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- An investigation of User Experience in relation to Interactive AI

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This project sought out to investigate whether an Interactive Unit AI System, called the Tactical AI System (TAIS), would influence the user experience of players, measured by the Continuation Desire (CD) framework, in a Tower Defense (TD) inspired game. An experiment based on the CD framework was designed, with traits from classical scientific experimentation, such as hypothesis testing, iterative development and isolation of independent variables. A prototype was designed and implemented iteratively with a series of pre-testers and pilot testers, using the Unity3D game engine. A final test was released on the Int net and 21 participants were gathered successfully through social media, causing an inherent bias. The test participants played through both scenarios in a within subject test, in an attempt to reject the null hypothesis H0 that there are no significant difference in players' continuation desire whether TAIS is included in a game or not. T-tests were used to evaluate the null hypothesis. The results failed to reject the null hypothesis. However, qualitative answers indicate that most participants preferred to play with TAIS, at least on a conceptual level

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Interactive AI in Tower Defense Games

An Investigation of User Experience in relation to Interactive AI

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Abstract

This project sought out to investigate whether an Interactive Unit AI System, called the Tactical AI System (TAIS), would influence the user experience of players, measured by the Continuation Desire (CD) framework, in a Tower Defense (TD) inspired game. An experiment based on the CD framework was designed, with traits from classical scientific experimentation, such as hypothesis testing, iterative development and isolation of independent variables. A prototype was designed and implemented iteratively with a series of pretesters and pilot testers, using the Unity3D game engine. A final test was released on the Internet and 21 participants were gathered successfully through social media, causing an inherent bias. The test participants played through both scenarios in a within subject test. The goal was to reject the null hypothesis H_0 that there are no significant differences in players' continuation desire whether TAIS is included in a game or not. T-tests were used to evaluate the null hypothesis. The results failed to reject the null hypothesis. However, qualitative answers indicate that most participants preferred to play with TAIS, at least on a conceptual level.

Keywords

Artificial intelligence; interactive artificial intelligence; tower defense; real time strategy; games; user experience; continuation desire; usability.

1 Introduction

Artificial Intelligence (AI) systems are receiving increasing attention in the game development industry, since a sophisticated and adaptive AI can help to create an immersive and engaging gaming experience. However, to the knowledge of the authors of this project, only few commercial games have implemented Interactive AI systems, here defined as: a system where the player is able to choose between a finite number of predefined behaviours on Non-Player Characters (NPCs), which then affects their behaviour. Two examples of commercially released games that have implemented an Interactive AI are: the Dragon Age series by BioWare[1] and Final Fantasy XII by Square Enix[2], through its so-called 'Gambit' system[3].

Both the Dragon Age Series and Final Fantasy XII are first or third person role-playing games (RPGs), and the Interactive AI is only applicable to a small number of 'companions'. However, Interactive AI systems could be applied to other game genres, although further research is needed to evaluate whether Interactive AI is actually beneficial to those other genres, such as the Real Time Strategy genre (RTS). In this project, the Tower Defense (TD) genre (a subgenre of RTS) was chosen. In TD games the player(s) defend against waves of incoming opponents (called 'creeps') by buying and placing defensive structures (called 'towers') (Avery, Togelius, Alistar, & van Leeuwen, 2011; Rummell, 2011, p. 1). TD games started as custom modifications to existing games, such as in the hugely successful Warcraft and Starcraft series by Blizzard[4], where a developer-provided 'Map Editor' program allowed players to create their own game concepts (Tong, On, Teo, & Kiring, 2011). Since then, TD games have become popular and, as a result, widely available on the Internet, often in the form of free Flash games.

The authors of this project have not been able to find a single TD game with an Interactive AI system, even though the genre itself facilitates Interactive AI quite effectively. It is easily imaginable that instead of non-moving towers with only one behaviour, movable units with Interactive AI could be designed and implemented, supposedly providing a more positive user experience for players, due to the assumed higher degree of immersion, engagement and control.

2 Adaptive & Complex AI in Tower Defense Games

In the academic community TD games have been used for several years, although mainly as testbeds for advanced AI algorithms, such as Artificial Neural Networks and Genetic Algorithms (Wang, Ng, Niu, & Shiu, 2009; Huo, Shiu, Wang, & Niu, 2009; Tong et al., 2011; Traish & Tulip, 2012), also dynamic and adaptive AI systems have been researched in connection with RTS and TD games (Buro & Furtak, 2004; Ponsen, 2004; Chung, Buro, & Schaeffer, 2005; Ponsen, Muñoz-Avila, Spronck, & Aha, 2006). Additionally, TD games have been researched in regards to optimal placement of towers (Wetzel, Anderson, Kout-

[1] Official Dragon Age by BioWare website: http://www.dragonage.com/.
[2] Official Final Fantasy XII by Square Enix website: http://www.finalfantasyxii.com/.
[3] User-Driven wikipedia with numerous articles on the Gambit system: http://finalfantasy.wikia.com/wiki/Gambits.
[4] Official Blizzard website: http://eu.blizzard.com/en-gb/.

staal, & Gini, 2012; Wetzel, n.d.) and other topics (van Lent, Fisher, & Mancuso, 2004; Straatman & Beij, 2005; Cox, Cairns, Shah, & Carroll, 2012). This project will not touch upon any of these topics, since they already enjoy seeing research elsewhere.

The motivations for researching with a TD game are practically the same as for research in computational intelligence and games in general. TD games provide a relatively simple environment for research testing and affords many different research topics, including procedural content generation, AI, competitiveness or collaboration and game design in general (Avery et al., 2011, p. 4-6). Additionally, the fact that most research teams should be able to implement working TD games (rather than implementing a 'proof of concept' type prototype, which is often the case for prototype games of other genres), means that TD games are quite useful for academic researchers, as also stated by Avery et. al.: "*It is this simplicity [of games in the TD genre] and availability [of willing online testers] that makes TD games a great test bed for Computational Intelligence (CI) research.*" (Avery et al., 2011, p. 1). This project aims to provide a different perspective in relation to AI research in TD games, namely with a focus on the user's perspective in regards to an interactive AI system. Therefore, the main hypothesis is that providing players with an Interactive AI in a TD game will influence the players' user experience, compared to the experience of playing the same game without the Interactive AI.

In this project a definition is given for 'Tactical AI System', or 'TAIS' abbreviated. The system is defined as: "*A system for facilitating units with an interactive artificial intelligence*". Units in TD games are normally defined as towers, but in the case of this project the units are meant to be movable, hence the term 'unit' seems more applicable. Interactive in the sense that the player can actively influence the AI, and thereby the unit's behaviour, by choosing between different predefined behaviours on the selected unit. It should be noted that the player may only influence the AI on his own units, not the opponents' behaviour. Thus, the main and most important requirement for the prototype game in this project is the inclusion of TAIS.

3 Prototype Design & Implementation

In this project it was decided to design and develop a new TD game from the ground up, since this would allow the developers to maintain complete control over the functionality in the game, etc. The prototype was developed in order to be able to execute the designed experiment with a group of test participants, and thereby to test the formulated hypothesis.

3.1 Prototype Design

While designing the Tactical AI System (TAIS) two main aspects were considered: 1) the functionality, or 'logic', i.e. making units behave differently depending on their current tactics, and 2) the interface exposed to the player. TAIS was designed iteratively through a series of small, informal tests, coupled with inspiration from existing commercial games with similar systems. Different versions of TAIS were designed. The TAIS interface was designed with heuristic usability guidelines in mind (Nielsen, 1992; Nielsen & Phillips, 1993; Nielsen, 2005), e.g. the 'visibility of system status' was considered and thus participants were always shown what wave they were in and whether it was a building

or combat phase, and 'accelerators' were implemented as keyboard shortcuts to common tasks, such as sending the next wave by pressing the spacebar key, spawning new units with the 1 to 4 keys and entering the main menu on the Escape key.

The inspirational games, Final Fantasy XII and Dragon Age, both feature a tactical AI system divided into three categories: actions/tactics, targets and conditions. The design of TAIS in this project therefore features a similar division of the overall Tactical AI System into three categories as a starting point. The three categories are:

Tactics Defining the overall behaviour intended and affecting the type of target and when to apply the condition.

Target What unit or enemy to 'apply' the tactic to.

Condition When the tactic is active, e.g. under what conditions the tactic is effective.

Four tactics, five target types and five conditions were defined for the final prototype version, while the very early prototype version in the pre-test had several more options, especially in the tactics category. The reason for the relatively low amount of tactical options in each category in the final prototype was due to the early pre-test showing that it is not beneficial to add a high number of options to the categories in TAIS, as discussed further in 3.2 Early Pre-Test on page 5. The reason for implementing these specific tactics, targets and conditions was a mixture of: 1) looking at the most utilized tactics from the pre-test, 2) asking participants in the pre-test which tactics they would prefer the most, 3) considering what the minimum requirements would be for actually gathering useful data from a final test, and 4) evaluating how many and which options were possible to design and implement in the allocated time for this project.

- Tactics

  Attack Default behaviour, attack the target at will as soon as it enters the perception range.

  Guard Attempt to guard (protect) the target ally unit, and attack any enemy that attacks the target ally unit.

  Assist Attempt to assist (follow) the target ally unit, and attack the same enemy as the target ally unit.

  Stand Guard Attempt to hold the current position and move as little as possible.

- Target Types

  Nearest The nearest ally or enemy unit.

  Strongest The strongest ally or enemy unit.

  Weakest The weakest ally or enemy unit.

  Most Damaged The most damaged ally or enemy unit.

  Least Damaged The least damaged ally or enemy unit.

- Conditions

  Always The tactics set is always active.

  Over 75% HP The tactics set is active if the unit has more than 75% of its health left.

  Over 50% HP Active when the unit has more than 50% health left.

  Over 25% HP When the unit has more than 25% health left.

Less than 25% HP When the unit is close to dying, i.e. less than 25% health left.

There were a few requirements to the interface, mainly that all options should be visible simultaneously. Sub-menus, dropdown-menus and similar, which generally decrease the overview, should be avoided according to usability heuristics. Additionally the currently selected tactic, target and condition should at all times be visible, to follow the 'visible system status' usability guideline. Color coding was identified as a viable option for categorizing who would be affected by the tactic, e.g. offensive tactics against enemies would be red, defensive tactics towards allies would be green and self-tactics (e.g. Stand Ground) would be blue.

In order to make the game a more immersive, multimodal experience a simple sound design was applied. Two pieces of music[5], one for the build- and one for the combat phase. The build phase music was selected because of its relatively low tempo, trying to creating a comfortable and relaxing sound theme for the player, so that they would feel less stressed while they were planning their next move, while the combat phase music was in a higher tempo to create a more suspenseful atmosphere and to let the player know that this was the 'action' phase. Additionally, both pieces of music were selected because of their somewhat medieval-inspired theme. The sound effects for attacking, being hit and dying, were selected also due to their medieval-inspired quality and to give the player more audio feedback cues so that they would have an easier time understanding what was going on in the game[6].

After designing most of the prototype game an early pre-test was deemed necessary to evaluate whether the designed game features were understandable for players.

3.2 Early Pre-Test

An informal, qualitative pre-test was carried out on a very early prototype. The main goal of the pre-test was to get user feedback on the early TAIS implementation, especially the TAIS interface. Additional purposes were to uncover general usability issues, discover technical bugs and define what instructions were needed for players to play the prototype game on their own. The test methods were a mixture of an unstructured interview, bodystorming (brainstorming in an ecological setting), and a 'think-aloud' test.

Participants were asked to play the game without any prior instructions. The participant could then ask questions to the interviewer relating to anything in the game. The participant was also asked specific questions by the interviewer, such as whether he or she noticed certain features, buttons or understood in-game explanations. Meanwhile an observer wrote down field notes. Five players participated in the pre-tests and a range of issues were detected. The main result from the pre-test was that the initial design of TAIS did not provide enough overview (players wanted to see all the tactics, target and condition options simultaneously) or enough instructions, and that the design of the TAIS interface could be better. Additionally it was found that the number of available tactics was too high in the early prototype, causing confusion for players. Finally, one

[5]Both pieces of music were found on: http://www.newgrounds.com/.

[6]All the sound effects were found on the Internet through the website: http://www.freesound.org/.

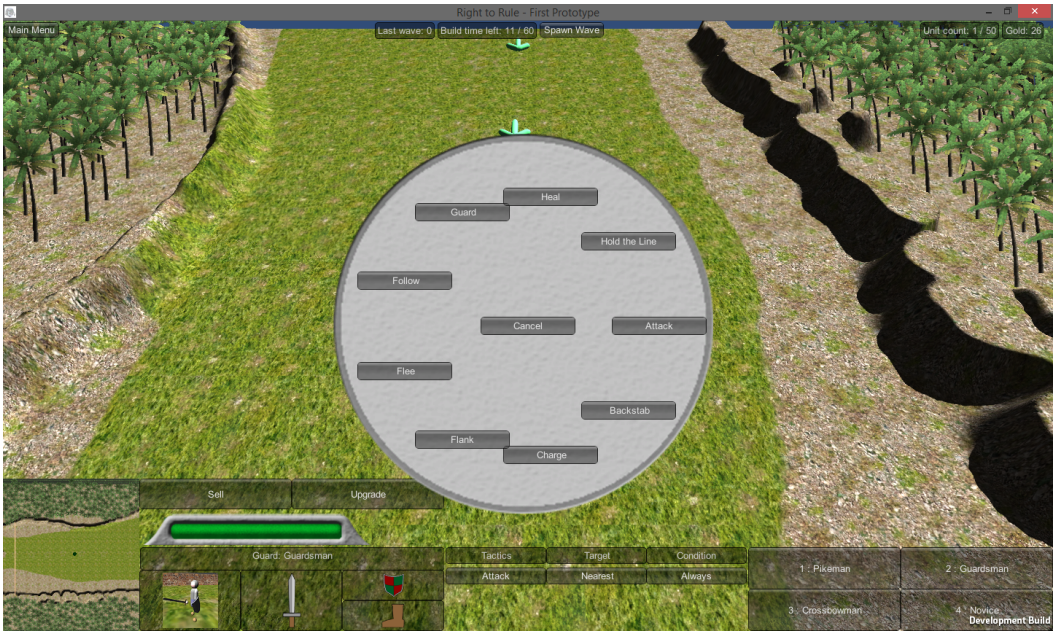

Figure 1 – *The very first prototype version (labelled version 0.0.1) tested in the pre-test. This screenshot shows the 'Tactics' part of the TAIS interface currently showing on the screen.*

participant suggested adding symbols to ease the interpretation of TAIS. A screenshot of the very early prototype can be seen in figure 1 on page 6.

After concluding the pre-test the received feedback was analyzed and categorized in order to evaluate which feedback points needed to be implemented and which points were too complex or time consuming to consider in this project.

3.3 Prototype Implementation

In this project the Unity3D game engine[7] was used to build the prototype game, due to it being available freely, being relatively easy to work with and because the authors of this project had experience with Unity3D. Autodesk Maya[8] was used to create 3D models and animations, while Adobe Photoshop[9] was used to create 2D graphical elements, such as the symbols. These software packages were used mainly due to the authors of this project being familiar with them.

The implementation of TAIS was reduced, due to time constraints, compared to the ideal design explained in the previous section. Ideally it would be possible to have multiple sets consisting of tactics-targets-conditions, since the conditions were meant to control when that particular set was 'active'. However, conditions were completely dropped from the final implementation, since it was not possible to implement more than one tactics set. Thus, since only one tactics set could be chosen, meaning that only one combination of tactics-targets-conditions could be set on each unit at any given time by the player the conditions were rendered useless. Ideally, more tactics sets could be chosen by the play-

[7] Official Unity3D website can be found at: http://www.unity3d.com.
[8] Official Autodesk Maya website at: http://www.autodesk.com/products/autodesk-maya/overview.
[9] Adobe Photoshop website: http://www.photoshop.com/.

ers, e.g. two or three full combinations of tactics-targets-conditions.

The four designed tactics for the final prototype version were discussed before implementing them, as mentioned previously in 3.1 Prototype Design on page 3. From a technical perspective, the assist tactic finds the target's attack target (the enemy that the ally target is currently attacking), and assist in killing that enemy. The guard tactic finds the target's last attacker (the last enemy to attack the ally target), and attempts to 'guard' the ally unit by killing the enemy attacking. Stand Ground means that the unit waits until an enemy reaches its attacking range, before moving and attacking that enemy. The strongest and weakest target types were implemented by calculating a 'unit score' for all units or enemies (within range), by summing up the attributes of the unit or enemy (some of them weighted).

The AI of the units and enemies were implemented simply using Finite State Machines (FSM). A range of states were defined, such as ATTACKING, FLEEING, HEALING, etc. Each state defined its own specific behaviour depending on the unit class. Players could change the current tactic and target through the TAIS interface, although in the non-TAIS scenario all units would simply default to attacking the nearest enemy.

As can be seen in figure 2 on page 8, a range of symbols for TAIS were designed and implemented in the final prototype. The symbols were designed using simple common sense principles and in an attempt to mimic game industry standards, such as two crossed swords for attack and a shield for guarding. The less standard symbols, such as the target symbols for most and least damaged, were designed in an attempt to depict the meaning of the target type as precisely as possible. To check that the symbols were understandable enough, a few test participants were asked to interpret their meaning. Their feedback indicated that the symbols were adequate for this project. The final TAIS interface was visually closer to that of the inspirational games, compared to the early implementation seen in figure 1 on page 6.

4 Experimental Design

In order to evaluate whether the Tactical AI System (TAIS) is beneficial for the player experience, the TD game prototype was used as a testbed.

The user experience in relation to games has been tested in many different ways, which consequently has spawned a multitude of player experience-related 'keywords', which researchers use to base their experimental design on. Three examples of some of the most popular keywords are: Immersion, Engagement, and Flow (McMahan, 2003; Brown & Cairns, 2004; Ermi & Mäyrä, 2007; Jennett et al., 2008; Csikszentmihalyi, 1991; Chen, 2007), although there are many others. However, there are disadvantages associated with a narrow focus on a specific keyword, e.g. a player's immersion or flow may be broken by simple distractors, such as technical bugs or even external distractors such as noises, smells or light changes. Another issue arises when using an invasive method for testing, e.g. pausing the game and asking questions, which is almost sure to break the player's immersion, engagement and flow (Schoenau-Fog, 2011a, p. 2).

Therefore, in this project the experimental design is based on the so-called 'Continuation Desire' (CD) framework (Schoenau-

Figure 2 – *The final implementation of the Tactical Artificial Intelligence System (TAIS) showing tactics and targets, from the final prototype version (labelled version 0.0.2). Conditions were removed from the final implementation due to time constraints.*

Fog, 2011b, 2011a; Schoenau-Fog, Birke, & Reng, 2012; Schønau-Fog & Bjørner, 2012; Schoenau-Fog, Lim, & Soto-Sanfiel, 2013). According to its author, CD is a fundamental concept that is not affected significantly by distractors or interruptions: "*(...) it can be argued that since the willingness to continue will remain, even if a user is interrupted, it would be possible to investigate his or her desire to continue during run time by pausing the experience and administering a self-report survey.*" (Schoenau-Fog, 2011a, p. 2). The author designed CD to be used for testing the 'evolution' of a player's CD while playing a game, by interrupting at certain 'events' or fixed time steps during gameplay, and possibly comparing with previous iterations (Schoenau-Fog et al., 2012, p. 2). However, if TAIS was tested using only a single scenario, there would presumably be a large bias caused by the learning effect. Players would be more likely to rate the later stages of the game with a higher CD due to the players learning the game, but not specifically because of the TAIS implementation. However, it could also be the other way around that players are likely to rate later stages with a lower CD, due to fatigue or the fact that nothing new is presented in the prototype game. Therefore, in this project the intention was to compare two different scenarios, one with TAIS and one without.

In 'classical' scientific experimental design a baseline scenario is compared to one or more treatment scenario(s), with a focus on reducing the amount of independent variables as much as possible, and using null hypotheses to evaluate whether there were significant differences between the scenarios (Rubin & Chisnell, 2008, pp. 22-26). Thus, this project mixes the CD framework with classic traits from scientific experimental design, in order to finally evaluate the effect of a single independent variable, the presence of TAIS, by comparing the players' reported CD from a scenario without

Interruptions	Questions
Before starting the game	Demographics (e.g. gender, age, frequency and amount of playing, favourite game/genre) Q1: Please indicate the extent to which you agree or disagree with this sentence: "I want to start the game". (7 point Likert Scale: Strongly disagree (-3) to Strongly agree (+3)) (Level of continuation desire) Q2: What makes you want/not want to start? (Reasons)
During run time	Q3: Please indicate the extent to which you agree or disagree with this sentence: "I want to continue playing". (Response options as in Q1) (Level of continuation desire) Q4: What makes you want/not want to continue? (Reasons)
After finishing playing the game	Q5: Please indicate the extent to which you agree or disagree with this sentence: "I want to try again". (Response options as in Q1) (Level of continuation desire) Q6: What makes you want/not want to try again? (Reasons)

Table 1 – *Basic Game ESQ (Schoenau-Fog et al., 2012, p. 2) - the only thing added in this project is completely open-ended 'comments' questions in all three interruption phases with the question: "Any other comments? (Optional)".*

TAIS to a scenario with TAIS. Therefore, to avoid bias caused by individual preferences, within subject design was chosen. This required randomization of the order of scenarios to minimize the bias caused by learning effect.

The questions utilized for the in-game questionnaire were almost exactly as defined in the CD framework (Schoenau-Fog et al., 2012, p. 2), with the only addition being open ended 'comments' questions, as can be seen in table 1 on page 9. In the prototype game participants were interrupted with questions before starting, at the beginning of the build phases in waves 3, 6 and 9 (last wave was wave 10) and finally when losing or winning. In order to avoid critical game- or test related issues a few pilot tests should always be carried out before releasing the final prototype test. The pilot testing phase should continue till no new notable information is discovered.

5 Discussion

After concluding most of the implementation, 3 pilot tests were carried out in an iterative way, meaning that feedback from each pilot test was considered and the important points were implemented before continuing on with the next pilot tester. This was done to avoid critical technical issues, serious usability issues and in order to fine-tune the instructions. After the pilot tests stopped revealing new critical issues, the final prototype was released and distributed through a website[10] and the website was promoted through social media. The sampling method mostly re-

[10]The website used for distributing the prototype (which all test participants had to go to) was: http://www.alphastagestudios.com/prototype (as of December 2013).

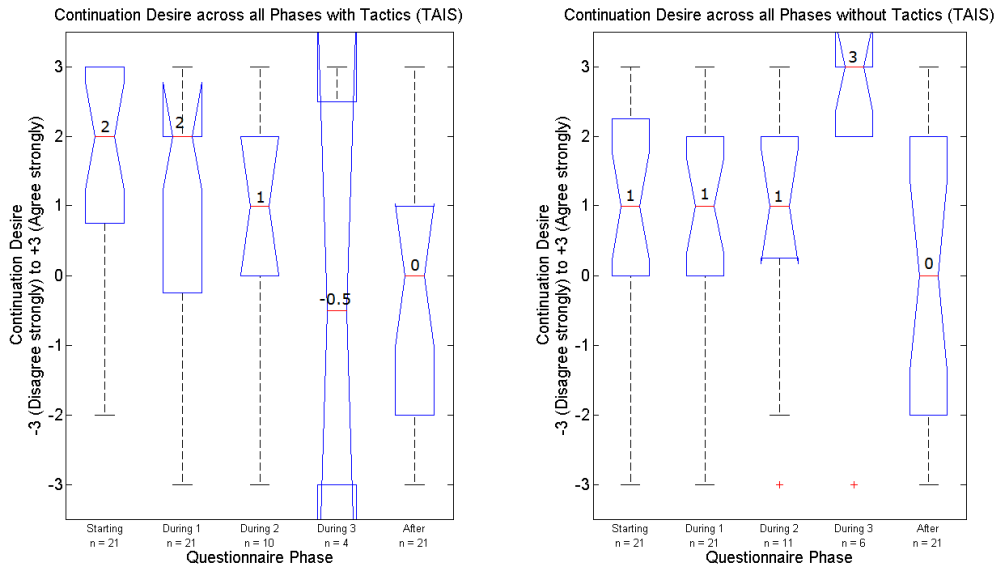

Figure 3 – *All questionnaire phases plotted in the two box plots. The left plot is the continuation desire results from the scenario with tactics (TAIS), while the right plot has the equivalent results from the scenario without tactics. The t-tests accompanying these box plots indicate that there are no significant differences between the two scenarios when looking at the individual questionnaire phases.*

sembles a non-probability convenience sampling method, although some snowballing effect could have occurred, as some participants were found through mouth-to-mouth exposure.

5.1 Results

The main purpose of the final test, as mentioned previously, was to uncover whether there were statistically significant differences between the two scenarios, i.e. whether there was a significant effect on players' continuation desire caused by the presence of the Tactical AI System (TAIS). One main null hypothesis was formulated, H_0: "*There are no significant differences between two scenarios where one includes an implementation of TAIS and the other does not*". Therefore, a paired samples Student's T-tests was executed to evaluate whether there were significant differences between the two scenarios. T-tests were chosen due to the presence of a single independent variable and two scenarios in the experimental design. All phases of the questionnaire were compared individually between the two scenarios, and also composited tests (where all phases were combined) were calculated.

The box plots in figure 3 on page 10 shows the 'evolution' of continuation desire in the two scenarios. The left plot shows the results from the scenario with tactics, and the right plot shows the results without tactics. It should be noted that the results from the third during phase, and to some extent the second during phase as well, are unreliable due to the very low number of participants who reached the last two during phases. This is caused by the fact

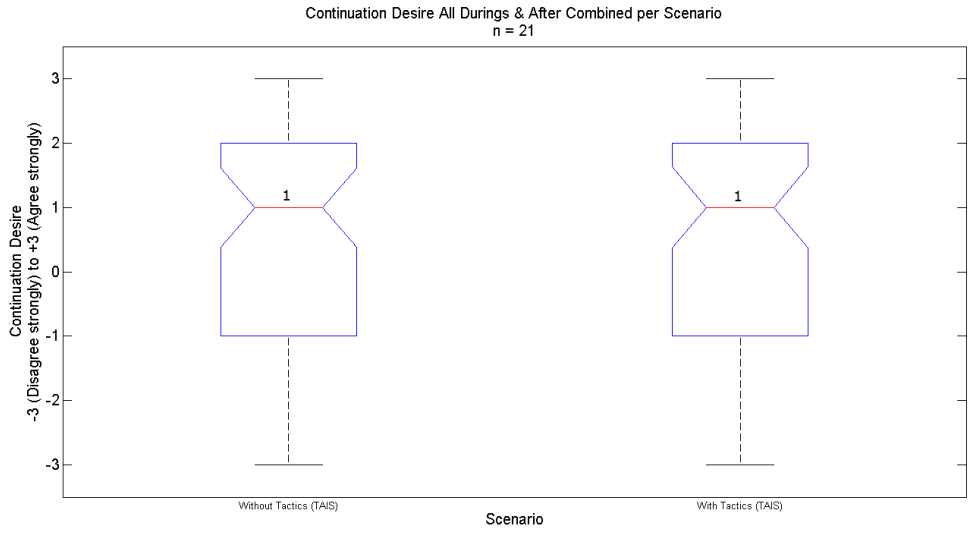

Figure 4 – *This box plot shows composited results from the test, where all the three during phases and the after phase were combined and compared between the two scenarios. As the box plots indicate, and the t-test confirmed, there were no significant differences between the two scenarios.*

that most participants lost the game before reaching the third during phase, and only half of the participants managed to reach the second during phase. All participants answered the 'after' part, since it was displayed both when they quit the game or when they won or lost. As the box plots and executed t-tests indicate, it was not possible to identify any significant differences between the two scenarios, thus the null hypothesis H_0 that there are no statistically significant differences caused by the presence of TAIS failed to be rejected at the 5% confidence level.

As mentioned previously a composited t-test was also executed ($p = 0.7846, tstat = -0.2748, df = 49$), where results from all the individual questionnaire phases were combined and compared between the two scenarios. The results can be seen in the box plot in figure 4 on page 11. The box plots show that there were no such statistically significant differences, this was also confirmed by the t-test. Thus this test also failed to reject the null hypothesis H_0 at the 5% confidence level. Please note that the starting desire was not included in this box plot or the accompanying t-test, because the starting desire does not say anything about whether participants preferred that scenario, since they would not have played it yet.

After completing both scenarios all test participants were asked explicitly which scenario they preferred. This would indicate on a subjective, qualitative level if participants generally preferred with or without tactics on a more conceptual level. Their answers can be seen in the pie chart in figure 5 on page 13. A majority, above 60%, chose the scenario with tactics as their preferred scenario. Although these results are not statistically significant, they do qualitatively indicate that most of the participants at least conceptually preferred to play with TAIS.

When looking at the purely qualitative responses, i.e. the reasons and comments that participants provided, it seems that most participants who mentioned TAIS also preferred it. One participant wrote in his 'after' comments, after playing his second scenario without TAIS: "*Though the tactics round seems to work awfully it still create more control of the game, creating a desire to perfect the strategy more than without, as only the position of the units have little effect on the outcome..*", a point about control that another participant also highlighted in his responses in the 'after' comments after playing his second scenario without TAIS: "*I prefer tactics as I get very annoyed when I lose whilst there are 4 enemies with low HP.*", which indicates that the participant liked the target selection, because it enabled him to set his units to focus a specific target (the one with the lowest health points).

Other participants seemed to experience the game as being easier, when provided with TAIS, as one participant noted in his 'after' comments, after playing his second scenario with TAIS: "*With tactics seemed to work better - I didn't feel like I got the same difficulty spikes like I did in the first scenario.*". Some participants seemed to indicate that the 'promise' of TAIS later in their test made them continue on with the test, as one participant wrote in his starting reasons before playing his second scenario with TAIS: "*would love to see the tactics phase*" or as another participant put it while playing the scenario with TAIS, in the second during phase as a response to the reasons question: "*I still want to explore different strategies*".

Some participants however also had negative critique on TAIS, with one participant writing in his second scenario with TAIS, in the first during: "*It seems like you can only win by doing one exact tactic. One of each unit and then upgrade. I don't like that idea, it's locking the gameplay forcing the player NOT to play his own game.*" and as another participant wrote as his first during comments in his second scenario with TAIS: "*it is a bit confusing, to play with strategy mode, because there is many choices and you don't have time enough to think over.*". It should be noted that it was definitely possible to complete the game using different strategies both with and without TAIS, and instructions to TAIS were available through the in-game main menu.

5.2 Open Issues & Challenges

There were a range of issues with the test; some known beforehand, but either too complex to implement or too minor to be prioritized, and some discovered after the release of the final prototype game. These issues ranged from technical issues, features that were not possible to implement in the allocated time, and general issues with understanding the two-scenario test form. There is also a bias to the dataset gathered, due to the gathering method being based on social media. This means that most participants were family, friends or acquaintances of the authors of this project, which naturally influences their choices and answers in the questionnaire.

The most challenging issue with the testing method seemed to be the presence of two scenarios, which many test participants did not understand or chose to ignore. The results showed that it took 34 participants in total to get 21 participants to perform the test correctly, meaning that they played through both scenarios in one session (with-

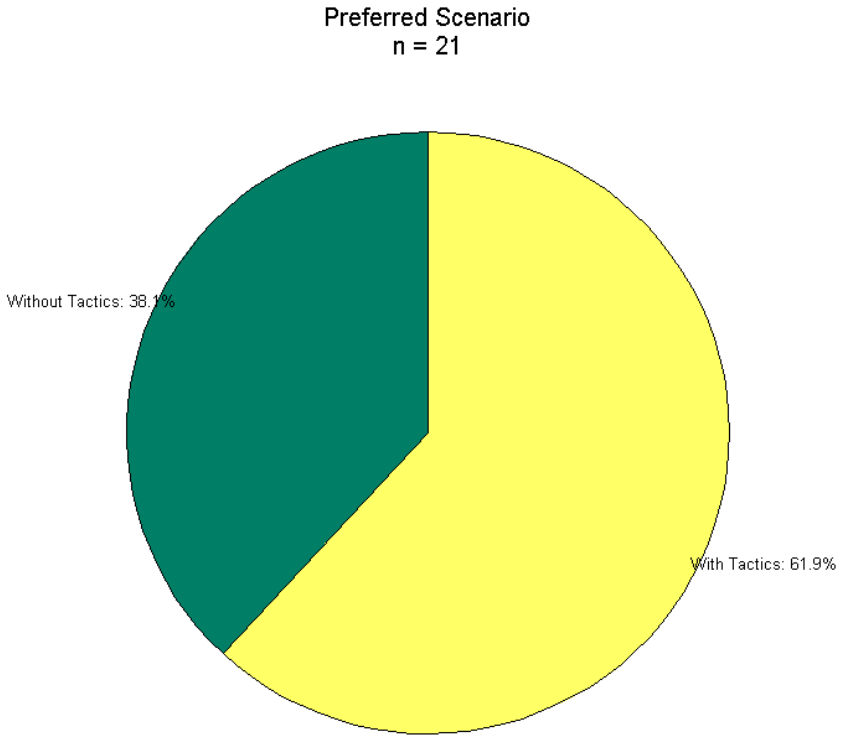

Figure 5 – *This pie chart shows the test participants' answers to the final question asked, after completing both scenarios, namely "which scenario did you prefer?". The results qualitatively indicate that a majority selected the scenario with tactics as their preferred scenario.*

out exiting the game). This leaves 13 participants who either played once or exited the game and then played again - in both cases the Continuation Desire (CD) results had to be discarded, since those participants only tried one scenario and thereby their CD results would bias the dataset due to individual preferences. This happened in spite of in-game instructions before and between the scenarios explaining the two-scenario test format, in addition to these instructions also being present on the prototype website. The game actually restarted itself after the first scenario, prompted instructions and asked the player to continue. It could be stipulated that these 13 unsuccessful participants did not read the instructions telling them to play through both scenarios or simply ignored them. Thus, perhaps auditory (speech) feedback should have complemented the textual feedback, or perhaps the textual feedback could have been even more clear, e.g. set in a larger type-font or been repeated more than once.

There were a few features that several participants requested, where some of them had been considered already, but simply were too complex to implement in the given time. Some examples are that several participants seemed to struggle with moving their units (RTS-style right click to

move), expecting to be able to drag-move units (holding the left mouse button down while moving it). The issues with moving units can be seen in comments from the results such as (given in 'After' comments): "*When I want to move a soldier sometimes I just rotate the view and he doesn't go where I want him to. Also moving the soldiers takes too much time compared to how much time I am given to do that.*". The drag-moving feature had already been considered and discussed as an alternate solution.

Some participants complained that it was 'boring' in the combat phase, having nothing to do other than spectate. As one participant wrote in the first during phase: "*way tooooo slow gameplay, during gameplay I have no interaction and can only watch?*". Naturally, this was also a known fact, as it is a common core game mechanic of games in the Tower Defense genre.

Several participants requested more assets in the game - more units, different enemies, more sounds, etc., as indicated by responses such as (given in 'After' as reasons): "*Now I have beat the game and learned how to do it, so there isn't a reason to play again unless I got more units and fought more advanced enemies (like ogres or a dragon). But if I play again I just have to use the same units and tactics, and there's no reason to play if I know I will win.*" and (given in during 3 as reasons for wanting to continue): "*I want the final boss + wave ...*", which indicates that the participant expected a final boss, a feature not present in the prototype game.

Finally, a few participants noted that the unit or enemy AI behaved unpredictably or even 'stupidly', sometimes being 'stuck in each other' for an example, although this did not seem to be an issue isolated to one scenario. As one participant put it when answering the starting desire reasons in his second scenario: "*I want to see if I can make the AI clutter up less, if I can set the tactics myself. (...)*" or as another noted in his 'after' phase: "*(...) my units started getting stuck in each other and wouldn't move forward (...)*". These issues most likely affected the participants' continuation desire choices, as general game issues usually affects the continuation desire negatively.

6 Conclusion

The conclusion of this project was based solely on the final test, although both the quantitative and qualitative data was considered. It should however be noted that the quantitative data provides a more scientifically valid result, compared to the qualitative data, since the qualitative data can be biased by individual differences between test participants.

The first and foremost purpose of the final test was to examine whether the formulated null hypothesis H_0 could be rejected. A series of T-tests were used to evaluate whether there were statistically significant differences in players' continuation desire between the two scenarios. These tests revealed that the null hypothesis H_0 failed to be rejected. This was the case when looking at each questionnaire phase individually, as well as when looking at the composited results.

Thereby this project effectively fails to conclude whether the inclusion of TAIS in the prototype game has any effect on the players' continuation desire. Even so, the qualitative data, including the explicit preference question, carefully indicates that most participants liked TAIS at least on a conceptual level, compared to playing

the same game without TAIS. Some participants liked the added degree of control that TAIS adds, while some participants felt that the game was easier with TAIS. However, some participants also noted that they needed more time to examine the different tactical options, while others felt that the amount of tactical options was too little, not providing enough freedom for the player. It could be stipulated that in a future prototype version, where most of the many critique points from the final test have been implemented, the results might more clearly indicate a favouring of TAIS. It could also be the case that a larger population sample size would have provided different results.

7 Future Perspectives

A future iteration of this project has many potential areas to focus on, if an attempt was to be made at achieving statistically significant results. In these future perspectives only the most noteworthy points are mentioned.

Since it seems that a majority of the test participants in the final test did not utilize the in-game provided instructions, based on indications found in the qualitative data, another form of training (learning the game) should be considered. Video tutorials as a supplement to the textual instructions might be more desirable for some participants. An actual in-game tutorial guiding the player through the different aspects of the game, and introducing the TAIS in a gradual way (e.g. one tactic at a time) would presumably be the most efficient way for most participants to learn the game, due to in-game tutorials being more immersive than reading text or watching videos. Therefore a future version of this project should consider designing and implementing an in-game tutorial in a 'training round' before the 'real' game begins. The efficiency of different types of instructions actually warrants further academic testing.

Another perspective is that the AI in general lacked sophistication and often seemed 'dumb' in the eyes of the test participants. Therefore, a future iteration should focus on improving the AI in general, both for units and enemies. A more intelligently behaving AI would presumably annoy less participants and possibly influence their opinion in favour of TAIS. This could be done technically by moving from finite state machines to behavioural trees and introducing an 'action queue' for units and enemies. As already mentioned earlier, especially the way that units are moved by players in this project was undesirable for some participants, which therefore warrants a more focused unit movement test in a future project.

Finally, and perhaps most importantly, a probability sampling method and a larger sample size would be necessary to actually reach any solid conclusions, rather than just indications. Therefore, any future version of this project should attempt to reach more test participants. Lastly, it should be considered if another testing methodology - instead of Continuation Desire - could provide equally valid results, especially if it could be done without an intrusive method, e.g. without asking participants questions while playing, since many participants simply dislike being interrupted while playing by the questionnaire.

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