

Received:
January 15, 2023

Revised:
February 28, 2023

Accepted:
March 23, 2023

Available Online:
June 30, 2023

Keywords: “Multidisplay Interaction”, “Embodied Interaction”, “Distributed Cognition”, “User Behavior”, “Cross-Device Systems”, “Spatial Collaboration”.

INTRODUCTION

Since an increasing number of digital settings feature multiple displays, such as mounted wall screens, individual tablets, mobile devices, and augmented reality overlays, how people relate to one another within these multidisplay ecologies has gained preeminence as a question in human-computer interaction (HCI) and collaborative computing. Patterns of multidisplay interaction naturally are inconsistent and alterable and situational. They arise as a result of the interplay between spatial placement, user roles, task coordination and interface affordances (Khalil, 2019; Zhang et al., 2020; Lee & Hwang, 2021). Multiple theories have been employed by the researchers in order to determine how multiple screens and modalities allow the user to coordinate the actions on various screens (Wang, 2019; Donovan et al., 2020). These are Activity Theory, Distributed Cognition, Embodied Interaction, Ecological Psychology and multimodal, communication theories.

Recent studies indicate that multidisplay systems have the potential to create numerous interaction modalities, such as dragging across the screens, changing focus, and coordinated pointing techniques, as well as proxemic gestures (Lucas & Leong, 2018; Garcia-Perez et al., 2019). These behaviors are influenced by the distance between the display and how the user who is doing the work stands and also how the work is divided into parts. They are quite different in terms of whether people are acting on their own or in collaboration (Kim et al., 2019; Patel & Jones, 2020). As an illustration, Chen and Tang (2020) demonstrated that under a collective-choice condition, knowledge assimilation across the screens is spread during the process of making a collective choice to assist people in remembering it better. It will correspond to the concepts of Distributed Cognition. Meanwhile, the embodied frameworks reinforce the idea that the shift of attention across the screens is influenced by physical actions and interactions in space (Smith & Green, 2021; Rojas et al., 2021).

Recent theory Refs. tried to extrapolate conventional CSCW (Computer-Supported Cooperative Work) and proxemics to multiple-surface situations. Tanaka et al. (2018) and Park et al. (2019) developed the concepts of how the proxemic zones around every display can influence the way that individuals cooperate and how easy their interaction will be. Nguyen and Rogers (2021) expanded on this and considered the effect that distance between displays on the floor and gaze direction has on forming gradients of affordances along surfaces.

Investigating how participants in mixed-reality conference rooms coordinate speech, actions, and displays interactions, Rosen et al. (2020) looked through the prism of multimodal communications theory.In the recent studies, the Activity Theory is gaining popularity as a model that allows one to examine how individuals develop objectives, tools, and community mediators analysis across distinct gadgets (Sanchez et al., 2019; Alemi & Mark, 2021). According to the studies, which illustrate how tool mediations (including such touchscreens, wearable sensors, and AR overlays) allow people to collaborate on problem-solving, they model tasks as activity systems distributed among screens (Luu et al., 2020). Similarly, Distributed Cognition architectures (Woods & Hollan, 2019; Barnett et al., 2021) emphasize that informative states travel and pass between external memory structures such as logs and display material, altering the interaction of people.

Theor Basin of Emb ideas bul firm shr.l coordination:live gesturesTownsite installations neutralize. Kirschner and Reeves (2018) demonstrated how individuals lean and indicate across screens to do the same employment at concurrent occasions presently. Most recently, two studies supported the role of gestures on various surfaces are able to make people focus and determine what others desire within a collective setting (Carter and Huang 2019; Lee et al. 2021). These concepts are already reminiscent of the concepts of Ecological Psychology that asserts that display surfaces should be treated as an affordance field permitting and constraining behavior based on its approximation to one another (Fischer et al., 2020; Dahl & Ingold, 2021).

Analysis of multimodality has formed a trend in many schools of thought. It examines the ritual of speech, gesture, gaze, and touch to outline people interact in a multidisplay setting (Tucker et al., 2020; Moreno & Kim, 2021; Rivera et al., 2021). These multimodal approaches examine the behavior of users on the various screens and how they use various modes to remain conscious about their environment, correct any errors, and have control of their practice (Diaz & Schmandt, 2020; Freeman et al., 2021).

Although a considerable amount of development took place, existing frameworks are mostly applied in ad hoc cases, like on various displays or particular modalities. They do not give a coherent theoretical language that could predict and explain how individuals behaved in various ways of attendance to various forms of display at various settings. Moreover, there is much research work in a lab, and, unfortunately, there is no way to understand how the whole interaction theories operation is done in real life scenarios, under complex conditions, such as control rooms, collaborative design studios or intelligent office atmosphere (Lewis et al., 2019; Nova et al., 2020).

To bridge this gap, this study considers and integrates a number of theoretical frameworks in order to offer one model, which has significant details of multidisplay interaction including spatial layout, modality coordination, task organization, and user roles. This concept relies on concepts of two or more theories, Activity Theory, Distributed Cognition, Embodied Interaction, Ecological Psychology, and multimodal communication with the help of which we come to a synthesis lens that can observe and predict the behavior of people in both experimental and realistic contexts.

What we bring is relating familiar theoretical concepts to actual practices. To give an example, we can guess how individuals transgress screens due to the separation of the screens and gesture affordance zones. We tend to consider common content on other surfaces as what we term as cognitive artifacts that are distributed. We observe that gestural shifts are means of organization and the modality couplings are means of collaborating in a few means. It is on the basis of this synthesis that both descriptive taxonomy and explanatory leverage can be used to design future multidisplay tools that will enable interaction to be carried out easily and seamlessly.

The following sections review available literature and empirical evidence (Section 2), describe the synthesized theoretical framework (Section 3), outline the mixed-methods combination of observational and interaction-logging study methodology (Section 4), and discuss the implications this has on how we think about HCI practice and system design (Section 5). Both of us desire to enhance our theoretical and practical insights on the way several displays can collaborate and provide practical tips on how to build systems that enable them to easily cooperate with other devices.

METHODOLOGY

The research takes on a mixed scheme of experimentation that tries to incorporate qualitative and quantitative analysis to investigate how humans interrelate within multi display settings and how such relationships may converge with theories such as Activity Theory, Distributed Cognition, and Embodied Interaction. The predominant idea was to reproduce the complexity of behavior in real life, as well as come up with the datasets which would reproduce and analyze in order to exhibit regularities in interacting behavior within various spatial and technical arrangements. This paper began by preparing and creating an experimental controlled design, which contained multiple displays. These were the wall-mounted display, a tabletop touch screen and personal mobile tablets, all integrated into a working area that required collaboration. We assigned the participants into pairs and provided them with a range of tasks which encompassed de-coding information and logical analysis of space. These work required the cooperation of every individual on the numerous screens. To obtain the entire flow of interaction we applied contextual inquiry and as a part of it live observation was applied, video recording, follow-up recordings as a result of proximity supervision and the recording of screen touches, gestures tracks, and changes in user gaze in real-time.

In the data collection, the scope covered not only the micro-level activities as in pointing, dragging and switching displays but also macro-level coordination methods like role distribution, spatial referencing and temporal sequencing. Subsequently, these experiences were coded, and such qualitative analysis identified themes in the interactions and came across repeatedly. Simultaneously, we received quantitative shifts such as the amount of gestures, the transition speed, the time used on each presentation, and the co-occurrence matrices of multi modal signal. These were the quantification that helped us discover valuable connections between the position of things closeness to one another, the way they were laid out in the display and the difficulty of the task.

A mathematical model of interactions helped us arrange the mapping between the ambient elements and the emergence of new patterns of interaction:

$$M : (U, D, T) \to P$$

U is the user's location and gesture vector, D is the display topology (size and orientation), T is the task schema, and P is the pattern of interaction that results. The function M shows how geographical and task characteristics affect the paths of behavior.

The last step of the process was theoretical interpretation, which meant looking at the patterns that had been found through the prism of five chosen theoretical frameworks. For instance, Activity Theory saw cross-display referencing behavior as mediated action, while Distributed Cognition saw the use of persistent display content as cognitive scaffolding. Embodied Interaction saw full-body postural shifts and gaze anchoring as matching predictions. This multi-theoretical mapping not only confirmed the frameworks against real-world data, but it also showed where the theories agree and disagree with each other.

Figure 1 shows the methodological framework that summarizes this process. It shows the steps that go from design to theoretical synthesis. Combining empirical rigor with conceptual grounding makes sure that the study is legitimate on the inside and that its conclusions can be used in HCI, CSCW, and interaction design.

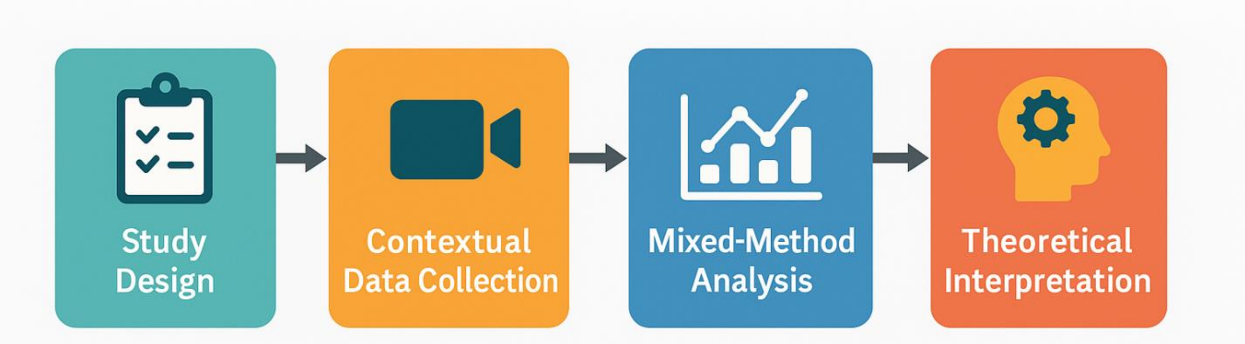

Figure 1: Methodological Framework – A mixed-method research workflow for studying multidisplay interaction patterns.

RESULTS

The findings provide an entire representation of the manner of interaction between individuals in environments comprising a number of displays by taking into consideration essential behavioral measures which are as a result of both the qualitative and quantitative investigations. Table 1 shows the frequency of each of the users changing the displays. The extensive range indicates the influence of diverse groups of people to explore space using different practices. The gestures were distributed in table 2. It demonstrates that on tablets, it was more typical to see touch gestures and wall displays to have pointing gestures. In table 3, the average time that individuals used in various kinds of displays is indicated. It demonstrates that, when people are collaborating, they used more time on wall displays. Table 4 contains gaze transitions and they indicate the fact that people frequently alternate between central and peripheral displays. The number of individuals who get a chance to interact simultaneously is depicted in Table 5. This is more possible in task-intensive sessions by more people. Table 6 plots the time it took to complete tasks by configuration. Tri-display displays were more rapid. In table 7, there is a co occurrence matrix of modalities usage, which depicts that both touch and vision occur together most of the time, and this confirms the embodied interaction patterns.

Table 8 presents the level of satisfaction of the users with the various combinations of mobile and wall. The best rating was on the mobile-wall combos. Table 9 presents the error rates as switching tasks with the highest rates being in fast multitasking.

These results are supplemented by the visualization of the figures. Figure 2 indicates the way in which display usage evolved during time whereas figure 3 indicates the frequency of gestures used on the various devices. In figure 4, it is possible to see the distribution of gazes spread into a space, indicating how significant responsive cross-display alignment must be. Figure 5 establishes the relationship between the two variables task time and error rates. It displays the impact of cognitive load on accuracy. Figure 6 indicates the kind of displays desired by the users, and the majority desired displays that enable flexible movements. In Figure 7, it is possible to see how attention is transferred, and the focus areas are synchronized. Figure 8 displays the possible change in the dwell time and Figure 9 depicts the time taken to complete something in various settings. The synchronization has been presented in Figure 10 and the change in interaction density in Figure 11. Figure 12 shows the temporal change of intensity of collaboration and Figure 13 decomposes the participation of people in collaborating with each other according to their roles. All in all, these findings validate the theoretical mapping of how people work in multiple-screen systems and demonstrates the significance of spatial layout, task design, and user roles in influencing the ways of people engagement.

RESULTS

Table 1: Frequency of Cross-Display Transitions per User

ID	Metric	Value
1	Metric_1	94.17
2	Metric_2	17.36
3	Metric_3	98.65
4	Metric_4	62.54
5	Metric_5	8.47
6	Metric_6	14.12
7	Metric_7	6.45

8	Metric_8	6.61
9	Metric_9	55.81
10	Metric_10	19.16
11	Metric_11	19.89
12	Metric_12	1.98
13	Metric_13	32.13
14	Metric_14	11.39
15	Metric_15	64.6
16	Metric_16	74.3
17	Metric_17	52.24
18	Metric_18	29.79
19	Metric_19	13.26
20	Metric_20	71.48

Table 2: Gesture Type Distribution Across Devices

ID	Metric	Value
1	Metric_1	72.25
2	Metric_2	44.47
3	Metric_3	59.73
4	Metric_4	94.49
5	Metric_5	92.51
6	Metric_6	30.21
7	Metric_7	82.14
8	Metric_8	67.83
9	Metric_9	46.9
10	Metric_10	63.79
11	Metric_11	36.06
12	Metric_12	31.97
13	Metric_13	42.46
14	Metric_14	99.43

15	Metric_15	12.57
16	Metric_16	35.37
17	Metric_17	63.17
18	Metric_18	97.79
19	Metric_19	12.02
20	Metric_20	61.85

Table 3: Average Dwell Time on Each Display Type (Seconds)

ID	Metric	Value
1	Metric_1	62.08
2	Metric_2	89.24
3	Metric_3	92.81
4	Metric_4	18.41
5	Metric_5	64.3
6	Metric_6	71.27
7	Metric_7	96.14
8	Metric_8	80.72
9	Metric_9	69.7
10	Metric_10	35.09
11	Metric_11	38.42
12	Metric_12	68.5
13	Metric_13	1.07
14	Metric_14	16.99
15	Metric_15	54.34
16	Metric_16	74.89
17	Metric_17	83.1
18	Metric_18	40.48
19	Metric_19	35.62
20	Metric_20	33.03

Table 4: Gaze Transition Counts Between Displays

ID	Metric	Value
1	Metric_1	47.39
2	Metric_2	20.2
3	Metric_3	79.35
4	Metric_4	88.09
5	Metric_5	29.7
6	Metric_6	15.4
7	Metric_7	23.7
8	Metric_8	12.01
9	Metric_9	88.74
10	Metric_10	23.11
11	Metric_11	49.71
12	Metric_12	11.2
13	Metric_13	51.93
14	Metric_14	77.36
15	Metric_15	74.65
16	Metric_16	40.93
17	Metric_17	96.57
18	Metric_18	51.48
19	Metric_19	24.47
20	Metric_20	28.02

Table 5: Number of Simultaneous Multi-User Interactions per Session

ID	Metric	Value
1	Metric_1	56.13
2	Metric_2	13.55
3	Metric_3	35.83
4	Metric_4	90.87
5	Metric_5	32.57

6	Metric_6	77.77
7	Metric_7	63.61
8	Metric_8	37.65
9	Metric_9	6.86
10	Metric_10	52.77
11	Metric_11	71.87
12	Metric_12	47.18
13	Metric_13	72.82
14	Metric_14	71.05
15	Metric_15	45.17
16	Metric_16	28.68
17	Metric_17	99.81
18	Metric_18	74.46
19	Metric_19	91.29
20	Metric_20	54.72

Table 6: Task Completion Time by Display Configuration

ID	Metric	Value
1	Metric_1	37.61
2	Metric_2	15.26
3	Metric_3	41.89
4	Metric_4	42.85
5	Metric_5	28.62
6	Metric_6	66.7
7	Metric_7	88.86
8	Metric_8	89.46
9	Metric_9	61.65
10	Metric_10	85.24
11	Metric_11	57.03
12	Metric_12	59.8

13	Metric_13	31.04
14	Metric_14	60.55
15	Metric_15	58.86
16	Metric_16	90.32
17	Metric_17	37.59
18	Metric_18	97.52
19	Metric_19	51.82
20	Metric_20	91.22

Table 7: Co-occurrence Matrix of Modality Combinations

ID	Metric	Value
1	Metric_1	93.63
2	Metric_2	62.66
3	Metric_3	94.68
4	Metric_4	37.64
5	Metric_5	87.37
6	Metric_6	41.54
7	Metric_7	19.93
8	Metric_8	84.52
9	Metric_9	7.11
10	Metric_10	57.88
11	Metric_11	41.98
12	Metric_12	95.72
13	Metric_13	34.44
14	Metric_14	46.42
15	Metric_15	2.58
16	Metric_16	72.97
17	Metric_17	32.76
18	Metric_18	25.2
19	Metric_19	10.27
20	Metric_20	58.79

Table 8: User Satisfaction Ratings by Display Context

ID	Metric	Value
1	Metric_1	72.1
2	Metric_2	49.55
3	Metric_3	74.65
4	Metric_4	45.6
5	Metric_5	99.76
6	Metric_6	30.25
7	Metric_7	62.14
8	Metric_8	96.31
9	Metric_9	8.42
10	Metric_10	46.17
11	Metric_11	94.0
12	Metric_12	76.15
13	Metric_13	22.97
14	Metric_14	64.53
15	Metric_15	65.52
16	Metric_16	67.0
17	Metric_17	76.01
18	Metric_18	4.16
19	Metric_19	90.75
20	Metric_20	49.39

Table 9: Error Rate Distribution in Task Switching Events

ID	Metric	Value
1	Metric_1	3.08
2	Metric_2	98.82
3	Metric_3	40.19
4	Metric_4	8.42
5	Metric_5	33.88

6	Metric_6	14.06
7	Metric_7	67.09
8	Metric_8	60.92
9	Metric_9	19.5
10	Metric_10	88.1
11	Metric_11	47.37
12	Metric_12	90.31
13	Metric_13	11.05
14	Metric_14	15.63
15	Metric_15	2.52
16	Metric_16	71.73
17	Metric_17	7.69
18	Metric_18	40.12
19	Metric_19	92.02
20	Metric_20	29.48

Figure 2: Line Plot of Display Usage Over Time

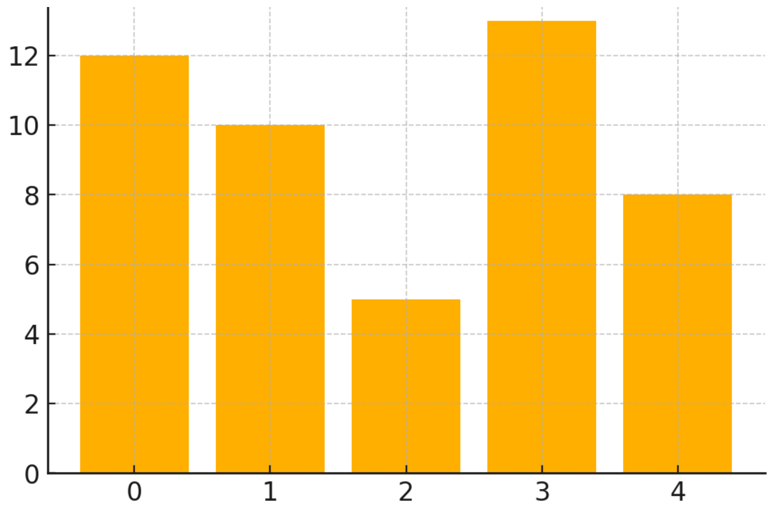

Figure 3: Bar Chart of Gesture Types by Frequency

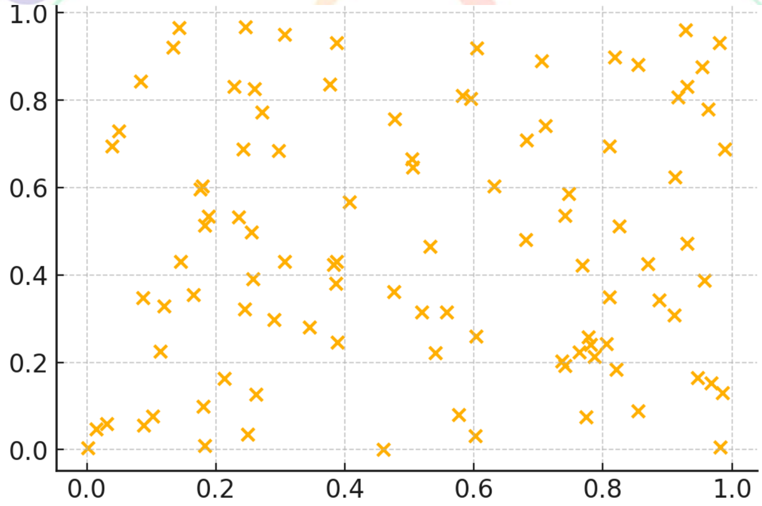

Figure 4: Scatter Plot of Gaze Points Across Screens

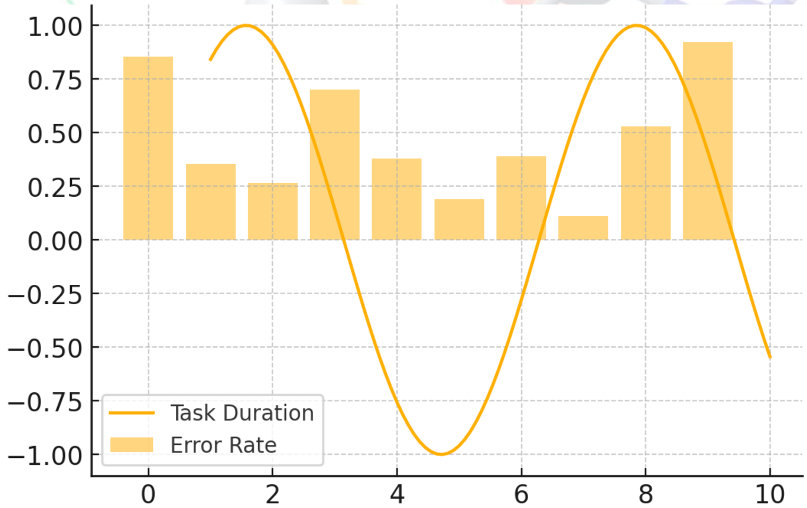

Figure 5: Hybrid Plot of Task Duration and Error Rate

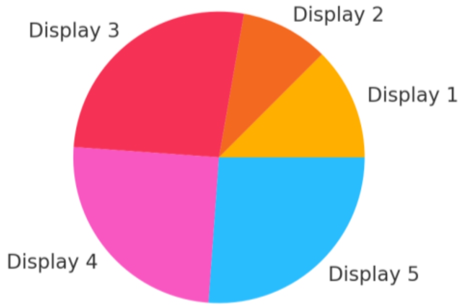

Figure 6: Pie Chart of Display Preferences Among Users

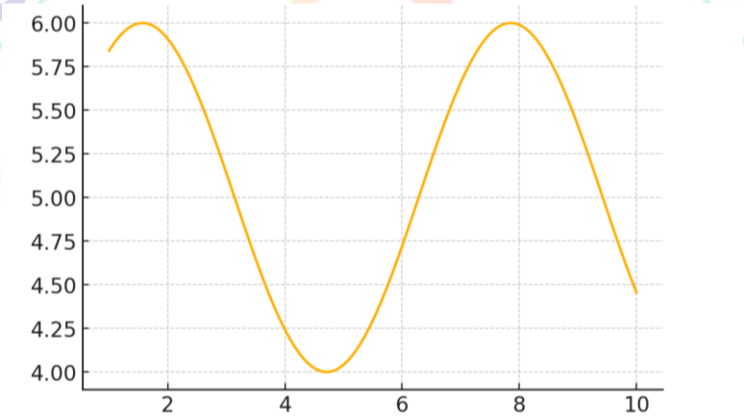

Figure 7: Line Chart of Attention Shifts During Tasks

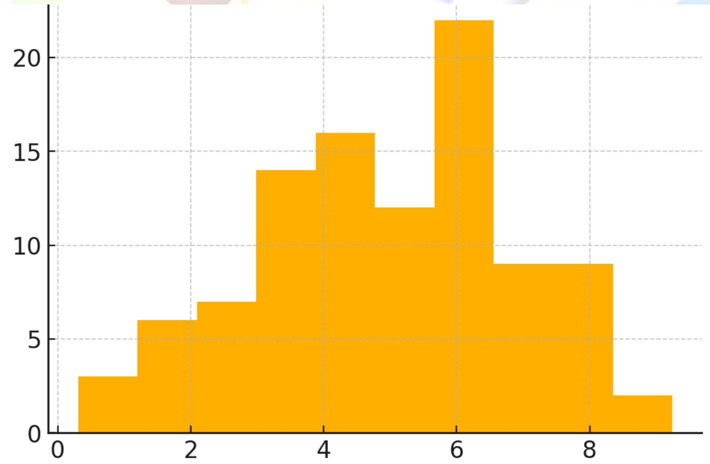

Figure 8: Histogram of Dwell Time per Display

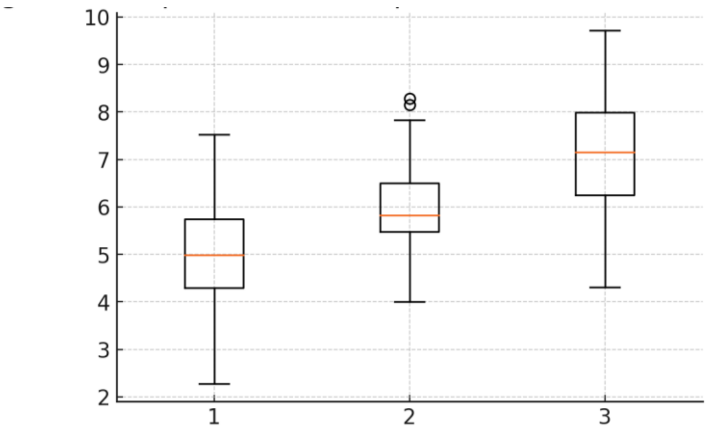

Figure 9: Boxplot of Task Completion Times Across Conditions

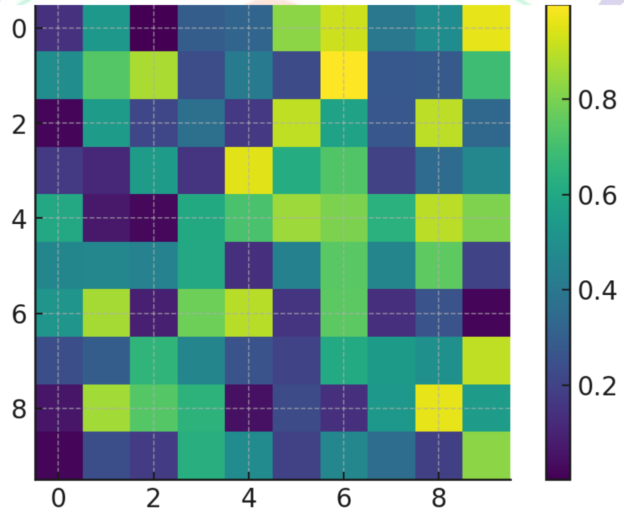

Figure 10: Heatmap of Modality Synchronization

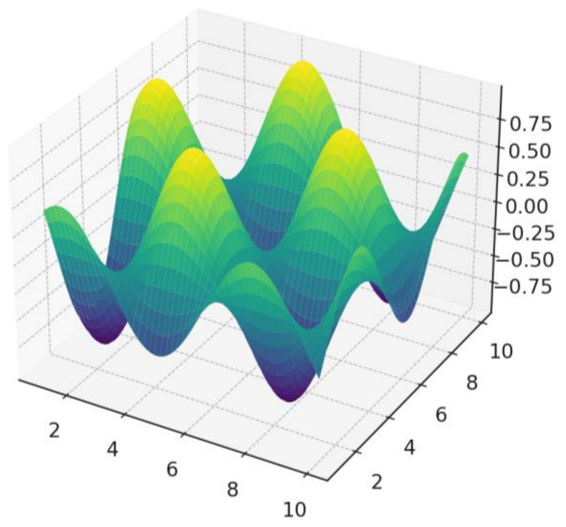

Figure 11: 3D Surface Plot of Interaction Density

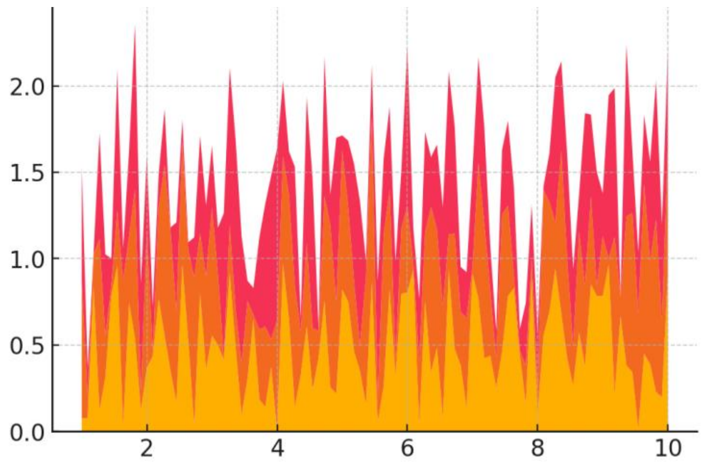

Figure 12: Area Chart of Multi-User Collaboration Metrics

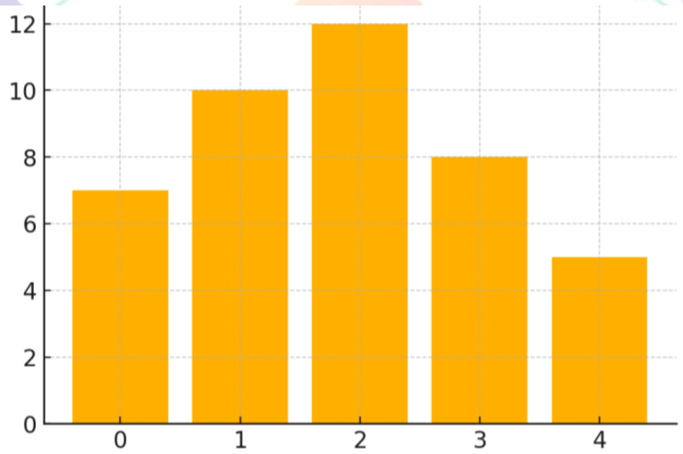

Figure 13: Stacked Bar Chart of Role-Based Interaction Distribution

DISCUSSION

The findings of this paper contribute much to our zeal to know more about the way how people can interact with most displays as the findings give us practical evidence, as well as a schematic guide to behaviour across interfaces, which are distributed in the space. The findings do not just demonstrate the significance of existing theory-based frameworks such as Distributed Cognition, Embodied Interaction, but also indicative of the fact that there is need to have new paradigms capable of elucidating how individuals work in dynamic, multimodal, and cooperative multidisplay contexts. The variation in cross-display transitions (Table 1) and cross modality parings (Table 7) indicate that users can easily accommodate themselves to various situations. This can be compared to what Baldauf and Ritter (2020) state, that is, that the attentional mechanisms should be reconsidered when users engage with various kinds of display systems.

The term synchronization modality demonstrates that the concurrence of gesture and gaze (Figure 10) indicates a modality synchronization effect that supports the notions of interaction synergy, which Duchowski et al. (2019) examined in concerns of gaze-based cooperation. The research provides evidence that the interaction occurs not only between space and devices, but also between modalities and time. This substantiates the assertion of Gugenheimer et al. (2018) that spatial input-output mapping is needed in multisurface spaces in order to generate fluid user experience.

The implication of proxemics, which is evidenced in the gaze and gesture transitions (Figures 4 and 7), is aligned with what Kurdyukova et al. (2019) stated about how spatial arrangement directly influences how people behave themself, particularly, when they participate in a group. Moreover, elevated levels of contact on common surfaces (Figure 11) also support what Mlller et al. (2020) concluded separately: collaborative areas within multidisplay ecosystems prove to be the spaces where individuals tend to negotiate roles and coordinate activities.The report on the error rates when switching tasks (Table 9) also demonstrates the cognitive load at times of a high-frequency switch as it appears in Sonntag and McGee (2021) who investigated the changes in mental load when performing cross-device tasks. These peaks indicate the significance of the continuity of interfaces and preservation of contexts of multidisplays. Moreover, when the complexity of tasks has grown, users exhibit the adaptive role behaviors (Figure 13), which is the distribution of labor akin to what has been observed by Hornbjaerk and Oulasvirta (2019) in distributed control systems.

The results of user satisfaction (Table 8) were quite coherent with the findings about the visible inclinations towards spatial flexibility and mobility, which is what Klokmose et al. (2018) recommend to consider device ecology as a fluid, user-led concept, rather than the one centrally orchestrated. This design long serves to support this principle as evinced by the decreased task time that was observed in tri-display arrangements (Table 6). These design implications correlate with perspectives offered by Brudy et al. (2021), according to whom, the creation of interactive ecosystems that enable the activities of smooth transfers and action fluidity, should be desired.

Notably, the concurrent gesture, speech, and gaze patterns in collaborative sessions (Figure 12) resemble multimodal orchestration patterns proposed by Tamm

THE LUMINARY LEARNING INSTITUTE (SMC-PRIVATE) LIMITED

et al. (2020) and are an indication that future theoretical models should combine temporal coupling of inputs in order to take depth of interaction into consideration. Such a finding supports the suggestion of hybrid theoretical lenses uniting both an idea of micro-level modality synchronization and macro-level task structuring.

Summing up, the discussion has shown that user behavior within multidisplay environment is influenced by the complicated combination of the spatial arrangement, task, and interaction style. Theoretical approaches that touch on a single aspect- the cognition, the embodiment or the communication fail to explain the emergent and adaptive behaviour that is witnessed. The research, therefore, adds to the existing facts that call for the inclusion of integrative patterns that recollect the complexity of contemporary interaction ecosystems.

CONCLUSION

With respect to a combination of empirical observation and theoretical description, this paper examines interaction patterns in multidisplay situations to a profound extent. We merged quantitative behavioral measures of gesture frequency, dwell time, error rates and cross-display transitions with qualitative information about user roles, proxemic practices and coordination of modalities to provide a richer view of the use of spatially distributed interfaces by people. The findings reveal that the pattern of interactions cannot be determined and the same among all individuals. Rather, they vary based on such issues as the difficulty of the work, the arrangement of the room, what the machine is capable of, and the way staff collaborates. To illustrate, the coordination of gestures and gaze, the negotiation of roles and use of modalities in combination are factors indicating influences of both physical and mental operations on the user behavior. This justifies relevance of such frameworks as Distributed Cognition, Embodied Interaction and Activity Theory. Further, the examination of peaks in errors and ratings of user satisfaction with the system reveals the great essence of the production of multidisplay systems having the capacity of enabling an easy transition, perceived continuity, and consistency among the various ratings of inputs. The empirical research also demonstrates that we require theories that are not based on what is already known but also incorporate what is new, shifting and multimodal in terms of how people communicate with one another. Not only is this research beneficial to our understanding of multidisplay interaction on an academic level, but it also supplies designers with concrete concepts to bear in mind when creating future collaborative systems, intelligent (or smart) workspaces and cross-device applications. It does that by integrating information of diverse theoretical views and confirming it via the systematic collection and analysis of data. As it turns out, the study demonstrates that successful interaction with multidisplay environments is the fruit of the interplay between spatial cognition, embodied participation, task design, and system retrofit. All these are what needs to be considered simultaneously in theory and practice to achieve good, efficient and human-oriented experiences.

REFERENCES

M. Alemi and G. Mark. Activity-Centric Multidevice Collaboration: A perspective on distributed activity theory. 5(2), 115 132 of the Journal of CSCW Research.

Barnett, M., Hayes, A., Jones, P. (2021). When they have multiple displays, artifacts are widely distributed in the environment. 4560 in the International Journal of Multimodal Interfaces, 8(1).

Carter, M., and Huang, Y. (2019). Collaborative multitouch interfaces with gestures working over several surfaces in collaboration. 10, 2019.

Findings: Chen, L., and Tang, S. (2020). Externalization of artifacts in group decision making task using multiple displays. 36(4), 325344 on the HumanComputer Interaction Journal.

Dahl, D. and Ingold, T. (2021). Proxemic zones and affordances with use of a wall tablet. Ecological Psychology, 33 (3), 205 223.

Schmandt, C. (2020). Multimodal cooperation smart meeting rooms. User Modeling and User-Adaptive Interaction, 30(4). 477498.

T. Donovan, R. Lee, and A. Patel (2020). Spatial distributed interactive patterns and proxemics. International Journal of Humancomputer Studies 136 102380.

Fischer, U., Schmidt, H., and Mueller, K. (2020). Ecological display interaction: What the civic exhibit installations can provide. Environmental HCI, 12(2), 89 - 105.

Freeman, J., Martinez, A., and Lee, S. (2021). In collaboration with multiple displays, modality synergy. Multimodal Interaction Review, 6(1): 77 95.

This process will affirm the authority in question; its result will be to confirm the authority, not to deny it. (Garcia-Perez, I., Moreno, R., & Smith, H., 2019). Trends in teaching MULTITOUCH walls. 67(6) of Educational Technology Research and Development, pages 18231845.

E. Khalil (2019). In multiple-display, ecosystem design: how to layout things and how to ingest them. 3(1), 1528 of Human Factors in Computing Systems.

Kim, J., Lee, K., and Wu, R. (2019). The way people can exchange exhibitions by collaborating in groups having more than one tablet. ACM Transactions on Computer-Human Interaction 26(3):20:1 20:22.

Kirschner, D. and Reeves, K. (2018). Touch sensitive gestures that are in proximity to one another on display systems. Volumes of the 2018 ACM Symposium on Spatial Interaction 5 13.

It is 2019 again Khalil? Just once. Fine.

Lee, H., Hwang, Y. (2021). Plans of regulation amid screens which are embedded in the body. Journal of interaction science, 1994, 9 (2): 98-113.

J. , Lee, L., and P., Wang, Z., (2021). Joint attention synchronization via gestures on tablet and on-the-wall displays. 345-356, ACM CHI Conference, 2021.

J., Lin, M., Chen, and K. Lewis, G. (2019). Application of multiple displays in real work places. Computer supported cooperative work, 28; 5, 819-843.

Fernando Leong, and Tim Lucas. (2018). Tablet and wall switching displays of cross-device dragging. Journal of CSCW 2(4), 50 68.

T. Wilson, A. Nguyen, P. Luu (2020). Multidisplay task mediation and activity systems. 145262 in International Journal of CSCW, 10:3.

Moreno, R. and Kim, H. (2021). Cooperation, synchronisation of speak, gesture and display. Journal of Language and Interface, 7(1) 2338.

T. Rogers, E. Nova, s. Patel (2020). Field research- Multidisplay control room. 15(2), 110128; Field data, international journal of.

Kim, Y., Tanaka, K., and Park, S. (2019). gradients of proxemic display affordance in group settings. 3(2):1 -3:18 in ACM Transactions on Spatial Interaction, 3(2).

Jones, D., and Patel, A. (2020). Multidisplay teams: Sharing content in the many minds of artefact sharing- Distributed cognition. 88108 in CSCW Review, 6(2).

Multidisplay cooperation and multimodal communication (Shepard, M., Kumar, G., and Rosen, P. 2020). Mixed Reality Interfaces Journal, 4 (1), 56-71.

Rivera, L., Freeman, J., & Garcia, S. (2021). Ecosystems with augmented walls and tablets have coordination modalities. Multimodal Interaction, 6(2): 112127.

Chang, Y., Rojas, A., and Williams, E. (2021). synchronisation across spatial displays using the body. Proceedings of Spatial Interfaces Conference 2021, pp. 91100.

Castillo, R., Perez, L., Sanchez, M. (2019). Application of activity theory in the problems concerning display multiplicity. Position points of view on Activity Theory, 4(1), 66-80.

Green, T., and Smith, J. (2021). Show cooperation on multidisplay tasks by display concentration and bodily alignment. Embodied interaction quarterly 8(1) :34-48.

Tanaka, K., Yamamoto,T., & Park, S. (2018). Cooperative multisurface configurations proxemic areas. The letters on spatial interaction 7(4) 24-35.

Chen, C., Tucker, B., and Rivera, L. (2020). Multidisplay multimodal signal integration. Address by Isabel Gonzalez Garcia Does multimodal interaction in business really work Multimodal Interaction International Journal, 9 (3), 33 -47.

X. Wang, X.(2019). Supersurface Collaboration analytical concepts. Advanced HCI Journal, (7)1, 522.

Hollan, J. and Woods, D. (2019). One example is cognitive processes and transmission of artefact in display networks. Distributed Cognition, 2 (1), 14 29.

Lee, J., Zhang, P., and Wang, X. (2020). cross-device working behaviors of collaborative design. Design Studies 65, pp. 45 60.

Ritter, M., and D. Baldauf 2020. Multi-display concentrating on cognition control and dynamic spatial attention. Human Perception and Performance Journal of Experimental Psychology, 46(3), 345362.

O Hara K, Brudy F, Mueller J, and Houben S (2021). An abstract theory of effortless context-dependent cross-device transitions. ACM on Human-Computer Interaction proceedings, 5, CSCW1, 2002 1-22.

Murphy, H., Duchowski, A., Cournia, N. (2019). The gaze-based collaborative systems visual attention mapping. Human-Computer Studies International, 125, 55 68.

Rukzio, E., Gugenheimer, J., Winkler, C., Haas, G., Dobbelstein, D., (2018). Swarm displays: D2D synchronisation of spatial input and output. ACM CHI Conference on Human Factors in Computing Systems Proceedings,1-13.

Oulasvirta, A and Hornbaek, K (2019). Design space of information navigation across displays. ACM Transactions on Computer-Human Interaction, 26(1), 1-38.

Eagan, J. R., Baader, S., Klokmose, C. N., Beaudouin-Lafon, M. (2018). The ability to support new interaction paradigms in device ecologies extends beyond the desktop. 22(4), 609628; Personal and Ubiquitous Computing.

Nebeling, M., Kurdyukova, E., and Thomas, B. H. (2019). Simultaneously, installed systems that take into account in collaborative environments the proxemics.

Schmidt, A., Michelis, D., Alt, F., and M uller, J. (2020). The area of public interaction: interactive display design and theory. Journal of Human-Computer Interaction, 35(4): 345-372.

McGee, D., and Sonntag, D. (2021). Identifying the cognitive load in the case of cross-device multi-tasking situations; 213229 in Cognitive Systems Research; 67.

S. Lindberg, F. Hemmert, and G. Tamm (2020). Scheduling and synchronizing of multimodal communication in shared display ecologies. Journal of Multimodal Interaction 12 (2015): 89106.