AN EMPIRICAL STUDY OF VISUAL NAVIGATION AND COGNITIVE LOAD IN MODERN GRAPHICAL INTERFACE TOOLS USING EYE-TRACKING METHODOLOGY (ON THE EXAMPLE OF SKETCH, ADOBE XD, AND FIGMA)

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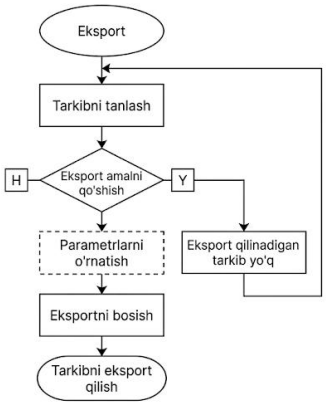
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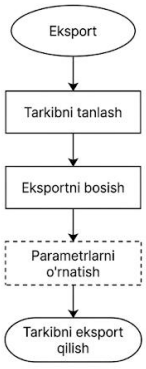
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Beyond the interface layout, the interaction design of the three applications also exhibits a number of differences and commonalities. Most of the common functions of the three applications are interacted with in the same way; for example, all users add or remove element properties by clicking the Add or Delete controls. The menu depth of the three applications differs. Some functions in Sketch require the user to navigate to a second-level submenu, whereas when using Adobe XD and Figma users only need to go to a submenu, and the overall interaction path is shorter. There are also differences in editing property parameters. Figma displays only the frequently edited parameters, while the rest are hidden in the corresponding submenu; Adobe XD and Sketch, by contrast, display all parameters in the first-level panel of the property inspector.

As shown in Figure 1, the export interaction differs. When exporting in Adobe XD, users simply select the desired content on the canvas and click the Export button. In addition, users can select the content to be exported and set the parameters in the Export dialog. In Sketch and Figma, users must first select the content, then add an export action and set the parameters in the property inspector, and finally click the Export button. If users click the Export button without making the content exportable, the system informs them that no content has been selected or that all frames will be exported by default. This process takes more time than the previous one.



Figma va Sketch ning eksport jarayoni



Adobe Xd ning eksport jarayoni

Figure 1. Comparison of the export process

According to skill level, users can be divided into beginners, intermediate users, and experts. The majority of users are intermediate users, whose number and frequency of use are stable. Therefore, the study should primarily focus on intermediate users and collect their opinions about the software along with the relevant data [1]. Participants had to be students or professionals in the design industry with at least 6 months of experience in UI design or other related software. Nielsen's research on the number of participants in usability testing served as the basis for the experiment [2]. Seventeen university students were recruited to take part in this experiment. All participants were aged between 19 and 25; 9 of them were male and 8 were female.

The main functions of UI design software were summarized and analyzed before the experiment. A set of interactive tasks covering the functions that users frequently employ in their daily work was defined by combining the results of a questionnaire on the use of UI design software; the tasks are presented in Table 1.

Table 1.

Experimental tasks

Task No.	Task description
1	Import the images [01.jpg], [02.jpg], [03.jpg] onto the canvas and resize them to 200px×150px.
2	Center and align [Figure1.jpg], [Figure2.jpg], [Figure3.jpg] vertically, keeping a distance of 30px between them.
3	Add an unfilled circle with a diameter of 100px; stroke style — dashed, color number [666666], weight 2; round caps, dash 5, gap 8, opacity 40%.
4	Create the circle drawn in Task 3 as a component and name it [circle].
5	Add the text "Usability Test": font size 14, font weight Medium Bold, font Pingfang-SC; line height 18, text box with automatic width, opacity 50%.
6	Add the [Shopping Cart] component to Frame 1 and detach it from the component.
7	Add a drop shadow effect to the [Shopping Cart]: x-direction 4, y-direction 8, blur 8, opacity 3%.
8	Export Frame 1 to the desktop as a 2x png file and name it [test number – name].
9	Save the document to the desktop and rename it [TestNumber].

As a case study, this experiment selected the Chinese version of Sketch 80.1, Adobe XD version 45.1.62.364, and the Chinese version of Figma v.99.0, which were the latest versions at the

time the experiment was conducted. During the experiment, all three applications were run on an iMac computer with a 27-inch display, and all participants were asked by the experimenter to complete the assigned tasks on this computer.

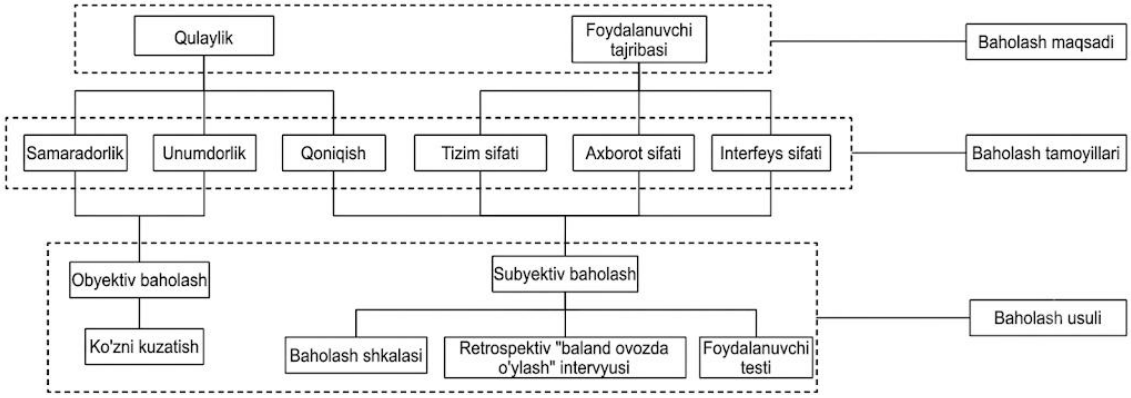


Figure 2. Usability and user experience evaluation system

In this experiment, user testing is a usability evaluation method that collects feedback data on user behavior and satisfaction indicators when using a particular human–machine interface. User testing identifies usability problems mainly by observing the process of completing a set of predefined tasks under a specific scenario and by asking participants to record their actual use. In this experiment, the usability of the software was evaluated by testing users, observing and recording the number of failures and the completion time when performing the tasks with each of the three applications, as well as by using a retrospective think-aloud interview to capture the participants' experience with the software.

The evaluation scales consist of the Post-Study System Usability Questionnaire (PSSUQ) and the After-Scenario Questionnaire (ASQ). The PSSUQ takes information quality and interface quality as the main evaluation indicators. The ASQ quantifies satisfaction by evaluating the system's helpfulness in completing tasks, the time spent, and the help information. Both questionnaires use a 7-point Likert scale, where 1 means "strongly disagree" and 7 means "completely agree," and a higher score on the scale indicates better usability of the system or higher satisfaction.

Eye tracking is a widely used data collection method in usability testing. Based on usability and user experience evaluation standards, the indicators of task completion time, number of task failures, and total fixation duration in the area of interest (AOI), as well as heat maps and gaze point maps, were selected for analysis. The number of failures and the task completion time are important indicators for evaluating the effectiveness and efficiency of the software. The total fixation duration in the area of interest can quantify the difficulty of the object the user is looking at, that is, the effectiveness of the system's information. Heat maps and gaze path maps are common forms of visualizing eye-movement data and mainly demonstrate the user's attention to information and the visual search path.

Each participant was given the same tasks to complete using all three applications. Due to the high similarity between the Sketch and Figma interfaces, the order of software use was set as

Sketch, Adobe XD, and Figma to avoid the learning effect. In each experiment, only one person was tested, in a quiet and well-lit environment. The procedure of the experiment is shown in Figure 3.

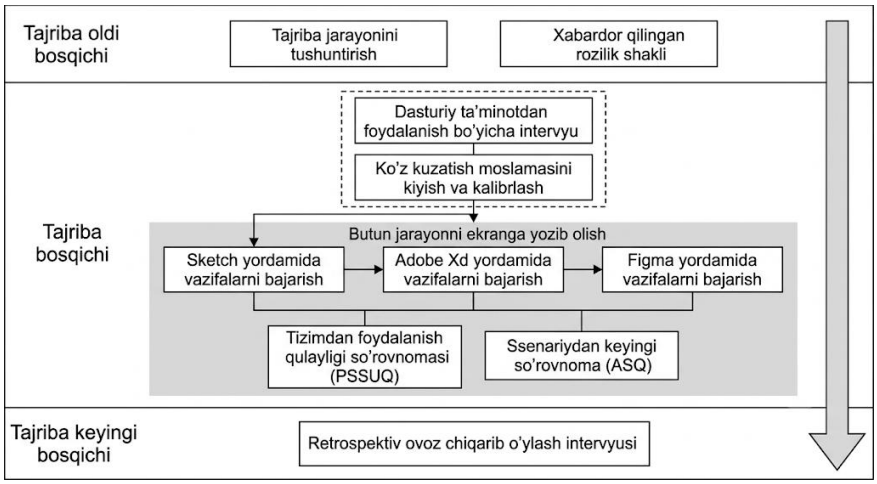


Figure 3. Experimental procedure

According to the data collected from the experiments, there are some differences among the three applications in the level of support for UI design.

1) Overall evaluation. The statistical results showed no significant differences when participants rated the three applications on the overall usability scale ($p=0.209>0.05$); however, in the post-test interview, almost 58% of the participants stated that the overall usability of Figma was noticeably better than that of Adobe XD and Sketch. Thus, the usability of Figma can be considered higher than that of Adobe XD and Sketch.

2) Effectiveness evaluation. The difficulty of obtaining actual information in an area and the attractiveness of the target to the participant are proportional to the fixation duration in the AOI [3]. Table 2 shows the fixation duration in the AOI while completing the tasks with the three applications, revealing that the three applications show no significant difference in Tasks 2, 4, and 6 ($p2=0.425>0.05$, $p4=0.398>0.05$, $p6=0.974>0.05$), while the statistics for the remaining six tasks show significant differences.

Table 2.

Comparison of differences in fixation duration in the AOI

Variables	Sketch	Adobe XD	Figma	Degrees of freedom	Significance (p)
Task 1	111.76	68.08	56.50	2	0.002
Task 2	81.04	56.60	87.52	2	0.425
Task 3	136.48	60.16	64.16	2	0.000

Task 4	53.92	85.81	76.89	2	0.398
Task 5	97.95	66.15	82.00	2	0.036
Task 6	65.31	61.61	61.96	2	0.974
Task 7	98.46	45.75	31.54	2	0.001
Task 8	120.09	45.96	89.48	2	0.013
Task 9	119.47	22.96	45.96	2	0.000
Total fixation duration	884.48	513.08	576.02	2	0.001

In addition, there are significant differences in the total fixation duration in the AOI ($p=0.001<0.05$). Table 3 shows the average number of failures made by participants while completing the tasks. According to the post-hoc test data, the difference in the number of failures between using Sketch and Adobe XD is significant ($p=0.038<0.05$). Combined with the analysis of the interface design of the three applications, it was found that some of Sketch's auxiliary information or icon meanings are unclear, which causes participants to spend more time in that area and increases the difficulty of obtaining actual information compared with Adobe XD and Figma; this was confirmed through the post-test retrospective think-aloud interview. In conclusion, the effectiveness of the three applications shows significant differences, and participants encounter difficulty in obtaining target information when using Sketch, which indicates that Sketch has the lowest effectiveness, while the difference in effectiveness between Adobe XD and Figma is not significant.

Table 3.

Comparison of differences in the number of task failures

Variables	Sketch	Adobe XD	Figma	Degrees of freedom	Significance (p)
Number of failures	1.21	0.21	0.79	2	0.038

3) Efficiency evaluation. Table 4 shows the average completion time of each task and the results of its one-way ANOVA test. The time of a failed task was not included in the statistics [4]. Table 4 shows that there is no significant difference among the three applications in the completion time of Tasks 2, 4, 5, and 6, while the total task completion time with Sketch is significantly longer than with Adobe XD and Figma ($p=0.00<0.05$). The heat maps and gaze point maps of Tasks 3, 8, and 9, on which participants performed worse during the experiment, were selected for comprehensive analysis. Hot spots of different colors can visually reflect the distribution of the participants' attention to information and their gaze points: longer fixation in red areas and shorter fixation in green areas [5].

Table 4.

Comparison of differences in average task completion time

Variables	Sketch	Adobe XD	Figma	Degrees of freedom	Significance (p)
Task 1	119.88	71.46	61.26	2	0.001
Task 2	77.52	54.64	61.80	2	0.327
Task 3	120.74	56.00	66.29	2	0.000
Task 4	48.10	78.67	60.65	2	0.273
Task 5	75.68	62.32	74.96	2	0.420
Task 6	59.98	54.80	46.88	2	0.687
Task 7	79.99	48.44	25.53	2	0.001
Task 8	68.11	47.79	38.10	2	0.022
Task 9	106.12	19.89	41.73	2	0.000
Total gaze duration	868.43	549.97	488.16	2	0.000

Task 3: Adding and editing a shape. In this task, participants were asked to add a new shape and adjust its property parameters. Figure 4 shows the detailed eye-movement map, in which the hot spots are the most widespread in the Sketch interface and the gaze points are the most densely located. Combined with Table 2, Table 4, and the post-test interview, it was found that Sketch's Add Layers function is hidden in the Insert submenu of the top panel, which differs from the usage habits of most participants. As a result, participants could not quickly find the required functions. The greater number of eye-movement intersections in Sketch and the longer adjacent trajectory segments indicate that the participants' eyes constantly shifted between the top panel and the canvas, and that their point of view was also more scattered when using Sketch. In Sketch and Figma, the hot spot area in the right column is larger, which indicates that participants spent more time in this area. Combined with the participants' results, this reveals that the information layout in the property inspector of Sketch and Figma is more compact than that of Adobe XD, which increases cognitive load and reduces the effectiveness of obtaining information and the efficiency of task completion when using these two applications.

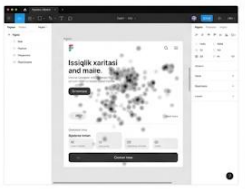
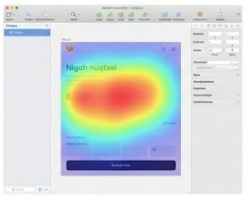
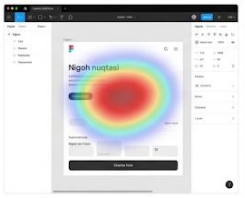
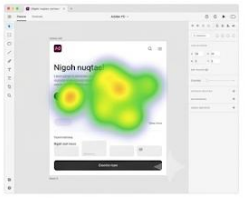
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Figure 4. Eye-movement diagram for completing Task 3

Task 8: Exporting a frame and setting the relevant parameters. Table 4 shows that participants spent the most time completing this task using Sketch and the least time using Adobe XD. The detailed eye-movement result is shown in Figure 5. The participants' eyes were mainly focused on the target function area when using Adobe XD, and most of them had shorter eye-movement trajectories and fewer red hot spot areas, indicating that their gaze did not remain long in any particular area. Combined with the participants' results, it can be seen that the location of Adobe XD's Export button in the Window menu matches the experience of most participants, and the parameter information is clear, so participants quickly understood the text and completed the task efficiently. The eye-movement hot spots were scattered across the Sketch interface, and the number of eye-movement intersections was greater than in the other two applications, indicating that the participants' attention to the interface was scattered. Participants reported that the Export button in Sketch is small and located at the edge, and the process differs from their usage habits, which makes it difficult to find the button quickly and requires a lot of time. In addition, participants spent the longest total fixation duration when using Sketch to complete Task 8 (see Table 2), which indicates that participants could not find the target and could not obtain the information quickly, resulting in low task completion efficiency.



Figure 5. Eye-movement diagram for completing Task 8

Task 9: Saving and renaming a file. Combined with the statistics in Tables 2 and 4, it is revealed that the participants' total fixation duration and completion time when using Sketch are significantly longer than with the other two applications ($p1=p2=0.000<0.05$). Figure 6 depicts the detailed eye-movement diagram for this task. The participants' eye-movement hot spots when using Sketch were concentrated in the window's menu bar and top panel. The large area of red hot spots and the large number of eye-movement intersections indicate that the participants' gaze shifted between the two areas several times and, moreover, that the viewing speed was slower than in Adobe XD and Figma. In the interview, participants stated that the main reason for spending a lot of time on this task using Sketch was that they did not understand that "Copy" means saving the file as a new file, so they kept searching for the "Save as" button. It can be seen that unclear wording can increase users' cognitive load and reduce their efficiency.

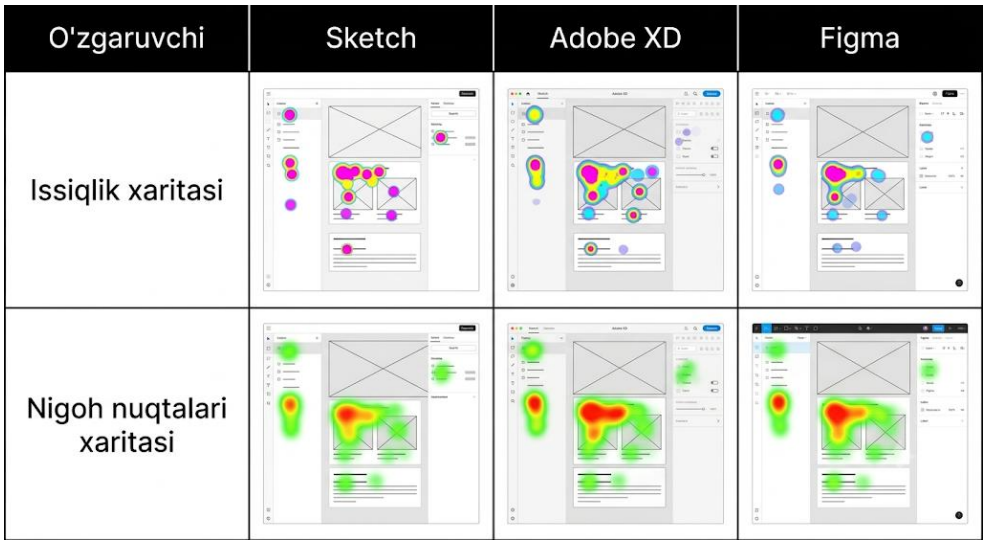


Figure 6. Eye-movement diagram for completing Task 9

4) Satisfaction evaluation. In the post-test interview, participants stated that they preferred Figma over the other applications because of its compact interface, rational layout, clear representation of icons, and the arrangement of the functions in the toolbar according to their frequency of use and priority. In addition, some common parameters are presented in the first-level interface, which allows users to shorten the interaction path and increase efficiency. Most participants considered Sketch's interface too complex, which led to low efficiency in searching for information, and the interaction path of some functions as well as the interface layout did not match their usage habits, which hindered efficiency. Based on the post-test interview, the satisfaction with the three applications can be ranked in the order Figma > Adobe XD > Sketch.

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