Display Size and Targeting Performance: Small Hurts, Large May Help (Supplementary Material)

Joohwan Kim
NVIDIA
USA

Arjun Madhusudan
NCSU
NVIDIA
USA

Benjamin Watson
NCSU
USA

Ben Boudaoud
NVIDIA
USA

Roland Tarrazo
NVIDIA
USA

Josef Spjut
NVIDIA
USA

ABSTRACT

CCS CONCEPTS

• **Human-centered computing → Pointing devices**; **User studies**; • **Hardware → Displays and imagers**; • **Applied computing → Computer games**.

KEYWORDS

pointing devices, mouse, mouse sensitivity, first person targeting, first person games

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1 ADDITIONAL DETAIL FOR THE PAPER'S EXPERIMENT

This section contains additional details that help better visualize and demonstrate the experiment, and further explain some results.

1.1 Additional Methods Detail

1.1.1 Virtual Screen Sizes. In the same 65′′ display, we emulated 4 smaller screen sizes as well. This was done by rendering to a central subset of the entire display area as shown in Figure 1. The areas surrounding the required display size were painted black and displayed no part of the virtual environment in those locations. Starting from the smallest 13′′ size at the innermost section of the screen, the covered area gradually increases as we work on larger display conditions. The 65′′ condition fills up the entire screen, without a virtual black border.

1.1.2 Maintaining Resolution Across Conditions. In order to retain perceived resolution, we display 'emulated pixels' that are a block of n×n pixels individually. We start with the 13′′ condition where each emulated pixel is a true pixel (of size 1×1). The 26′′ condition has an emulated pixel size of 2×2, and so on until the 65′′ condition has an emulated block of 5×5 pixels. As the emulated pixel block size grows, the viewing distance across the conditions also increase, therefore appearing visually similar to players. Figure 2 demonstrates this in detail.

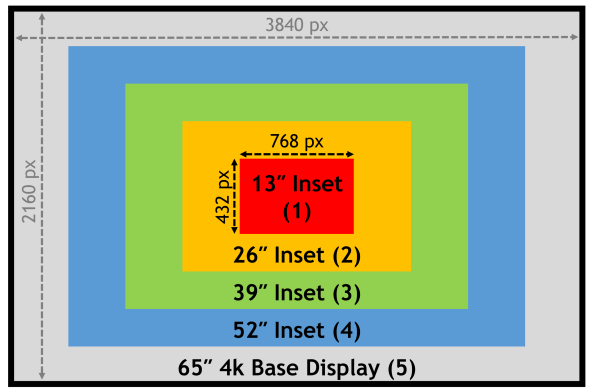

Figure 1: Each color represents a screen size (from the borders to the center). The virtual environment is rendered within the colored rectangle, and any larger screen size areas are painted black.

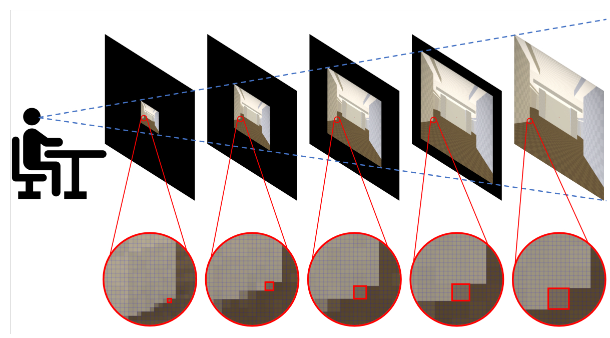

Figure 2: From left to right (upper section) shows how the virtual environment is rendered for each size condition starting from 13′′ to 65′′. The bottom section shows a zoomed in portion of the rendered image. The red squares indicate an emulated pixel (1×1 block on the left most and 5×5 block on the right).

1.1.3 First Person Environment. In the First Person Environment used for our experiment, the player is placed in a 'hallway'. While the tool supports movement, we do not use this through any of our

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experiments. The only controls a player has within this environment is the mouse. Moving the mouse changes where the camera looks at, thereby changing the player's view.

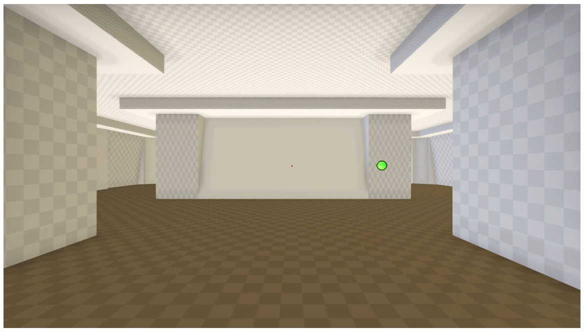

Figure 3: The first person environment a player will see. The green hexagon is the target, and the red dot at the center is the crosshair.

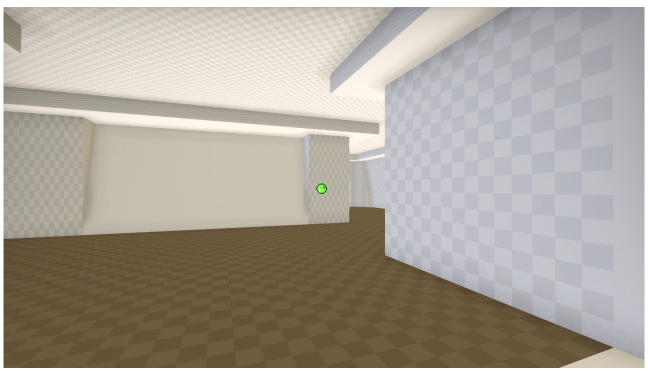

Figure 4: When the player moves the mouse towards the target, the crosshair stays fixed at the center of the screen and the whole view is instead rotated to match the mouse movement.

Figure 3 and Figure 4 show what the environment looks like during a task. The red marker at the center of the screen is the crosshair, and the green hexagon is the target the player must aim at.

1.1.4 Visual Acuity Measurement. We measured participants' visual acuity at two extreme viewing distances, 31 cm and 155 cm. We used a letter recognition task to estimate visual acuity. One trial consisted of three letters, which were randomly selected from ten alphabet letters with similar legibility as suggested by Bailey and Lovie [1976]: DEFHNPRUVZ. Participants verbally reported their best guesses of the three letters, and they had to guess even when the letters were too small to read. A non-serifed font (Arial, bold) was used, and the spacing between letters were kept at twice the letter width (Fig. 5). We scaled the letter size depending on participants' answers using a staircase procedure with a 1-up/1-down rule. The scaling factor was 27%, being close to the recommended 26% [Bailey and Lovie 1976]. Letter sizes ranged from 3.2 to 12.7 arcmin (′). The visual acuity was estimated as the letter size with 80% performance level in this task. The procedure took about 10 min for the two distances.

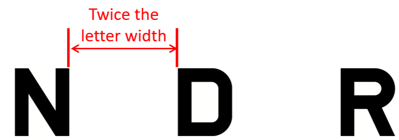

Figure 5: A sample stimulus of letter recognition task. We estimated participants' visual acuity based on the smallest letter size they could recognize at the nearest and farthest viewing distance (31 and 155 cm, respsectively).

1.1.5 Survey Questions. Participants answered the following survey questions after completing the experiment.

- Which monitor size do you have the most experience of playing shooter games on?
- What is the monitor size(s) of your current gaming setup?
- How long have you been keeping the current gaming setup?
- What controllers do you play shooter games with (choose all that you are familiar with)?
  - Mouse
  - Controller (game pad)
- Apart from the score, on which monitor size (inches, diagonal) in this experiment did you feel most confident about your aiming?
  - 13″
  - 26″
  - 39″
  - 52″
  - 65″
- Any words to add about the feeling of confidence, and how it relates to the monitor size?
- Which monitor size (inches, diagonal) in this experiment did you like the most?
  - 13″
  - 26″
  - 39″
  - 52″
  - 65″
- Could you explain the reason for your preference?
- Please leave any other thoughts you would like to share with us!

1.2 Additional Results Detail

1.2.1 Means and Statistical Significance. We report mean values and statistical significance of paired T-tests. Values corresponding to highest score, highest accuracy, or lowest completion time are bold-faced. These best performance results occurred in the 65″ condition for most cases, although they did not reach statistical significance.

Table 1: Average score as a function of display size conditions.

Display Size ($''$)	Score
13	142.50
26	151.63
39	152.84
52	152.52
65	**153.77**

Table 2: Paired T-test (df = 29) results comparing average scores between display size conditions. P' was adjusted using the Holm-Bonferroni method[Holm 1979] for multiple comparisons.

Comparisons	t	P	P'
13$''$ vs 26$''$	-9.03	<.001	<.001
13$''$ vs 39$''$	-8.18	<.001	<.001
13$''$ vs 52$''$	-8.92	<.001	<.001
13$''$ vs 65$''$	-10.07	<.001	<.001
26$''$ vs 39$''$	-1.16	.25	1.0
26$''$ vs 52$''$	-0.74	.46	1.0
26$''$ vs 65$''$	-1.77	.088	.52
39$''$ vs 52$''$	0.32	.75	1.0
39$''$ vs 65$''$	-0.87	.39	1.0
52$''$ vs 65$''$	-1.31	.20	1.0

Table 3: Average completion time as a function of display size conditions.

Display Size ($''$)	Completion time (s)
13	0.785
26	0.755
39	0.747
52	0.755
65	**0.746**

Table 4: Paired T-test (df = 29) results comparing task completion time between display size conditions.

Comparisons	t	P	P'
13$''$ vs 26$''$	5.68	<.001	<.001
13$''$ vs 39$''$	7.45	<.001	<.001
13$''$ vs 52$''$	5.34	<.001	<.001
13$''$ vs 65$''$	8.14	<.001	<.001
26$''$ vs 39$''$	1.71	0.098	0.44
26$''$ vs 52$''$	0.03	0.97	1.0
26$''$ vs 65$''$	1.76	0.089	0.44
39$''$ vs 52$''$	-1.63	0.11	0.44
39$''$ vs 65$''$	0.20	0.85	1.0
52$''$ vs 65$''$	1.86	0.073	0.44

Table 5: Accuracy as a function of display size conditions.

Display Size ($''$)	Accuracy
13	90.07
26	91.27
39	91.29
52	91.63
65	**91.87**

Table 6: Paired T-test (df = 29) results comparing accuracy between display size conditions.

Comparisons	t	P	P'
13$''$ vs 26$''$	-2.07	0.048	0.38
13$''$ vs 39$''$	-1.66	0.11	0.75
13$''$ vs 52$''$	-2.62	0.014	0.14
13$''$ vs 65$''$	-2.62	0.014	0.14
26$''$ vs 39$''$	-0.03	0.98	1.0
26$''$ vs 52$''$	-0.68	0.50	1.0
26$''$ vs 65$''$	-0.98	0.33	1.0
39$''$ vs 52$''$	-0.79	0.44	1.0
39$''$ vs 65$''$	-1.14	0.27	1.0
52$''$ vs 65$''$	-0.53	0.60	1.0

Table 7: Average score as a function of display size conditions, skilled group.

Display Size ($''$)	Score
13	155.01
26	165.43
39	166.39
52	164.64
65	**166.61**

Table 8: Paired T-test (df = 9) results comparing average scores between display size conditions (skilled group).

Comparisons	t	P	P'
13$''$ vs 26$''$	-7.56	<.001	<.001
13$''$ vs 39$''$	-4.20	0.002	0.016
13$''$ vs 52$''$	-4.37	0.002	0.014
13$''$ vs 65$''$	-5.39	<.001	0.004
26$''$ vs 39$''$	-0.49	0.64	1.0
26$''$ vs 52$''$	0.39	0.70	1.0
26$''$ vs 65$''$	-0.77	0.46	1.0
39$''$ vs 52$''$	0.74	0.48	1.0
39$''$ vs 65$''$	-0.13	0.90	1.0
52$''$ vs 65$''$	-1.01	0.34	1.0

Table 9: Average score as a function of display size conditions, competitive group.

Display Size ($''$)	Score
13	142.12
26	150.99
39	153.49
52	154.67
65	**154.68**

Table 10: Paired T-test (df = 9) results comparing average scores between display size conditions (competitive group).

Comparisons	t	P	P'
13″ vs 26″	-3.84	0.004	0.028
13″ vs 39″	-6.36	<.001	0.001
13″ vs 52″	-9.46	<.001	<.001
13″ vs 65″	-12.31	<.001	<.001
26″ vs 39″	-1.13	0.29	1.0
26″ vs 52″	-1.50	0.17	0.97
26″ vs 65″	-1.53	0.16	0.97
39″ vs 52″	-0.68	0.51	1.0
39″ vs 65″	-0.59	0.57	1.0
52″ vs 65″	-0.00	0.99	1.0

Table 11: Average score as a function of display size conditions, casual group.

Display Size (″)	Score
13	130.39
26	138.46
39	138.65
52	138.23
65	**140.01**

Table 12: Paired T-test (df = 9) results comparing average scores between display size conditions (casual group).

Comparisons	t	P	P'
13″ vs 26″	-5.31	<.001	0.005
13″ vs 39″	-4.05	0.003	0.026
13″ vs 52″	-3.79	0.004	0.030
13″ vs 65″	-3.95	0.003	0.027
26″ vs 39″	-0.15	0.89	1.0
26″ vs 52″	0.15	0.88	1.0
26″ vs 65″	-0.66	0.53	1.0
39″ vs 52″	0.51	0.63	1.0
39″ vs 65″	-0.69	0.51	1.0
52″ vs 65″	-0.94	0.37	1.0

Table 13: Average score as a function of display size conditions, small targets.

Display Size (″)	Score
13	40.05
26	44.57
39	**45.70**
52	44.68
65	45.12

Table 14: Paired T-test (df = 29) results comparing average scores between display size conditions (small targets).

Comparisons	t	P	P'
13″ vs 26″	-6.74	<.001	<.001
13″ vs 39″	-8.65	<.001	<.001
13″ vs 52″	-6.78	<.001	<.001
13″ vs 65″	-7.66	<.001	<.001
26″ vs 39″	-1.85	0.074	0.45
26″ vs 52″	-0.16	0.87	1.0
26″ vs 65″	-0.72	0.48	1.0
39″ vs 52″	1.81	0.081	0.45
39″ vs 65″	0.99	0.33	1.0
52″ vs 65″	-0.67	0.51	1.0

Table 15: Average score as a function of display size conditions, medium targets.

Display Size (″)	Score
13	49.73
26	52.34
39	52.67
52	52.72
65	**52.77**

Table 16: Paired T-test (df = 29) results comparing average scores between display size conditions (medium targets).

Comparisons	t	P	P'
13″ vs 26″	-4.87	<.001	<.001
13″ vs 39″	-4.80	<.001	<.001
13″ vs 52″	-5.03	<.001	<.001
13″ vs 65″	-4.94	<.001	<.001
26″ vs 39″	-0.92	0.37	1.0
26″ vs 52″	-0.78	0.44	1.0
26″ vs 65″	-0.64	0.52	1.0
39″ vs 52″	-0.10	0.92	1.0
39″ vs 65″	-0.17	0.86	1.0
52″ vs 65″	-0.10	0.92	1.0

Table 17: Average score as a function of display size conditions, large targets.

Display Size (″)	Score
13	52.72
26	54.72
39	54.47
52	55.11
65	**55.88**

Table 18: Paired T-test (df = 29) results comparing average scores between display size conditions (large targets).

Comparisons	t	P	P'
13″ vs 26″	-4.96	<.001	<.001
13″ vs 39″	-2.71	0.011	0.070
13″ vs 52″	-4.94	<.001	<.001
13″ vs 65″	-7.40	<.001	<.001
26″ vs 39″	0.46	0.65	0.94
26″ vs 52″	-0.73	0.47	0.94
26″ vs 65″	-2.48	0.019	0.096
39″ vs 52″	-1.17	0.25	0.75
39″ vs 65″	-2.76	0.010	0.070
52″ vs 65″	-2.08	0.046	0.18

Table 19: Duration of initialization phase as a function of display size conditions.

Display Size (″)	Initialization time (s)
13	0.238
26	0.227
39	0.223
52	0.223
65	**0.221**

Table 20: Paired T-test (df = 29) results comparing initialization time between display size conditions.

Comparisons	t	P	P'
13″ vs 26″	8.07	<.001	<.001
13″ vs 39″	5.29	<.001	<.001
13″ vs 52″	6.32	<.001	<.001
13″ vs 65″	7.91	<.001	<.001
26″ vs 39″	1.57	0.13	0.51
26″ vs 52″	1.83	0.078	0.39
26″ vs 65″	2.92	0.007	0.040
39″ vs 52″	0.02	0.99	0.99
39″ vs 65″	0.99	0.33	0.66
52″ vs 65″	1.26	0.22	0.65

Table 21: Duration of movement phase as a function of display size conditions.

Display Size (″)	Movement time (s)
13	0.383
26	0.368
39	0.366
52	0.366
65	**0.361**

Table 22: Paired T-test (df = 29) results comparing movement time between display size conditions.

Comparisons	t	P	P'
13″ vs 26″	2.89	0.007	0.051
13″ vs 39″	3.34	0.002	0.021
13″ vs 52″	3.26	0.003	0.023
13″ vs 65″	3.51	0.001	0.015
26″ vs 39″	0.41	0.69	1.0
26″ vs 52″	0.22	0.82	1.0
26″ vs 65″	1.15	0.26	1.0
39″ vs 52″	-0.07	0.94	1.0
39″ vs 65″	1.08	0.29	1.0
52″ vs 65″	0.85	0.40	1.0

Table 23: Duration of verification phase as a function of display size conditions.

Display Size (″)	Verification time (s)
13	0.141
26	0.136
39	**0.132**
52	0.135
65	0.139

Table 24: Paired T-test (df = 29) results comparing verification time between display size conditions.

Comparisons	t	P	P'
13″ vs 26″	1.05	0.30	1.0
13″ vs 39″	2.13	0.042	0.42
13″ vs 52″	1.49	0.15	1.0
13″ vs 65″	0.63	0.54	1.0
26″ vs 39″	1.08	0.29	1.0
26″ vs 52″	0.25	0.81	1.0
26″ vs 65″	-0.58	0.57	1.0
39″ vs 52″	-0.91	0.37	1.0
39″ vs 65″	-1.46	0.16	1.0
52″ vs 65″	-0.85	0.40	1.0

Table 25: First submovement error as a function of display size conditions.

Display Size (″)	Error (°)
13	0.409
26	0.328
39	0.326
52	0.297
65	**0.278**

Table 26: Paired T-test (df = 29) results comparing first submovement errors between display size conditions.

Comparisons	t	P	P'
13″ vs 26″	-3.35	0.002	0.016
13″ vs 39″	-4.89	<.001	<.001
13″ vs 52″	-6.00	<.001	<.001
13″ vs 65″	-7.66	<.001	<.001
26″ vs 39″	-0.08	0.93	0.93
26″ vs 52″	-1.23	0.23	0.69
26″ vs 65″	-2.06	0.048	0.19
39″ vs 52″	-2.42	0.022	0.11
39″ vs 65″	-2.61	0.014	0.086
52″ vs 65″	-1.08	0.29	0.69

Table 27: First submovement speed as a function of display size conditions.

Display Size (″)	Speed (°/s)
13	27.65
26	28.40
39	28.05
52	28.25
65	**28.43**

Table 28: Paired T-test (df = 29) results comparing first submovement speed between display size conditions..

Comparisons	t	P	P'
13″ vs 26″	-1.65	0.11	0.98
13″ vs 39″	-1.39	0.18	1.0
13″ vs 52″	-1.54	0.14	1.0
13″ vs 65″	-2.18	0.037	0.37
26″ vs 39″	0.90	0.37	1.0
26″ vs 52″	0.43	0.67	1.0
26″ vs 65″	-0.05	0.96	1.0
39″ vs 52″	-0.60	0.55	1.0
39″ vs 65″	-0.96	0.35	1.0
52″ vs 65″	-0.42	0.68	1.0

2 EXPLORATORY EXPERIMENTS

Before conducting the main experiment, we also conducted 2 other experiments that portray similar trends in aiming behavior across screen sizes. The first experiment, in contrast to moving a single 65″ display, consisted of 5 different displays. The second experiment was a control experiment across various independent variables such as resolution, screen size, and FoV (field of view). This document shall talk about both of those in detail.

2.1 True Various Monitors

This experiment accounts for verifying whether simulating the visuals on scaled versions of the same display affected the performance of players.

2.1.1 Method. The conditions for this experiment were quite similar to the main setup - we measured accuracy and task completion time in the same first person environment. The difference lies in using different displays of varying sizes rather instead of using a single display with a scaled output.

2.1.2 Participants. There were a total of 30 players (aged 22 to 44) who volunteered to be a part of this study. The players were equally split across 3 different skill groups - viz. Casual, Competitive, and Skilled Competitive. According to our grouping, Casual players are ones who occasionally play FPS games in a non-competitive situation. Competitive players are those who actively engage in 'ranked' gameplay across one or more esports titles such as Apex Legends, Counter Strike: Global Offensive, Valorant, and Overwatch. Skilled competitive players are those who also rank amongst the top 40% of the players in their respective games.

2.1.3 Apparatus. We conducted this experiment using 5 displays, with each display being fixed at a predetermined distance from the player. The displays used for each size are as follows:

- **17″ display:** Predator Triton 500 laptop's built in-display.
- **24″ display:** Alienware AW2521H
- **32″ display:** Asus PG32UQ
- **55″ display:** Philips Momentum 55″ 4K Monitor
- **83″ display:** LG C1 83

All of the displays were capable of over 120 Hz refresh rates, and have an aspect ratio of 16:9.

The 17″ display was a powered by the laptop it was a part of, while the 24″ and 32″ displays were connected to a single system. Similarly, displays 55″ and 80″ were powered by a single system. Each of the machines were capable of running our virtual environment at 120 Hz as per the experiment specification.

Despite our effort to minimize confounding factors, we could not remove them completely. Most notable was latency. We equated *end-to-end latency*, the time from user input to presentation of an associated change on the output device, across the 5 displays by adjusting frame buffer lengths in the rendering. The adjusted mean end-to-end latency per display were 40.7 ms (17″), 33.9 ms (24″), 39.2 ms (32″), 34.9 ms (55″), and 37.8 ms (83″). The average latency did not deviate more than 8 ms, which is the best we could control by adjusting frame buffering on 120 Hz displays. Besides latency, brightness and contrast also differed by up to 10 % from the target value.

A chin rest was set up to ensure correct viewing distance, and identical keyboards and mice were used across all displays to maintain consistency.

2.1.4 Task. Participants performed a targeting task in a first person environment. Moving the mouse changes the rendered view, and the participant tries to align a target to the virtual crosshair (center of the screen) to aim at it. The participant can press the left mouse button when they feel they've completed their aiming action. When the button is pressed, if the crosshair and the target are aligned correctly, the target disappears and we call this a hit. If not, the target still disappears but it is called a miss, and is not credited towards the participant's score. Targets appear on screen one at a time, and the next one appears after a short delay once the player hits (or misses) the existing target. The participants were asked to

Figure 6: A visual demonstration of how displays are positioned at a distance - allowing a constant field of view. The chin rest can be seen to the left.

hit the target as quickly as possible, while trying to maintain their accuracy.

2.1.5 Conditions. Each of the display sizes (17″ , 24″ , 32″ , 55″ , and 83″) are treated as a separate condition. The seating position for the participants were calculated in a manner that ensured the Field of View (FoV) stayed a constant 49.80° while moving across differently sized monitors. Each display size contains 1 session. Each session contains 5 blocks, and each block contains 45 targets split equally across 3 sizes (small, medium, and large targets). There are 2 other sessions - adjustment and training - that allow the player to get comfortable with the environment and the task. The adjustment session has similar targeting tasks that lets the player tune the mouse sensitivity as per their preference. The training session is identical to whichever display size conditions the player will face first, but this data does not fuel our analysis. We use a balanced Latin square design to decide the order in which the participant goes through the five display size sessions to make sure we don't induce any learning bias.

2.1.6 Procedure. Players started with a visual acuity test which ensured that all participants had good vision that would not hinder their performance in our experiment. Players' vision was tested on a 17" screen as well as the 83" screen to check whether they were able to clearly see across all the display sizes used. Once the visual acuity test is completed, the player begins with the adjustment session, followed by the training session. After training, they complete one session in each of the display sizes in a predetermined order.

2.1.7 Results. To look at these results, we revisit the score metric as used in the main experiment. The score is a cumulative sum of the remaining duration (in seconds) in each successful trial. Each trial has a maximum duration limit of 1.5s. If a player hits the target in 0.5s, a trial score of S = 1.5 - 0.5, i.e. 1.0 is added to the total score. If the player misses, the trial score for that round is 0. The trial score is displayed to the player after each target, meaning they can see whether they did well that round or otherwise. This mechanic strongly encourages players to be more accurate in their shots.

We observed a generally rising trend in score as display size grew. This experiment convinced us that there is more to display size than what we initially expected. At the same time, we were unsure if the 'M' shape of the graph is due solely to display size or because of confounding factors such as latency. In other words, it was unclear if increasing display size is always beneficial, or there is a certain optimal size where one should stop. This motivated us to control confounding factors more strictly by emulating different display sizes using the same physical panel.

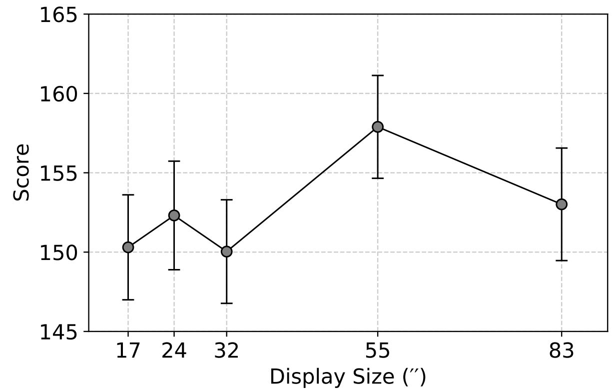

Figure 7: Average task completion time compared between different conditions (sessions). We were unsure if the observed trend was caused by display size only or a combination of display size and other confounding factors such as latency.

2.2 Laptop vs Desktop: Size, FoV, and Resolution

A second control experiment aims to discern the effect of other factors related to display and target size, controlling 3 variables. As the other experiments deal with varying display sizes, we wanted to make sure there were no confounding factors that affected performance. Using a part of the screen rather than the whole means the player is looking at fewer pixels being lit up on the display, i.e. there is a change in resolution.

2.2.1 Method. This experiment required players to move closer/farther away from the display in order to control the viewing distance. A tracking system was implemented to ensure that they were following the required measurements. This experiment used 2 screen sizes, with the smaller one being rendered in a central subset of the display (much like the main experiment).

2.2.2 Participants. 9 participants remotely engaged in this study. They were sent the required equipment including a desktop machine, a keyboard, a mouse, and a 24″ monitor. Participants were given instructions on how to set up and run the experiment.

2.2.3 Apparatus. To run the experiment, all participants were given identical systems that was capable of running and displaying our virtual first person environment at 240 Hz - the required refresh rate for this experiment. The monitors used were 24″ displays. Participants were also sent custom tracking headbands that they were required to wear during the experiment. They were also required to have a webcam that could detect these headbands.

2.2.4 Task. The task is very similar to the other experiments. The participant tracks a green target that appears on screen and tries to align it with the crosshair in the center. On pressing the left mouse button, the trial registers a hit or a miss depending on whether the crosshair and the target aligned correctly.

2.2.5 Conditions. This experiment had 4 conditions that controlled 3 independent variables. The first variable (in line with the previous experiments) is screen size. We wanted to check whether the screen size simulation in experiment 2 had any confounding effects due to the reduced resolution in smaller screen sizes, so we chose resolution as the second variable. The third variable was the participants' viewing distance / Field of View. When faced with a smaller screen size, a player might subconsciously move closer to the screen in order to get a better view. To combat this change, participants were instructed to sit at certain distances when completing each session in the experiment. This experiment had 4 sessions, provided in Table 29, with each session consisting of 30 blocks of 3 target size sets.

Table 29: The Screen Size, Viewing Distance, and Resolution show the setting for respective independent variables. The Field of View and Angular Resolution are a result of combining the three other variables and their conditions.

Condition	Display Size	Distance	Resolution
Desktop	24″	60 cm	1920x1080
Desktop - Low Res	24″	60 cm	960x540
Laptop - Near	12″	30 cm	960x540
Laptop - Far	12″	60 cm	960x540

Screen sizes labelled Full were rendered on the entire 24″ display. Reduced screen sizes emulated a physical 12″ monitor instead - a size commonly found in tablets and compact laptop formats. Long viewing distances were at 60 cm (23.62″) and short viewing distances at 30 cm (11.81″). Full resolution Desktop condition and both the Laptop conditions rendered each pixel as its own. The Desktop - Low Res condition used an emulated pixel of 2×2 pixels each.

2.2.6 Procedure. Participants wore a calibration headband, which was used to measure the distance between them and the display constantly. Before starting the experiment, participants were asked to run a calibration script that detected and recognized the headbands being worn. This calibration also allowed for accurate distance measurements once the experiment began. The distance tracker would alert the participants if they moved out of the required viewing distance range. After calibration, the participants would go through an adjustment and a training session, followed by the 4 conditions in a predetermined order.

2.2.7 Results. In Figure 8, we see that the Desktop conditions were by far the better performing sessions. Smaller screen sizes showcased poorer (slower) task completion times. A rather interesting way to look at these results is to interpret different pairs of sessions together.

The Desktop and Desktop - Low Res conditions did not show a noticeable difference. Resolution was not playing a major role in the performance of players in this experiment. Comparing Desktop and Laptop - Near sessions allows us to look at screen size effects while FoV was kept constant. Larger screen size was beneficial over the smaller size. Comparing the Desktop and Laptop - Far conditions shows the effect of reducing FoV while distance was kept constant. This reduced performance the most, showing the importance of studying FoV and screen size independently.

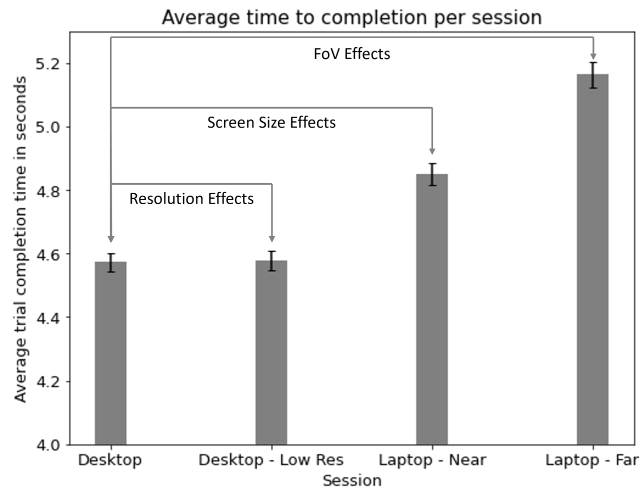

Figure 8: Average task completion time compared between different conditions (sessions).

2.3 Discussion

Both experiments listed here add towards the significance of our paper's experiment. Using physical displays of different sizes affected targeting performance, but we were unsure if the observed trend was due to display size only or an effect combined with confounding factors. Thus we decided to strictly control confounding factors by using the same panel and emulate different display sizes. The second experiment revealed that the viewing angle had a noticeable effect on performance, as players performed much better with larger FoV while sitting at the same distance. Therefore, we worked towards ensuring a consistent FoV in the 65″ display experiment.

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