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Adi's Maze and the Research Arcade:

A long-term study on the impact of gendered representation on player preferences

Christopher J. Headleand[1], Bethany Davies[1] and Benjamin Williams[1]

[1] School of Computer Science, University of Lincoln, UK

Abstract

Gender representation in games is a much discussed topic in the field of games design. A number of papers have explored the issues around sexist, and sexualised representation, and there even evidence that the assumed gender of a character has an impact on player behaviour. We introduce Adi's maze, a simple arcade game with 4 selectable characters, with male, female, and ambiguous gendered representation. In the game, the player has to collect coins in a maze while avoiding enemy NPCs in a similar format to the popular 1980's game Pac-Man. Regardless of the selected character, the player has the same objective to complete. We installed this game on two publicly accessible arcade machines (the Research Arcade) and left them in situ for 18 months. We collected all data regarding the character selection and player behaviour and we report the results from this study. Furthermore, we report insights from the development of the research arcade, and comment on it's effectiveness as a research tool.

CCS Concepts

• ***Social and professional topics*** → ***Gender;*** • ***Software and its engineering*** → ***Interactive games;***

1. Background and Introduction

A common criticism of the video game industry is how gendered characters are represented [GSMC18]. Research from Downs and Smith [DS10] found that female characters appeared far less frequently in video games than male characters, with females being making up 14% of their sample. This is a similar trend with previous research finding female characters making up just 12% of characters [GMPE01]. Female characters are often depicted as helpless, or taking on the role of the damsel in distress [SM14] acting as an object or objective. research has argued that users will usually create avatars that are similar to themselves [MGS*08]. However, this may force some players to assume a character that may not match their values.

This representation extends to clothing and other visual accoutrements, for example male characters wearing more armour then females. This notion is a frequent criticism of the design of female characters, where they are often represented wearing "skimpy" clothing [DT07]. Additionally, we often see female characters hypersexualised [JM07] [HT04] [BCS02], with "an often unrealistic body image, and depicted wearing sexually revealing clothing and inappropriate attire" [DS10, GSMC18]. While games developers are arguably more sensitive to representational issues in recent years, this is far from a solved issue.

There is evidence that representation may have an impact on an individuals behaviour in a virtual world. For example, dissimilar avatars have also been shown to to help reduce public speaking anxiety in avatar therapy sessions more than similar avatars [AFKB14]. Changing a body scheme to reflect different core views could have a direct impact on a users psychology [Bio97, KGS12]. Other research has demonstrated that player behaviour in-game may also change significantly. Lehdonvirta et al [LNLB12] found that male players typically had an inhibition for seeking help when playing as a male avatar, but when using a female avatar, they overcame this and were more likely to seek help in game. Another study investigating player sociability when altering the characters gender and appearance similarly found some interesting results. Banakou [BC10] setup a study in which they had 2 male and female avatars, where one would have a default look and the other having an elaborate appearance (which included a different body type, clothing and makeup). They found that both male and female participants were more likely to engage in conversations with the attractive (elaborate) avatars than default avatars. Furthermore, when female users played the attractive avatar, they were more likely to speak to male avatars, but when using the default avatar, they were more likely to speak to female avatars. This notion of confidence coming from avatar choice is similarly noted by Yee and Bailenson [YB07]. Their research explored the relationship between character attractiveness and height to play-style, identifying that players with a taller avatar displayed more confident behaviour in negotiation tasks then participants with shorter avatars. An increase in confidence was similarly noted when playing more attractive avatars, where players exhibited more intimate behaviours.

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Interacting with other avatars has also been shown to eliciting specific behaviours, for example, players have been shown to demonstrate "stereotypical feminine behaviour" when interacting with male avatars [SHW14]. Headleand et al. [HJP*15, HJW*16] demonstrated that players will respond very differently to an AI character if they perceive the gender to be different, despite the behaviour being identical. Specifically, players were more protective of the female character than the male, and a gender neutral character was largely ignored.

The gender representation of video game characters has been shown to impact a players character selection in game. Gao et al [GMS17] investigated this phenomena, and found that female players were more likely to play female characters, and male players more likely to play male characters. Many games provide players with the option to chose, or create their own in-game avatar. This avatar is often treat as a visual depiction of the identity, of themselves or of a character they wish to portray [MSGB*14].

Our review of the literature highlighted that the representation of a characters gender has a direct impact on players behaviour. While there were some studies which explored the impact of gender of character selection, there are very few that have done this 'in the wild' or for an extended period.

Figure 1: *Meltzer: One of our two Research Arcade machines*

2. Methodology and the Research Arcade

The purpose of this research was to contribute to the literature with a long-term 'in the wild' study. The intention was for the game to (as best as possible) resemble a real game rather than a an artefact of research. Part of this included not adding any additional steps such as questions or demographic collection which would not be present in a traditional game. Instead, the game-play and user behaviour is the only content captured, and this is done without the need for additional user interaction.

With regards to distributing the game we decided on two options, either publishing as a web-game on an existing platform (such as itch.io) or deploying as a physical installation. We decided to go with the second option, and build two physical arcade machines.

Building a physical cabinet has a number of advantages. From a practical standpoint, it allows us to provide the player with a dedicated gaming interface. Meaning we know the hardware they are using is capable of running the game, and it will be rendered consistently every time the game is played (reducing a number of potential confounding variables). Furthermore, an arcade machine has a clean user interface, where the player will only have access to the joysticks and control buttons. This makes it easy to prevent the player from accessing anything outside of our arcade emulator or being distracted by other software.

From a practical research standpoint the cabinet also provides a certain amount of protection, allowing the games to be placed in-situ for an extended duration. Any number of accidents could easily damage a desktop machine, but the arcade machine is significantly more robust. Furthermore, repeated public use could quickly wear out standard PC interfaces such as a keyboard. Arcade machine controls are using are heavy duty and designed to survive.

We decided to build the machine out of 18mm Birch Ply. Plywood is a sheet material constructed layers wood veneer that are glued together. Each layer is rotated by up to 90 degrees (a process called cross-graining) which which provides a number of structural benefits. Notably, it reduces possible expansion, shrinkage and warping, providing dimensional stability. Furthermore, the strength of the panel is consistent across all directions. Furthermore, the layered construction of ply can be leveraged for its aesthetic quality. This thickness and construction also allowed us to build the cabinet without any need for an internal sub-frame.

We chose to cut the parts on a CNC router. This allows us to largely avoid significant amounts of carpentry, while ensuring that we get tight, accurate joints. The two sides have a number of rectangular holes cut into them. These allow the other components to slot into them like a 3D puzzle. The plans for this machine were published open source along with the CNC files, and image of which is detailed in figure 2.

Inside the cabinet is a basic windows 10 desktop. Once booted, the task scheduler opens up a web-browser in 'kiosk mode' (making the browser full screen and without border, address bar etc) pointed at our arcade server. All games built for the arcade machine are created to run in-browser, through WebGL or HTML5. Although the games look like they are running naively, they all run in this manner. This provided us with a number of advantages, the main one being that it was easy to deploy new games to the machines (we simply needed to upload them to the server).

2.1. Data Collection

The arcade machines were deployed for 18 months in one of the university campus buildings which is largely occupied by the school of Computer Science, during which time they were in constant use (excluding the Christmas holidays). They were used dur-

Figure 2: *The Research Arcade Machines were designed to be cut by a CNC router*

ing public events, open days, and during the day to day activities of the university. The research game developed was called Adi's maze (which we describe in detail in the next section). In Adi's maze, the player can select either a 1 or a 2-player game, they also have a choice of four characters.

We provided the player with characters designed with a gendered representation. We gave two characters a male name, and two a female name. Furthermore, the female characters were given a bow as a further stereotyped gendered representation. The bow is also a well-known trope from video games, and has been used to identify female characters since the Ms. PacMan game.

In addition, previous research [HJP*15, HJW*16] identified that the colour representation of a character could have an impact on a players behaviour. So we gave one of the male characters, and one of the female characters a stereotypical gendered colour (namely blue and pink respectively), the other two characters were neutrally coloured white. This can be observed in Figure 3.

When a player starts the game, we randomly select one of these four characters as their 'initial character'. This is done randomly in an effort to remove selection bias, and achieve a uniform distribution of initial characters.

When the player started their game we collected the following information:

- **Game Mode:** Is this a One or a Two Player game?
- **Initial Character:** The random character the player was first offered. This is recorded independently for player one and player two.
- **Selected Character:** The character the player chose. This is recorded independently for player one and player two.

3. Adi's Maze

The player's objective in Adi's Maze is to collect the in-game coins, whilst trying to avoid capture from the AI-controlled monsters. The player only successfully completes the level upon collection of all the available coins throughout the in-game level.

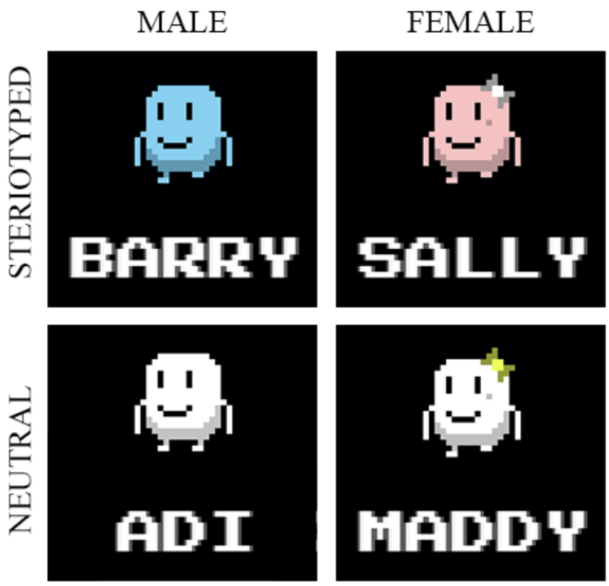

Figure 3: *The four characters of the Adi's Maze game. Barry, Sally, Adi and Maddy.*

3.1. Design

The primary inspiration for Adi's Maze is the *Pacman* series of game, first developed and released by Atari in 1980. Pacman is the epitome of retro arcade games, as a challenging fast-paced puzzle game in which the player collects coins and outruns enemies in a maze. There are several similarities between the two, including the level design, aesthetic and gameplay objectives. Similar to Pacman, Adi's Maze allows the player to move through the maze with 4-directionality; Up, Down, Left and Right. This is achieved by joypad inputs, which are mapped to each of the corresponding directions. It is worth noting that players can only move to empty cells which are 4-directionally adjacent to the in-game avatar.

The player is given a total of three in-game lives, which are decremented upon capture via the AI-driven enemies. In the case of two concurrent players, the life count is decremented upon the successful capture of both players in-game. When the number of lives reaches zero, the player(s) are presented with a 'game over' screen signalling their loss, along with options to retry or exit the game. On the other hand, if the player(s) collect every coin within the maze before the number of lives reaches zero, a 'win' screen is shown to signal their success. At this point, regardless of whether the player wins or loses, the collected in-game data is pushed to the online database.

Adi's Maze was developed using HTML5 and the Phaser.js library for web-based games development. The reason for targetting this particular platform is largely due to the compatibility with the front-end of the arcade machines, which is also web-based. Another reason is the easy integration with a a JSON-based database to store participant data for further analysis.

3.2. Maze Generation

The game uses a binary boolean matrix to represent the world as a tiled-based map, where the value 1 represents an occupied space (a wall) and 0 represents an empty/free space. The use of this system enables the easy creation of a maze system, by calculating the values inside the matrix. These values can then be used to create a graphical representation of the maze in-game.

For each play-through, the maze is procedurally generated via a randomised version of Prim's maze generation algorithm. It is worth noting that maze generation did not occur for each life lost, but instead when the player initialised the game. However, the maze was regenerated if they wished to replay the game. In addition, the PRNG used in maze generation was seeded with a random value prior to generation. This seed was recorded along with every attempt, to easily reconstruct the maze and level conditions. Additional checks were carried out to ensure the maze was entirely navigable using a Minimum Spanning Tree (MST) algorithm. Finally, each maze was altered after generation to include a surrounding border (the top, bottom, left and right corridors). This was done to increase player navigation and reduce the game's difficulty. An example of a generated maze can be seen in Figure 4.

Figure 4: *An example of a randomly generated maze in Adi's Maze.*

3.3. Monster Behaviours

We wanted each monster to have a unique set of behaviours giving the impression of a personality. This was a key feature of PacMan we wished to recreate in Adi's Maze. In pursuit of this, we developed a total of five AI-controlled characters, each with a unique set of behaviours. An image showing the visual representation of these enemies can be found in Figure 5.

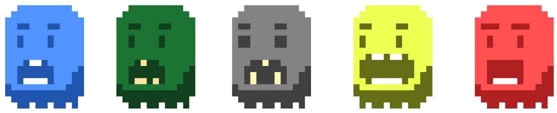

Figure 5: *The visual representation of the AI enemies in Adi's Maze, from left-to-right: Ditsy, Stinky, Squiffy, Chomp and Red.*

For this, we developed four key behaviours: wander, chase, patrol and protect. The first, the 'wander' pattern, is based on a simple pseudo-random direction selection algorithm. More specifically, for each junction in the maze (a cell with one or more adjacent empty cells), a random direction is chosen from the possible directions. The enemy will then traverse the maze in this direction, providing a random movement behaviour. The wander behaviour does not attempt to navigate to a particular location in the maze, nor does it involve chasing the player.

Instead, the 'chase' behaviour embodies this process. The chase behaviour firstly involves visibility testing to check if the player can be chased. Player visibility to the enemy AI is tested via 4-directional line-of-sight testing at each cell traversed. If the player is within the line-of-sight of the enemy, then the position is noted and the enemy will move towards this position. Whilst in line-of-sight, if the player makes a directional change, the chase behaviour will also note this change and recreate the turn at the observed position. This exhibits a 'chasing' behaviour causing the enemy to move and follow the player's actions within the level.

The purpose of the 'patrol' behaviour is to patrol the surrounding border of the map in a clockwise fashion. To do this, the enemy first checks if it is on a border corridor (top, bottom, left or right). If the enemy is on the perimeter of the maze, then the movement directionality is calculated in such a way that circumnavigates the maze perimeter. If however, this is not the case, the enemy will navigate to the closest point on the perimeter from its current location. In a similar sense, the 'protect' behaviour performs the opposite – by biasing movements around the centre of the maze. To do this, the distance between the enemy and the centre of the maze is calculated, and used to weight movements in the direction closest to the centre.

The five enemies all embody some combination of these four behaviours in a type of subsumption architecture. For example, Ditsy only carries out the wander behaviour throughout the game. Similar, Squiffy performs the wander behaviour, however, also chases the player if in their line-of-sight. Stinky, the third enemy, performs a similar combination of the patrol behaviour but additionally the chase behaviour if the player is visible. Chomp however, performs the opposite, using a combination of the protect and chase behaviours. Finally, Red randomly switches between the subsumption architecture of Stinky (patrol & chase) and Ditsy (wander) every 10 to 13 seconds.

3.4. User Interface

When the player initially loads the game, they are firstly presented with a start screen, with three options. The player can navigate the menus throughout the game by using the joysticks and buttons on the arcade machine. A marker is also used to highlight which option is currently in focus. Of the three options presented, the player is prompted to select the number of players (either single player, or two-player co-op), or exit the game. A screenshot of this process can be seen in Figure 6.

Figure 6: *The main start screen of Adi's Maze.*

If the player selects either menu option to play the game, they are then shown another notice explaining the game's controls, along with a note informing them of collection of their in-game data throughout their play. If the player does not consent to this data collection, they are prompted to press the 'Exit' button on the arcade to leave. If however, they wish to play, they are then taken to a character selection screen after pressing the 'Start' button. The character selection screen shows for each player of the game, and is identical in terms of design for both players. If two players are to play the game, two selection screens are shown: one for the first player, and one for the second player immediately afterwards.

The character selection screen shows a visual representation of the character, along with their name. An example of this can be seen in Figure 7. Initially, a random character is selected for both players of the game, and shown in the character selection screen. The player then has the choice to navigate through the range of characters, using the joysticks to move left and right in a cyclic menu. When the player has selected their character, they can then press the 'Start' button to start playing. After this, the game is initialised and started.

Figure 7: *An example showing both character selection screens, with an initial randomly selected character.*

4. Results

Over a 12 month period the game was played a total of 2395 times, with 1314 games being played in single player mode, and 1081 games being played in two player mode. This resulted in a total of 3476 players - however, due to the nature of the installation we can't argue as to how many of these are unique players, and how many are return visitors. However, we do know that certain players made repeat visits due to observations of the installation.

As mentioned in the methodology, the initial character presented to the player was randomised. This random allocation was checked to ensure a uniform distribution before the analysis was conducted, the total number of initial allocations is presented in Figure 8. The Adi character was shown slightly more often, however, not significantly. As such, we can assume that the initial character had no specific bias on the overall selection behaviour.

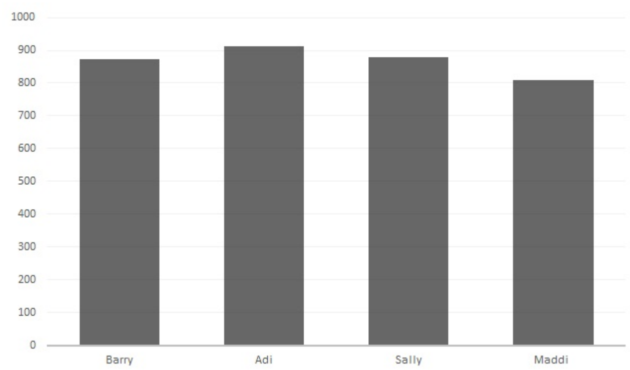

Figure 8: *The number of times each character was presented to the player as an initial selection choice*

4.1. Character Preference

Of the four characters available to the player (Adi, Barry, Maddi, and Sally) the players showed a preference towards the male representations (Barry and Adi) with 2117 choosing to play as a male representation, and 1359 choosing to play as a female representation. Of the four there was a strong preference for Barr, in total, 1208 players selected to play as Barry, by comparison Adi was selected 909 times, Maddi 637 times, and Sally 722 times. This is detailed in Figure 9.

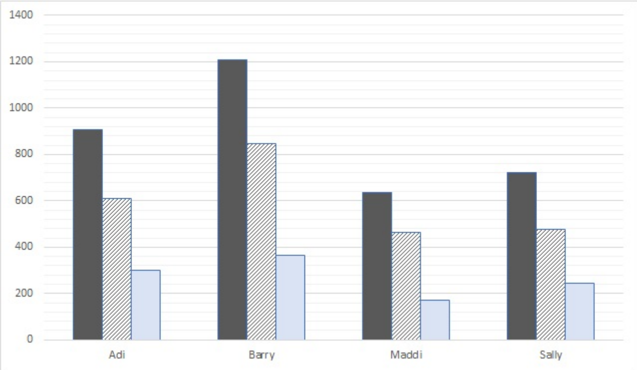

Figure 9: *The number of times each character was selected. For each character, the leftmost column represents the total number of times the character was selected. The middle column represents the number of times Player 1 (both one player and two player games) selected the character, and the right hand column represents the number of times the Player 2 (two player games only)*

There is no difference in the distribution of selections between Player 1 and Player 2. With Barry being the most selected, and Maddi being the least in both one player and two player modes. Notably the the characters that have gendered colouring (Barry and Sally) are both more popular than their neutrally coloured counterparts (Adi and Maddi).

Furthermore, 1930 players chose to play a gender-coloured character, 1546 played a neutrally coloured character.

4.2. Changing Selection

As noted in the methodology, when a player starts (Player 1 and Player 2) they are presented with a randomly selected character from the bank of available characters. Both can choose to play as the same character should they wish, and the start screen makes it obvious that they can (and how to) change their representation. A total of 1469 players chose to change their character representation.

Out of the 1081 One-Player games, just around a quarter (388) chose to change their representation. In 448 of the 1314 two player games, both players changed their character, in 504 one of the players changed their character, and in only 129 games, neither player chose to change their character. This data is interesting, as significantly more games featured players who changed their character when playing in two player mode, suggesting that representation is more important when you are playing with someone else. This is represented in Figure 10.

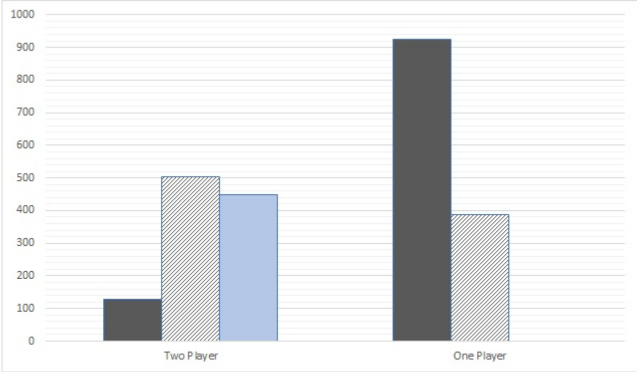

Figure 10: *The number of times players chose to change their character in one player and two player games. In both groups, the left most column represents the games where the player chose not to change their character. The patterned column shows games where one player chose to change their character. In the two player group, the right most column shows the games where both characters changed their representation.*

This could be explained due to the social need for representation when playing with another person. However, this may be a tactical choice by the player. By choosing their own character it may make your character easier to spot when there are other players on the same screen. This would be an interesting area for further research.

4.3. Selection Behaviour

Looking in more detail at the 1469 players who changed their representation provides some additional insights.

Firstly, 1170 changed character to a different gender, 420 changed from a male character to a female, and 750 changed from a female to a male character. As noted in the methodology the arcade machines were placed in a building largely occupied by the School of Computer Science, which has more male than female students. So, it is likely that the players have been biasing towards characters that represent their own gender.

Looking at the gender-coloured vs neutrally coloured characters in selection we also see some differences. Of the players provided with a gender-coloured character, 506 Chose to switch to a neutral coloured character, and of the players provided with a neutral coloured character, 682 switched to select a gender coloured one.

4.4. Two Player Game Selection Behaviour

Finally we wanted to explore the impact of a two player game in greater detail. Firstly we decided to explore whether the gender representation of one player had any correlation to the representation of the second player. In 681 two player games the players chose a mixed representation (one selecting a male and one selecting a female character). Conversely, only 400 games were played when the players both picked a character of the same gender representation.

A very similar trend is seen with the colour of the characters. In

699 games the players picked a mix of gender-coloured, or neutral-coloured characters. Conversely in only 382 games both players picked gender-coloured, or neutral-coloured characters, again suggesting a mix was generally preferred. Notably, only 95 games were played where the players picked the same character.

5. Conclusion

In our introduction we noted that gendered representation continues to be an area of controversy in the development of commercial video games. We note that player behaviour will often change based on how they represent themselves within a game world, and as such there is a need for further research. We identified that most studies in this area work with very small sample groups, in a lab environment. While this provides interesting data, we noted that 'in the wild' studies also provide useful insight, and this perspective has not yet been explored.

We developed a game based on the popular arcade game PacMan. We chose PacMan as it remains popular today, and is still available on many popular modern consoles. The game mechanics are instantly recognisable, giving it a very low barrier to entry from the player. Furthermore, by selecting an old fashioned 2D game, we had the opportunity to develop something clean and polished that looked like a commercial offering.This game (named Adi's Maze) was deployed on two physical arcade machines, and left as an installation for 18 months collecting data. During this time the game was played over two thousand times.

In analysing the data we discovered a number of key trends. The one which is most noteworthy is that players seemed to be more concerned with their in-game representation when playing in 2-player mode. In the single player game, players changed their character around a quarter of the time. However, only 8.3% of the two player games did no one change their character representation. This may suggest that players are more concerned with their representation when they are playing socially with other people. In this mode, players also seemed to bias slightly towards a mix of genders (with one player selecting a male character, and the other selecting a female). Future work is needed to establish the impact of character selection, and gendered representation in social gaming to better explore this trend.

In future work, it would be interesting to validate character perception to observe if character sprites are perceived in-line with our experimentation. Another interesting avenue would be to consider participant behaviour at the character selection screen, such as examining if players examined all characters options before their selection. This could give insight into whether players actively chose a particular character, or passively chose the default selection. Finally, observing similar effects in an alternative methodology (e.g. a smaller-scale mixed-methods approach) could offer some interesting insights.

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