

## Evaluation of Input Devices for an FPS Program used in Law Enforcement Tactics Training

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Computer simulation as a method of tactics training has recently piqued the interest of law enforcement communities. This paper describes an experiment designed to evaluate the relative effectiveness of three input devices (keyboard + mouse combination, joystick, and gamepad) as control mechanisms for a desktop computer-based first person shooter program currently in use at several U.S. law enforcement training agencies. Participants completed three abbreviated tasks representative of the three most fundamental skills necessary to successfully navigate real scenarios within the program. Differences were found in task completion times and participants' subjective preferences between the three devices that indicate the inherent suitability of the keyboard + mouse combination as the device of choice for this type of simulation.

### INTRODUCTION

Faced with ever-increasing challenges, it is no wonder that more and more law enforcement agencies are establishing as a primary mission the goal of identifying and channeling new instructional methods and high quality training tools to benefit trainees and accomplish instruction in an efficient manner. As in many other domains, it will likely be successful utilization and integration of technology that enables law enforcement communities to achieve this goal. Current interest is focused on broad-range technologies capable of impacting multiple areas of training, one example being computer simulation. As a method of tactics training, simulation is highly versatile and rich in potential. It provides a fast, flexible medium for trainers to increase learning opportunities by allowing for creation of complex real-life situations and decision-making scenarios, including ones too dangerous to reenact with live action role-playing exercises. Students can then act through the simulated scenarios in the manner they would need to if the scenes were reality – all at much lower cost in terms of resources and time.

#### First Person Simulations

One type of computer simulation that has captured the interest of law enforcement communities is the desktop computer-based first person program, and in particular the first person shooter (FPS) program. The working concept behind this sort of training simulation is akin to FPS games popularly instantiated on personal computers and gaming consoles. Indeed, many such simulations are specially built upon existing game engines. The operator perspective is that of an actor in the game – the computer monitor displays the player's field-of-view on screen as if he or she were immersed within the environment, seeing the landscape, moving through it, and directly acting upon the objects in it.

Orienting the actor within an FPS game world generally requires two manual operations – one to control position or movement and one to control viewing direction. In the case of the latter, a distinct cursor at center screen indicates the exact point of visual focus, and inputting a command to align this

cursor with an object elsewhere on screen allows one to focus on that object. This is very similar to a conventional pointing task, though it does differ slightly in that instead of the cursor moving around a fixed interface or environment, it is the environment that moves with respect to the cursor. In other words, the world reorients itself in order to line the object up with the cursor, which remains loosely fixed at center screen. The movement and viewing operations function in concert for many game skills. For instance, in order to walk to an object to the front and right of the operator's current position, he or she would use one aspect of a control device to input a "walk forward" command, while at the same time using a different aspect to input a "look to the right" command (as in a pointing task, moving the cursor to the right with the desired object as the target). Since games are programmed so that an actor veers in the direction of viewing, this causes a rightward turn in the walk (the world reorients around the actor to line the object up with the cursor, giving the impression of turning), allowing the actor to reach the object as desired.

#### Technology Integration

*DARWARS Ambush!* (Ambush) is an FPS program that was originally intended to serve as a platform for military convoy training (DARWARS, 2005). Recently, law enforcement agencies have sought to adapt Ambush for their own purposes, with several incorporating it into their existing training programs on a limited basis. Though this process is in its early stages, Ambush and other similar first person programs have demonstrated great promise for improving student training.

Attempts to further integrate Ambush into training programs require that some technical issues be addressed, an important one being the question of which input device to employ. Many FPS programs, including Ambush, are designed to support interfacing with a multitude of input devices. Given this variety of possible devices, it is likely that there will be individuals who prefer one over another for any number of reasons. However, allowing students to select their own device of choice would result in numerous logistical issues in terms of

orientation and preparation time. Technical matters are also a concern, as it is highly likely that some of these devices may be more suitable than others on a number of points. From a variety of converging perspectives, it would be most efficient to standardize protocol and choose just one device for blanket use by all students.

The expressed goal of this research is thus to determine which input device among several options presents as the most suitable control mechanism for FPS programs, *as used in law enforcement tactics training*. This distinction is central to the study presented here – the goals of law enforcement are vastly different from those of the gaming community. Agencies use FPS programs as tools for training situational judgment, not minute details in execution. Within the simulated world, a student's ability to engage suspects is secondary to his or her ability to judge whether circumstances warranted use of force in the first place. Thus, rather than an emphasis on accuracy of detail as would be paramount for regular game play, what is vital to law enforcement is affordance for a gross ability to complete tasks and execute commands as desired. Just as important is that any given group of students, experienced or inexperienced with FPS games and assorted input devices, be able to quickly learn and adequately use whatever device as necessary. In this light, what amounts to a suitable input device for the purposes of law enforcement tactics training is one that is easily learned and used by a diverse population possessing varied gaming and input device experience, and affords simple execution of commands that will not interfere with the real purpose of the training.

For our purposes, we choose to narrow our examination to a mouse + keyboard combination, a joystick, and a gamepad, the reason being that all three are considered to be some of the more common FPS device configurations.

We base our evaluations of suitability on the criteria of preferences for likability, ease of use, ease of learning, and optimal performance. Likability is an important factor to consider, as the degree to which a person is interested in, or is motivated to learn a certain device will surely affect their learning performance (Schiefele, 1991). It is not a sufficient measure alone however, given the abundance of documented cases where people prefer devices that result in suboptimal performance over better alternatives (Smallman & St. John, 2005). Ease of use is also important because the ultimate goal of this type of simulation training is to improve students' tactical judgment, decision making, and situational awareness skills in the field – students should not be concentrating their efforts on finger dexterity or capacity to recall arbitrary device button mappings. How easily a device can be learned is crucial because class time to train students is limited, and the more time that is spent on teaching a student how to manipulate a device, the less time there is for training in scenarios. Lastly, optimal level of performance offers a succinct summary of the actions and accomplishments a device affords.

### Previous Research

Despite existing anecdotal evidence, there has been little empirical research comparing across input devices within the

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framework of a complex application domain such as FPS simulations. An exception is Isokoski and Martin's (2007) study evaluating the performances of a wheel mouse, an Xbox360 controller, a mouse + keyboard combination, and a trackball mouse in FPS target acquisition within an artificially constructed simple game world. They found that aiming with any one of the mice was more efficient than aiming with the gamepad.

There has also been research suggesting that different input devices are uniquely suited for different types of tasks. Sobhi and Kelly (1999) examined the performance of four devices for controlling placement and direction of traffic light cameras, finding that both keyboard and mouse interfaces outperformed joysticks and touchscreens. Operators of the latter two devices committed significantly more camera selection errors, implicating limitations in pointing accuracy – either of the finger or joystick – as the main culprit for their poorer performances.

Joysticks have throughout history been the go-to choice for aviation matters as wide-ranging as remote control of guided missiles and bombs (Schliephake, 1987; Hermann, 1987), to aircraft controls and flight simulators (Zeller, 2005). Despite joysticks not being as widely used for commercial FPS games, there exist firmly entrenched beliefs that controlling a character with one would be highly intuitive, as the movements of a joystick closely resemble the physical movements of a person (i.e. moving the joystick forward, a person walking forward). Indeed these notions are directly in line with established human factors principles that moving control parts should ideally mimic real-life movement (Roscoe, 1968).

For console systems, gamepads have traditionally been the popular method of control for FPS games. Nearly all current versions have adopted a design that prominently features two thumbsticks (miniature joysticks, each operated by a thumb), including the Microsoft Xbox, Sony Playstation, and Nintendo Gamecube controllers. Even the Nintendo Wii, praised for its nonstandard controllers, still offers a lesser-known alternative Classic Controller that retains the traditional two thumbstick layout (Yu, 2006).

Recall the control of viewing direction in an FPS simulation that is reminiscent of a cursor pointing task. This function plays a major role in virtually all skills needed for a first person simulation, and overall performance is likely to be heavily influenced by this task alone. A plethora of literature can be found on two-dimensional pointing tasks, including the particular characteristics of devices that contribute to or detract from performance (Fitts, 1954). Many studies exist that implicate the computer mouse as a superior pointing device, its performance almost uniformly surpassing all other alternatives due to its zero-order nature (displacement of the mouse controls displacement of the cursor) (Wickens et al., 2004). Several notable ones contrast its performance to various types of joysticks. Mithal and Douglas (1996), through comparison of the mouse to a finger-controlled isometric joystick in a basic target acquisition task, determined that differences in movement microstructure of the two devices accounted for the performance gap between them, as properties inherent to the isometric joystick encouraged random, uncontrollable

fluctuations in velocity control (joysticks being first-order in nature, with displacement of the stick controlling velocity of the cursor). Kloczek and MacKenzie (2006) arrived at a similar conclusion from their newly developed performance measures in a comparison between a mouse and an Xbox gamepad thumbstick in various artificially constructed target tracking tasks.

Given the prominence of a pointing-like task in nearly all aspects of an FPS, it is expected that the mouse + keyboard combination will result in the best performance, as the same properties that make the mouse an ideal pointer device will likely also make it an ideal input device for FPS platforms. Given the intrinsic intuitiveness of the joystick, it is possible that it may be the most easily learned among the three devices.

## EXPERIMENT

Three short scenarios were created using the Ambush editor software, each designed to be representative of one fundamental skill necessary for navigating through a full-scale scenario law enforcement students may run through in an actual tactics training course. These skills were movement, the ability to walk and control direction through a scene; shooting, the ability to aim a weapon and hit a target; and driving, the ability to steer and navigate roads. The notion was that gauging people's subjective reactions to the three devices after having performed the test scenarios, as well as comparing their objective performances, would help clarify the strengths and weaknesses of each device as a control unit and evaluate their suitability for use with first person training programs.

### Input Devices

The devices were Merc Gaming Keyboards (Ideazon, 2006) + Logitech G7 Laser Cordless Mice (Logitech, 2005), Logitech Freedom 2.4 Cordless Joysticks (Logitech, 2002), and Logitech Cordless Rumblepads 2 (Logitech, 2004). In terms of FPS function mappings, actor movement is controlled by designated keyboard keys, the main stick of the joystick, or the left thumbstick of the gamepad. Viewing direction is controlled by the mouse, the hat switch (a thumbstick located at the top of the joystick), or the right thumbstick of the gamepad. Scenarios were tested on Dell desktop computers.

### Test Scenarios

The movement scenario begins as an outdoor scene with various objects visible in the field-of-view (Figure 1). The objective is to navigate through these objects to a predefined endpoint, as specified by instructions given before testing.

The shooting scenario is a sparse environment with a single target on screen. Following a fixed time span the target begins to move randomly, after which the objective for the operator is to hit the target, tracking as necessary.

The driving scenario is a city scene that begins with the operator already seated in a car. The objective is to drive through the streets of the city to a predefined endpoint, adhering to directions given before testing.

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Figure 1. Ambush scenario designed to test the FPS skill of movement.

### Method

*Participants.* Forty-eight people from a law enforcement training facility, average age 35.7 years, 16 female and 32 male, 12 left-handed, participated in this experiment. All participants were volunteers and did not receive compensation.

*Design.* A between-participants design with three conditions was used, each corresponding to one type of input device: keyboard + mouse combination, joystick, and gamepad. Participants were randomly assigned to a condition. The dependent measures were scenario/task completion time, and subjective preference ratings for each device.

*Procedure.* Participants were run in a single session lasting no more than one hour. Demographic information gauging previous experience with FPS games and each of the three devices was gathered for informational purposes. Out of forty-eight participants, forty-seven self-reported moderate to high experience with keyboards and mice, five with joysticks, thirteen with gamepads, and eighteen with FPS games. As with other studies conducted in this vein, no effort was made to control for previous experience, as this would have been virtually impossible given the sharp divide between the number of people who are experienced with keyboards + mice vs. joysticks or gamepads. Controlling for previous experience was also not a significant concern given our stated goal. Participants were given a fifteen minute orientation to Ambush and trained in the usage of one of the devices, dependent upon condition assignment. For the three scenarios, they were alternately shown a video of the task to perform, and then tested on four trials of the task for a combined total of twelve scenario runs. Scenario order was fixed – movement, shooting, driving – as this is the common default order to learn FPS functions, and because some orders simply do not make sense and would never occur in practice (i.e. learning to drive before knowing how to walk to a car). A post-test assessment was then administered to determine subjective attitudes toward the devices used in the context of these scenarios.

Participants' scenario runs were recorded for analyses using Fraps video screen capture software (Fraps, 2007).

**RESULTS**

Task completion times were obtained from the scenario video recordings. The post-test assessment was in the form of seven-point numerical scales with accompanying verbal labels. Post-hoc analyses were conducted to determine differences between conditions (devices).

**Task Completion Times**

Times were averaged across all trials and participants for each scenario type, by condition (Figure 2). For movement, participants using the keyboard + mouse were faster than those using the gamepad,  $F(2, 45) = 6.91, p = 0.002$ . For shooting, participants using the keyboard were faster than those using the gamepad  $F(2, 45) = 7.93, p = 0.001$ . For driving, participants using the keyboard were faster than those using the joystick  $F(2, 45) = 4.47, p = 0.017$ , or the gamepad  $F(2, 45) = 8.23, p = 0.001$ .

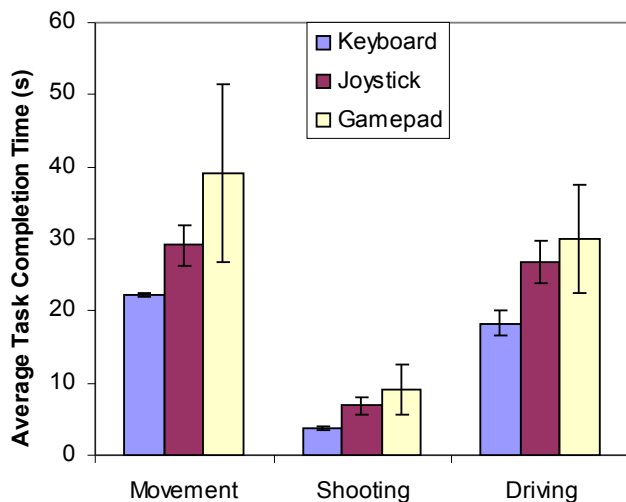


Figure 2. Task completion times for each scenario by device. Error bars represent 95% confidence intervals.

**Subjective Preferences**

Participants rated ease of learning, ease of use, and likability for a device as a whole on a 1 (bad) – 7 (good) scale, with numbers averaged across all participants, by device (Figure 3). Participants rated the keyboard as easier to learn than the gamepad  $F(2, 43) = 3.51, p = 0.039$ . The keyboard was rated as easier to use than both the joystick  $F(2, 42) = 3.60, p = 0.036$  and the gamepad  $F(2, 42) = 6.52, p = 0.003$ . In terms of likability, participants preferred the keyboard over both the joystick  $F(2, 45) = 3.25, p = 0.048$  and the gamepad  $F(2, 45) = 6.68, p = 0.003$ .

**DISCUSSION**

Results are strikingly uniform in favoring the keyboard + mouse over the other two devices. Factors that may have contributed to each device’s performance are discussed below.

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**Keyboard + Mouse**

Before testing, the keyboard + mouse was met with skepticism from some participants who had never used it for gaming. At first glance, certain aspects of its use in FPS simulations are counterintuitive, such as the need to operate two separate controls for what appears to be one unitary action (i.e. turning while walking requires coordinated input from the keyboard and mouse). However, the combination has higher familiarity on its side as an ally (47 of 48 participants reported moderate to high experience levels), one that likely played a substantial role in the excellent performance it achieved, even despite much of that familiarity having been garnered from more traditional usage platforms such as word processing.

Additionally, the keyboard contains built-in forcing functions that do not allow users to perform certain suboptimal actions that the other devices do. For example, the command to “walk forward” is executed with one key on the keyboard, while on the gamepad it is a forward movement of the left thumbstick. Since joysticks inherently allow 360° of rotational freedom, any intentional or unintentional sideways deviations in the movement of the thumbstick will interact and interfere with straight forward movement of the character.

**Joystick**

Prior to testing, many individuals reporting little to no gaming experience expressed beliefs that the joystick would be the optimal device. Its appearance and function, analogous to that of a moving human, promote the idea that it would be easy to learn and use, a powerfully intuitive premise with existing research to back it (Roscoe, 1968). However, this study found neither objective nor subjective data to support this claim. Properties like the joystick’s first-order nature and its greater degree of rotational freedom likely hurt its performance. Akin to the problem with the gamepad left thumbstick as described above, forward walking only requires stick movement along the Y axis, but many participants also inadvertently varied stick position along the X axis, conflating forward movement of the character with other functions.

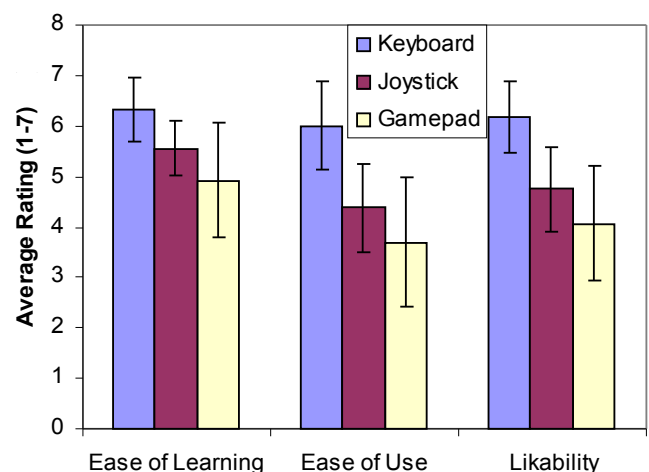


Figure 3. Overall ease of learning, ease of use, and likability ratings by device. Error bars are 95% confidence intervals.

## Gamepad

Nearly every participant who had not previously used gamepads complained vehemently about the two thumbstick configuration being difficult to learn and use. Similar to the keyboard + mouse, this arrangement divides into two inputs what is intuitively one action. But the gamepad does not have familiarity on its side to potentially compensate (many more people possess experience with keyboards and mice than gamepads). The two thumbsticks are also visually and operationally identical, a setup that provides no aid in helping users parse the two FPS functions, as the dissimilar mouse and keyboard might. While those with experience using gamepads did not similarly complain of learning difficulties, many were not shy in expressing their overall distaste for the device. On the whole, it appears gamepad user's performance may have been hindered by joysticks (the right thumbstick especially) being suboptimal first-order pointing devices, an interpretation that is consistent with findings from previous literature.

## Conclusions

Theoretically, this paper puts to test theories and hypotheses generated during the course of research on suitability and operability of input devices within simple artificially constructed tasks, in a richly complex simulation environment. From our findings, it would seem that micro-level analyses of input device performance can potentially scale up into consistent performance differences in macro-level tasks, an encouraging connection between basic experimental paradigms and real world functional applications. Practically, our results may speak to issues facing others who wish to make similar use of these programs, but are uncertain regarding the suitability of these input devices.

Several methodological aspects of this study warrant caution in considering the results. Task completion time as a dependent measure was a coarse compromise resulting from features of the program software that rendered finer-grained measures unviable. However, it could be argued that a coarse measure may be more fitting for our study given our expressed purpose to use these programs primarily as training tools for judgment, rather than the detailed minutiae of execution. For example, it is not of utmost importance that the operator of a simulated vehicle is able to stay perfectly within road lanes, but rather it is a gross ability to travel from point A to B in an effective and timely manner that will likely lead to the most valuable tactics training experience. Regardless, it should be noted that it is nearly always the case that deviations from the ideal path would slow down the trainee, and thus still be roughly captured by the task completion time measure.

It may also be more telling to compare devices on the level of an individual using a within-subjects design rather than the between-subjects design used here. Unfortunately, having drawn from a pool of volunteers with fulltime work/training schedules, it would have been unfeasible to request the amount of time necessary to mount such a design for all three devices. This was also the reason why just four trials of each task were conducted. This low number of trials is not without

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advantages though, as it paints a distinct picture of achievable performance with miniscule amounts of practice – the exact conditions under which training is likely to take place.

Future research is planned to compare the keyboard + mouse combination and the joystick using a within-subjects design. A related project is in order to determine the optimal amount of time students need to familiarize themselves with a device so they can comfortably run through scenarios.

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