"This Is a *Lot* Easier!":
Constrained Movement Speeds Navigation

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ABSTRACT

This paper reports on an experiment comparing constrained and unconstrained movement in a 2D zooming environment. Results for a directed search task showed a significant decrease in time on task when movement was constrained, accompanied by considerable reductions in all mouse movement activity. Detailed analysis suggests that subjects were calmer, more confident in their actions and experienced less spatial disorientation, and indicates that judiciously constrained movement can reduce both mechanical and cognitive demands of navigating.

KEYWORD

Navigation, Locomotion, Steering, Constrained Movement, Movement, Multiscale, Jazz, Lodestone, Leyline.

INTRODUCTION

Most techniques for supporting and controlling movement aim to increase freedom of movement, giving users the option of going anywhere. However, limiting where users *can* go may make it easier for them to get to where they *want* to go. A variety of techniques for constraining movement has been proposed, typically limiting movement to algorithmically defined regions [1, 2] or trajectories [3, 5, 6], but empirical evidence for their effectiveness is lacking. This paper reports on an experiment comparing constrained and unconstrained movement in directed search.

TWO MODELS OF MOVEMENT IN JAZZ

Jazz [4], a 2D spatial zooming interface, was the interaction environment used for the study. Jazz employs a metaphor of an infinite two-dimensional surface that can be viewed at an infinite range of magnifications. Movement is by zooming—changing the scale of the view—and panning—changing its planar coordinates. The experiment compared *Pad* mode, conventional unconstrained movement, to *Leylines* mode, constrained movement based on Predictive Targeted Movement (PTM) [5].

In Pad mode, movement is relative to the surface: The system centers zooming on the surface point under the mouse. In Leylines mode, movement is relative to objects on the surface: The system uses the mouse location to predict the user's intended destination and then moves the viewpoint along a trajectory that will center the target in the view, filling the view. The predicted target is the object closest to the mouse (zoom-in) or the "Top of the World," the most magnified view that contains all objects on the surface (zoom-out). Movement stops when the target is reached.

Consequently, it is possible to move to any area of the surface in Pad mode, but only possible to move toward an area that contains objects in Leylines mode. In the experiment, the actions required to direct movement were identical in the two modes; only the system response differed. Pure panning was available only in Pad mode.

EXPERIMENTAL DESIGN

The experiment used a 1x2 within-subject design with repeated measures, alternating the mode used first. The experimental stimuli consisted of a set of photographs sparsely distributed on the surface. The subjects' task was to move from their current location to the photograph at a specified target location (Figure 1). A target had to be reached before the next was presented. The layout was designed so that the view had to be significantly magnified before photographs were visible (Figure 3). This ensured that the task entailed movement to out-of-view targets and required thinking about how to get there. Subjects trained extensively, then were tested, with one mode before training and testing with the second.

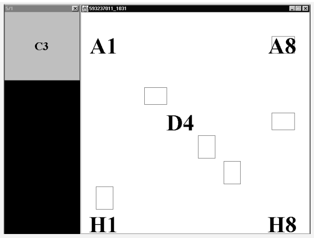

Figure 1 Experimental stimuli: The small (grey) window cues the target location (here **C3**); the large (white) window is the view of the surface. *Photograph outlines shown for illustration only—these were not seen by subjects.*

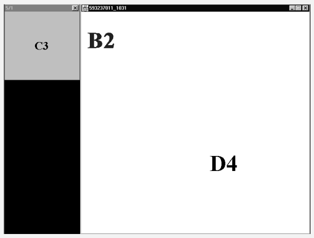

Figure 2 View zoomed in. Note the appearance of the **B2** location marker.

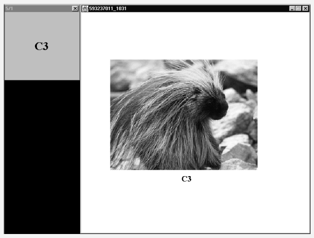

Figure 3 View zoomed in so that target at **C3** is visible.

In order to help subjects navigate, a conceptual grid subdivided the occupied portion of the surface and alphanumeric cell designations were used to reference specific locations (e.g., Figure 1 shows an 8x8 grid with 6 photographs). This gave subjects a means of

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	Pad	Leylines	%	t(23)	p <
Time on task	94.2	66.0	-29.9	4.93	.0001
View move time	47.9	37.2	-22.3	3.12	.005
Mouse move time	52.4	27.9	-46.8	7.08	.0001
Mouse drag time	27.8	14.3	-54.4	5.22	.0001
Mouse non-drag time	24.7	13.6	-44.9	7.61	.0001

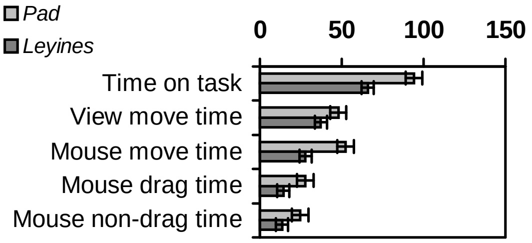

Table 1 Mean time usage per net surface unit between targets. (milliseconds/surface unit). Times are normalized because of differences among target sequences in total distance between targets. % column shows change from Pad to Leylines.

"knowing" where to go without requiring them to learn a specific configuration of objects. Fixed size grid markers appeared on the surface at regular intervals to help users navigate. The corners and center of the grid had permanent markers (Figure 1), while other markers appeared as the view magnified (Figure 2). Testing layouts used a 23x23 grid containing 50 photographs, with 16 serving as targets.

RESULTS

Data from one subject were excluded due to technical malfunction, leaving 12 in each starting condition. Tables 1 and 2 show results of one-tailed t-tests of timing data. View "move" and "non-move" is time spent actually moving and not moving the view, respectively. "Mouse move" is time spent moving the mouse. The latter comprises "drag" and "non-drag," moving the mouse with and without a button pressed, respectively. Note that a button press is synonymous with view movement.

Table 1 shows that constrained movement (Leylines) yielded a significant decrease in time on task, accompanied by considerable reductions in all mouse movement activity. Subjects moved the mouse less even when the view was stationary (non-drag time), suggesting that they were calmer and more confident in their actions.

Table 2 shows that subjects distributed their time differently within activities. Most notably, they spent a larger proportion of the total task time looking at a stationary view (view non-move time) with unconstrained movement (Pad mode)—presumably planning for movement—yet got to destinations faster when movement was constrained. Subjects also spent a larger percentage of view non-move time moving the mouse—"doodling," using the mouse as a visual aid to reasoning, or preparing for view movement—when movement was unconstrained, suggesting that they were experiencing more spatial disorientation.

These conclusions are corroborated by subjects' comments. Subjects proclaimed themselves lost more often in Pad mode. Several remarked appreciatively on how Leylines mode required less precise mouse control, with one subject spontaneously exclaiming, "This is a *lot* easier!" Overall, quantitative and qualitative data indicate that judiciously constrained movement can speed navigation by reducing both mechanical and cognitive demands of navigating.

REFERENCES

1. Galyean, T. A. (1995). Guided Navigation of Virtual Environments. *1995 Symposium on Interactive 3D Graphics.* ACM Press.
2. Hanson, A. J., Wernert, E. A., Hughes, S. B. (1999). Constrained Navigation Environments. In Hagen, H., Nielson, G. M., and Post, F. (eds.), *Scientific Visualization: Dagstuhl '97 Proceedings*, IEEE Computer Society Press.
3. Igarashi, T., Kadobayashi, R., Mase, K., Tanaka, H. (1998). Path Drawing for 3D Walkthrough. *Proceedings of ACM UIST 98*, ACM Press.
4. http://www.cs.umd.edu/hcil/jazz
5. Jul, S. (2002). Predictive Targeted Movement in Electronic Spaces. *CHI 2002*, ACM Press.
6. Mackinlay, J. D., Card, S. K., Robertson, G. G. (1990). Rapid Controlled Movement Through a Virtual 3D Workspace. *SIGGRAPH '90 Conference Proceedings*, in *Computer Graphics* 24 (4).

	Pad	Leylines	%	t(23)	p <
View non-move time/ Time on task	.49	.42	-14.3	3.89	.001
Mouse move time /Time on task	.57	.43	-24.6	6.84	.0001
Mouse drag time/ Mouse move time	.52	.50	-3.8	.53	.6
Mouse drag time/ View move time	.58	.38	-34.5	7.24	.0001
Mouse non-drag time/ View non-move time	.56	.48	-9.0	3.62	.005

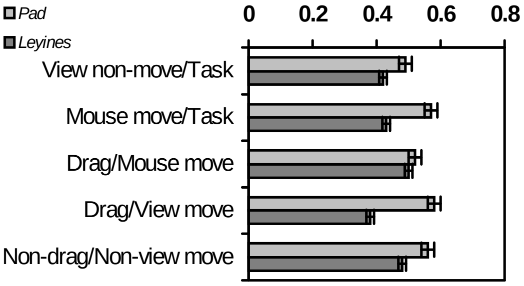

Table 2 Time distribution within activities. % column shows change from Pad to Leylines.