The effect of input methods on accuracy in a game with a genre-nonstandard input method

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Abstract

In computer games, input devices have a great effect on the ability of a player to interact with their surroundings accurately. Prior research has often analysed players using existing games, or re-created common controller schemes, which may simply be measuring existing skill with that format. A game entitled *Infinity Passage* was developed for study; a first-person game akin to an endless runner in which the player needed to pass through randomly generated gates. 40 participants used a mouse, analogue stick or D-pad to navigate through these gates, with the game automatically recording performance metrics. The game used an input format which has never been widely employed in the genre, to avoid simply testing established skills. The results showed that mouse users scored approximately 3.9 times higher than analogue stick or D-pad users on average, a difference far higher than had been anticipated. This may indicate that other studies using existing games or replicating existing control schemes are influenced by participants' existing skill with a format- and further research is required to investigate the difference in accuracy between a mouse and other input methods in a non-standard games context.

Introduction

Computer games have been framed by their input devices since the inception of the medium. In today's game industry, where games are regularly released across multiple platforms simultaneously, understanding the effectiveness for different input methods at different tasks is of increasing importance to games user research. This is particularly an issue when balancing cross platform multiplayer, as well as in scenarios where multiple input methods are accepted on the same platform.

The consequences for not accounting for input methods can be significant, and it is a matter that is still under consideration today. In 2017, Blizzard Entertainment identified that players of the first-person shooter *Overwatch* (Kaplan, Metzen, & Keller, 2016) were attaching third party keyboards and mice to their consoles and outperforming controller users (Frank, 2017). In 2021, a cross-play format was added to *Overwatch*, allowing a wider range of console players (on controllers) to compete against PC players (generally using mice). Console players were swiftly outclassed by PC players in the format (Park, 2021). Epic Games' *Fortnite Battle Royale* (Mustard, 2017) resolved a similar issue by simply separating console keyboard-mouse users from controller users for matchmaking purposes, though this solution comes at the expense of cross-play flexibility (Duwe, 2018).

While the literature has already compared coordination and tracking accuracy with different devices, there is a need for studies that examine the magnitude of this effect in a games scenario. This paper presents an endless runner game created for the purpose of studying input method and input sensitivity, while making use of a nonstandard control scheme for the genre to avoid testing established skills among players.

Literature Review

Interfaces and accuracy

Klochek & MacKenzie (2006) investigated target tracking accuracy through simple tasks which were presented with rudimentary 3D graphics- with participants tracking a coloured circle moving across a 3D grid. Comparing a mouse with Xbox analogue sticks, the research demonstrated that the mouse users had a much better ability to correct for errors and make smaller adjustments to their cursor.

Natapov, Castellucci & MacKenzie (2009) evaluated a mouse, Wiimote and analogue stick (specifically the analogue input of the Wii Classic Controller) in a simulation akin to target shooting. This had participants move a cursor over a target, and were permitted to rest before clicking the "ready" shape which would spawn the next target. Participants were judged based on their speed and accuracy in reaching the target. The results showed strong preference for mouse over the other options, with mouse users taking less than half the time to meet targets as compared to analogue stick users. Participants also expressed frustration with the analogue stick. The simulation used in question was presented using simple coloured shapes which needed to be overlapped using input.

Isokoski & Martin (2007) developed a very simple first-person shooter environment for evaluating several mouse types against an Xbox 360 controller. The game replicated the interface of the first-person shooter *Halo 2* (Jones, 2004) to a very detailed level, matching rotational velocity for player orientation for example. The study found that mouse users were twice as efficient at hitting targets. However, Isokoski & Martin acknowledge that by replicating the control scheme of *Halo 2* for the experiment, their study may simply be measuring "the user's previous training". All eight participants did report playing FPS games prior to the commencement of the study. Kavakli & Thorne (2002) used the driving game *Need for Speed II* (Blackwood & Lemke, 1997) to assess keyboard, mouse and analogue stick performance and found that the analogue stick players recorded the shortest lap time. Their participants were divided into novice and experienced players, though the study may suffer from the same problem of pre-existing format familiarity identified by Isokoski & Martin (2007).

Interfaces and experience

Gerling, Klauser & Niesenhaus (2011) observed players of the first-person shooter *Battlefield: Bad Company 2* (Goldfarb & Kertz, 2010) and found there was no significant correlation between platform related effects, such as controller type, and overall player enjoyment, recording only minor changes in engagement.

McGloin & Farrar (2011) suggest that gameplay is dependent on one or more mental models the player possesses, a degree of abstraction about how the real world functions. For example, most players will possess a mental model of how a car functions in the widest possible terms- understanding that turning the wheel will change the direction of travel, etc. In a games context, the duty of the method of input is to "minimize the gap between the virtual world and the user's ability to interact with the world in terms of learning or applying existing skills". That is, a physical wheel that the player can turn in lieu of a car's steering wheel- a highly natural mapping (Skalski et al, 2011), which will enhance "the gamer's ability to make accurate decisions within the virtual environment" (McGloin & Farrar 2011).

Summary

Many studies examining point tracking and targeting have been conducted using simplified exercises that are presented to participants as “tasks” or “tests”. These generally employ simplified graphics such as simple coloured circles (Klochek & MacKenzie, 2006; Natapov, Castellucci & MacKenzie, 2009). Others study or replicate existing titles, but these studies may be influenced by participants’ prior knowledge of the titles, or familiarity with a particular control scheme (Isokoski & Martin, 2007). The established literature generally supports higher accuracy with mouse over analogue stick use, though this was not consistent across all use cases (Kavakli & Thorne, 2002).

Methodology

Software

A simple video game, entitled *Passage Infinity*, was developed in Unreal Engine 5 for the purpose of the study. It is an endless runner, a genre in which the player is presented with an unending series of randomly generated obstacles to traverse (Dormehl, 2019). The game could be controlled with either a mouse, analogue stick, or directional pad (D-pad). *Passage Infinity* was not available to the public, nor to any of the participants prior to the commencement of this study.

Selection of game concept

The basic concept of *Passage Infinity* was largely inspired by the 2006 Flash title *Missile Game 3D* (Clarke, 2006) which involved sliding the mouse to reposition in space, and no further input outside of menu navigation. Under the typology identified by Skalski et al (2011), this input method constitutes *directional natural mapping*- where directional movements of the mouse will correspond to the movements on the screen. This is “the most basic manner” in which natural mapping can be achieved.

Missile Game 3D (Clarke, 2006) could be considered a forerunner to the endless runner genre, in that the avatar moves forwards automatically and faces randomly generated obstacles to evade. It is among several precursors to the genre, such as *BC’s Quest for Tires* (Banks & Bate, 1983), an auto-running sequence in the Mr. Dark’s Dare level of *Rayman* (Ancel & Hascoët, 1995) and the boulder chase segments of *Crash Bandicoot* (Rubin, 1996). However, the endless runner genre was not firmly established until the sidescroller *Canabalt* (Saltsman, 2009) and the lane-based *Temple Run* (Shepherd, Luckyanova & Tchangov, 2011), which set the format going forward. Subsequent titles in the genre were primarily aimed at the rapidly growing mobile sector (Chong, 2015), and controlled with taps or swipes on touchscreens. *Subway Surfers* (Kiloo, 2012) had become the most installed mobile game worldwide by 2017, and employed lane based gameplay akin to *Temple Run* (Riaz, 2018). Indeed, the genre’s success has been characterised by its compatibility with touchscreen devices in particular (Parkin, 2013).

The free 3D movement of *Missile Game 3D,* originally built for use with a mouse on personal computers, therefore is a control scheme which was never widely adopted among games of the genre. This was the reason for its selection in the study. The use of a more widely known control scheme would have encountered the same problem identified by Isokoski & Martin (2007), where the study would simply have been measuring existing skills with that format.

Design

In *Passage Infinity,* the player flies an avatar along a 3d tunnel structure, which is blocked by a series of rotating panels with holes in, henceforth referred to as *gates*. Should the player successfully orient themselves using their input device and pass through a gate, a score counter in the corner will increase by one. If the player strikes the walls of the tunnel, or the frames of the gates, the game ends. The player's speed will gradually increase over time, making it increasingly difficult to pass through subsequent gates (Um, Kim & Choi, 2007). In line with Frahm's recommendations (2018, p.55) each session begins with a short gap containing no gates at all, to allow "time to adjust" to the environment and controls. This period lasts approximately five seconds.

There were four gate variants in total with different shapes, and their orientation and sequence are randomly generated for each playthrough. This means that memorisation of a set route through the tunnel was impossible. Like other endless runners, players are however capable of peering ahead at future obstacles to plan actions- in this case looking at the tunnel extending beyond the nearest gateway. The game engine loaded the tunnel to a depth of eight gates ahead of the player- past the point where they would reasonably be viewable. The avatar in use is a simple collision sphere around a first-person camera, with the sphere used for hit detection.

Art

Figure 1: A screenshot of Passage Infinity showing typical gameplay

The passageway and gates were rendered using a realistic 3D science fiction aesthetic, adapted from stock assets available on the Unreal Engine marketplace. These were specifically drawn from the pack *Modular Sci-Fi Environment A* (Crebotoly, 2018), which were then modified to meet the needs of the project. An earlier version of the game involved colour coded lights for the different gate types, but the colour coding was removed to avoid placing colour-blind players at a disadvantage. In the final version, highly contrasting values are used to distinguish the gates and walls, using warm orange for gates and cold blue for walls. This follows the colour-blind inclusive design recommendations of Plass et al. (2013).

Hardware

All participants played the game on the same gaming laptop: an Acer Nitro 5 AN515-45, with a 39.6cm 1080p monitor, AMD Ryzen 5 5600H processor, and an NVIDIA RTX 3060 graphics card. The hardware was kept consistent so as to avoid performance issues such as variable frame rates occurring across different machines for example, as this could have impacted player performance (Claypool, Claypool & Damaa, 2006). The game was presented using this hardware at a steady 60 frames per second (fps), with the framerate capped at that level. Without capping, the laptop could render approximately 100 to 110 fps, but it was kept locked at 60 for consistency.

An Acer wired optical mouse was used for input, along with a standard wired Xbox 360 controller with a USB adaptor, with the latter used for both analogue stick and D-pad input. Switching between the different input modes was handled by the game, which would disable the other controls and instruct players on which hardware was required for the next session at the appropriate time.

Participants

Data collection took place at Solent University in March 2022, with the participants being students of the Computer Games (Art) and Computer Games (Design) degrees. The 40 participants were all young adults from a variety of backgrounds, of which 30 self-identified as male, 9 as female and 1 as nonbinary. Gender data were collected on an aggregate basis only, to avoid a potential data re-identification risk. No further personal data was collected during the study, with each player simply identified via time stamps recorded into the text log. The participants took part voluntarily, and were not paid for doing so. The study received ethical approval from the university prior to data collection, as while human participants were involved, there was no risk to their health, financials or personal data. All 40 participants completed 15 runs each (5 with each input method) for a total of 600 runs.

Procedure

At the start of a session, participants were able to self-select their handedness using a menu, choosing between left handed, right handed and ambidextrous. Their choice was recorded to the output log but did not otherwise influence the game. The participants were also given the option to invert their Y axis. The exact reason a minority of players prefer this option is in need of further research. It has been suggested that Y inversion is more common among those introduced to the medium by flight simulators, where pulling back on a flight stick will raise the nose of the plane. A minority of players apply it across other game genres (Stuart, 2020). As mismatched Y inversion preferences may impact spatial reasoning and immersion, the option was presented for those who wished to invert (Frischmann, Mouloua & Procci, 2015). Only one participant made use of the feature.

Participants all played five runs with each of the three input modes, for a total of fifteen runs each. The input sensitivity varied from run to run, with different sensitivity multipliers being employed for each input method. The order of the three input modes and respective sensitivity settings were randomly selected by the engine for each participant. Had the order not been varied, those occurring later in each play session could have been affected by task similarity bias (Thomas & König, 2018).

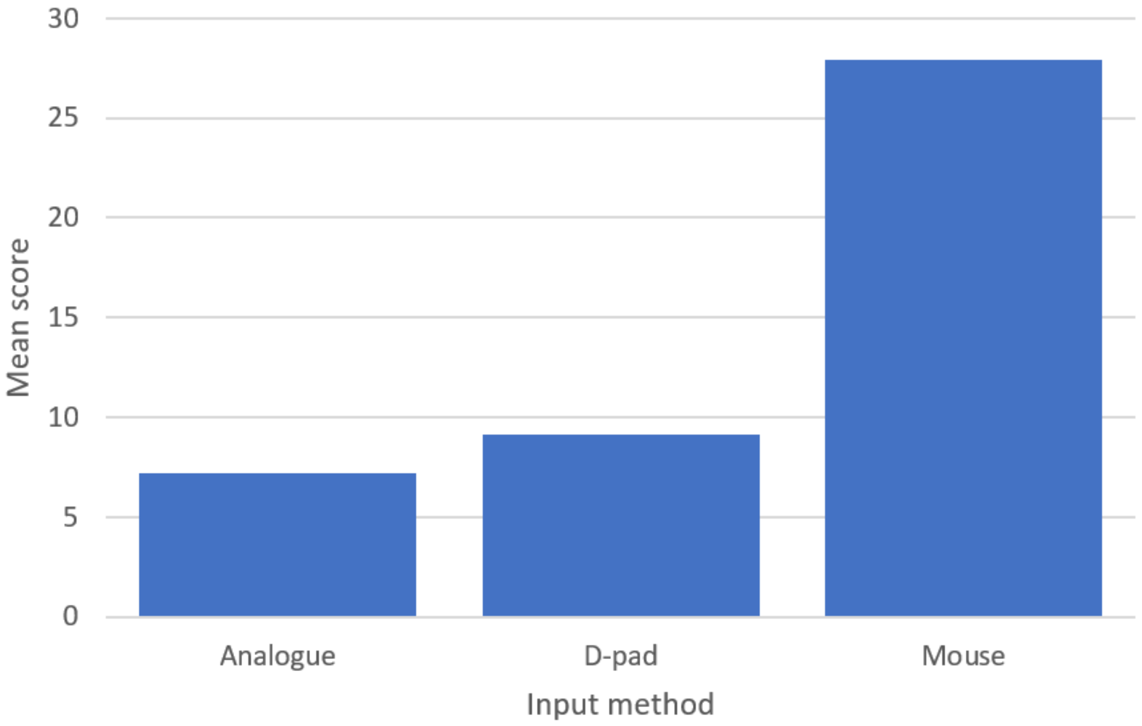
Each time a player struck an obstacle, the game would end the current run and record data from the recent session to an output log. These were stored in the form of comma separated values, achieved using the Unreal Engine 5 version of the Victory Plugin (Rama, 2021). These logs were not displayed to the players, and stored the following data for each run:

- Timestamp (recorded at the start of the fifteen runs, and used to identify players)
- Handedness (left handed, right handed, or ambidextrous)
- Y inversion preference
- Input method
- Input sensitivity setting
- Death type (whether the player struck the gates or outer walls of the tunnel)
- Score (the number of gates traversed)

Results

Analysis of the data was conducted using SPSS. Handedness and Y inversion preference were not analysed, as of the 40 participants, 37 selected “right handed” and 39 chose not to invert. It was deemed that the sample sizes for the alternatives were therefore too small to draw meaningful conclusions.

Input method and score



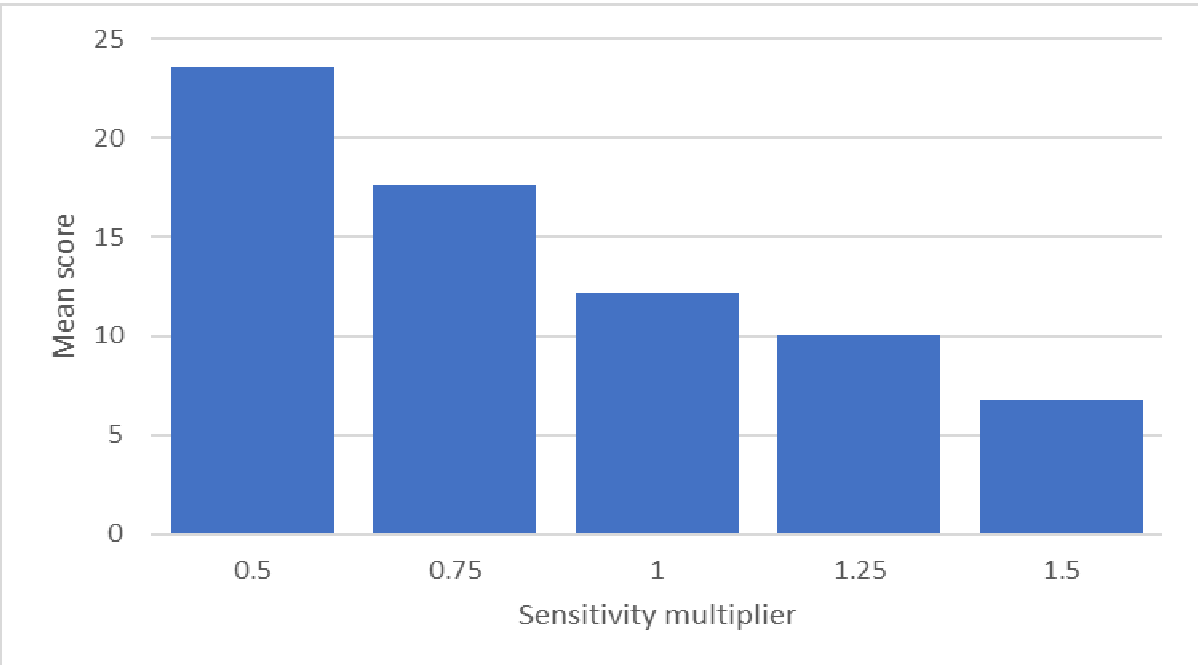
Input method	Participant's mean scores per input method				Standard deviation
	Lower Q	Median	Upper Q	Mean	
Analogue stick	2.650	5.900	9.950	7.185	5.863
D-pad	4.850	9.000	12.350	9.105	5.197
Mouse	17.750	24.600	35.750	27.94	13.245
All methods	5.150	10.500	18.800	14.74	12.884

Mouse users achieved far higher scores than any of the other input methods on average. A Friedman test was carried out using the mean score for each individual participant with each method to compare the three input devices, and found statistical significance ($\chi^2(2)= 56.013$, $p < 0.001$). Dunn-Bonferroni post hoc tests showed significant differences between the mouse and D-pad, and between the mouse and analogue stick ($p < 0.001$), though not between the D-pad and analogue stick.

The mouse performed even better than would be expected, based on the findings of Isokoski & Martin (2007). This may indicate that the use of an existing widespread format, such as the first-person shooter game based on *Halo 2* which was used for that study, may influence results.

Most of the highest scoring individual runs were achieved using the mouse, though it is worth noting that participant 24 achieved a score of 78 using an analogue stick, the highest scoring run out of the full data set. It is possible they were simply extremely skilled, as no other participant came close to matching their scores with an analogue stick- the next highest being Participant 10 with a score of 52. Participant 24 was the sixth highest scoring player on average, while Participant 10 was the highest scorer overall with an average of 30.933 across all input methods, also achieving the highest mouse score of 75. Participant 10's mean score was more than double that of the average participant.

Sensitivity and score



Sensitivity multiplier	n	Mean score	Standard deviation
0.5	153	23.63	18.869
0.75	113	17.58	16.983
1	112	12.19	16.350
1.25	112	10.09	14.539
1.5	110	6.80	14.624
All sensitivities	600	14.74	17.620

A Spearman's correlation reported strong significance (r_s= -0.431, n = 600, $p < 0.01$) between sensitivity and score, with low sensitivity runs achieving higher scores. This was expected, as users were better able to make small adjustments to their locations when approaching a gate. We also expected a drop in score at the very lowest sensitivity, as it would be harder to make rapid movements when facing the faster gates later in the game, but this did not emerge from the data set.

A minor bug was noticed after data collection that led to a slightly unequal distribution of sensitivity settings. Each participant had been intended to experience all five settings in a random order, but instead occasionally experienced a duplication of the 0.5 sensitivity and an omission of one of the other four. This explains why, for example, there were 113 runs with 0.75 sensitivity instead of 120. Considering the sample size, the statistical effect is likely very minor.

Death type and score

Death type	n	Mean score	Standard deviation
Struck outer wall	390	19.44	18.485
Struck gate frame	210	6.02	11.676
All death types	600	14.74	17.620

Death type- the type of obstacle the player struck- emerged as a significant factor (r_s= -0.469, n = 600, $p < 0.01$). Striking the outer wall would indicate that the player did not die from hitting the obstacles themselves, but rather the walls of the passageway between gates. Interestingly, players that died by striking the outer walls of the tunnel achieved much higher scores on average, when compared to those who struck the edge of a gate. This may be because players facing the faster gates that emerge later on overcompensate, making a rapid movement to clear a gate only to strike the tunnel wall of the section beyond it.

Fumbles

A number of false starts were observed, where players would inadvertently smash into the walls before the arrival of the first gate, sometimes very quickly after a session had started. This was sometimes caused by simply fumbling with the controller after picking it up for example. Such false starts accounted for 36 runs, which was 6% of the total. These were not removed from the data set prior to analysis, as no correlation was observed between fumble rate and any of the variables under study.

Player experience

No correlation was observed between score and player experience- that is, the later runs did not score more highly than the early runs. It’s possible that five runs with each input method did not offer ample time for participants to gain proficiency with the game.

Conclusion & recommendations for future research

It was expected that the mouse would out-perform analogue sticks, based on Isokoski & Martin (2007); however the scale of difference was surprising. Isokoski & Martin’s study, using *Halo 2*’s control scheme, showed that mouse users outperformed analogue stick users by approximately a factor of two, but in our study the factor was approximately 3.9; a far wider margin than had been anticipated. It is clear that there is a need for further research in this area, to ascertain whether this difference was caused by presenting participants with a nonstandard control scheme- therefore avoiding simply testing established skills with a given format.

There are several other aspects that could be studied by future research, such as additional input methods, or existing controller preferences and the effect of a mismatch. Secondly there is the matter of framing; whether the simulation is presented as a “game” or a “test”, which has been shown to have an impact in other contexts (Mekler et al., 2013, Ntokos, 2019). Further studies could also make use of multiple original games in a variety of genres to include a broader range of formats beyond Skalski’s directional natural mapping (2011).

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