**An Initial Understanding of How Game Users Explore Virtual Environments**

**Abstract**

Spatial exploration is a core component of play in a rich and diverse range of modern video games. However, there is insufficient research into understanding spatial exploration in order to design better gameplay experiences. In this paper, we investigate the gameplay behaviors of 25 players across three types of exploration games by collecting in-game data, think-aloud data, questionnaire responses and post-game interview data. We use thematic analysis to analyze the data and map out four player exploration archetypes (PEAs): *Wanderers*, *Seers*, *Pathers* and *Targeters*. Then, a lens analysis is conducted to investigate the behavioral traits of these four archetypes to highlight different aspects of exploration. Gender, weekly gameplay time and real-life navigation abilities are the three factors which have been found to significantly impact the archetypes. Finally, the relationships between the participants’ preferences to the terrain features and their archetypes are also investigated. These results match the participants’ traits.

**Keywords**: Game user research; gamer typology; spatial exploration; think aloud; thematic analysis.

**1. Introduction**

Exploration is a common discovery-based activity that players perform in modern video games. In some games, like Journey[[1]](#footnote-1), the game can be simply about exploration. In other games, ranging from adventure games to first-person shooter (FPS) games, exploration is a core game mechanism that is essential for players to advance in the game. The most common type of exploration in games is spatial exploration, which includes:

* mapping environments
* collecting bonus items
* discovering locations, landmarks and specific game items

Mapping game environments is a design manifestation of the spatial exploration mechanics in games, where players have to reveal unknown environments by travelling on them (e.g., uncovering the fog-of-war in a real-time strategy (RTS) game). In these scenarios, players normally explore the game world to cumulatively build up their knowledge of the map, which makes it easier for them to navigate between locations to find game objects of interest. Often, exploration also adds to the variety of gameplay, e.g., rewarding players when they uncover hidden trap doors to secret levels, or finding secret game items with special abilities.

Although spatial exploration is essential to most digital gameplay, human behaviors in performing this type of exploration tasks are insufficiently understood. Investigating how human players explore virtual game environments can contribute to better game design, e.g., how game objects are hidden and distributed around the map as well as the design of believable non-player characters (NPCs) that use human-like exploration techniques. Prior work has devised several player types, which have been shown to effectively reflect the behavior features of different groups of players [[1](#_ENREF_1), [2](#_ENREF_2)]. Although the player typology derivations and findings are highly valuable to game design, they are lacking in terms of their consideration of player exploration behaviors. In general, human exploration behavior in virtual worlds has not been adequately studied.

The purpose of this research is to generate new knowledge in understanding how players explore game worlds. Our research focuses on analyzing behavior patterns and discovering new classifications of players based on exploration. Our main research questions are:

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**Q2**. Can we classify and extract types of exploration behaviors?

**Q3**. What factors affect exploration behaviors?

In our study, we organize game-playing experiments, in which think aloud, interview and in-game play records help to capture players’ behaviors and the corresponding self-descriptions of players. To identify players’ types in exploration, we use an inductive research method that yields a rich data set from which to extract commonalities and patterns. Instead of starting from pre-determined personality typologies [[3](#_ENREF_3)] or following up the methods of neurobiology research [[4](#_ENREF_4)] , we investigate players’ behaviors directly. We extract patterns across the datasets collected within and after players’ gameplay sessions. Thematic analysis provides a theoretically-flexible analysis method, which is suitable for tasks such as identifying themes from the users’ experiences. Using thematic analysis, we analyze data gathered from twenty-five participants’ exploration experiences when playing three different exploration games: the *pure exploration game*, the *killing game* and the *searching game*, built with StarCraft: Brood War[[2]](#footnote-2).

This research into the design of game environments can directly benefit two types of applications. The first type is the development of autonomous exploration agents. As Angigoni [[5](#_ENREF_5)] has shown, several applications, ranging from classical map building to search and patrolling, fall within the scope of the broad exploration problem. Correspondingly, the *pure exploration game* simulates typical instances of classical map building applications; the *searching game* simulates the search applications; and the *killing game* simulates patrolling applications.

The second type of application is spatial exploration mechanics in digital games. These three exploration scenarios represent a broad range of exploration mechanics in games, such as mapping game environments, collecting items and discovering bonus chances. Understanding players’ behaviors in the three games promotes the development of human-like exploration agents as well as the design of exploration mechanics in video games because the three games represent the key scenarios of both applications.

In the next section, we review the related work on player classification and human navigation. The description of experiments, accompanied by thematic analysis and classification of gameplay instances, is presented in the Method section. The Results section outlines archetypes, instance classification, impact factors of archetypes and preferences in relation to environment features. Finally, we present the knowledge that has been discovered from the results in the Discussion, Limitation and Conclusion sections.

**2. Related Work**

*2.1 Gamer topology*

The broad field of research in classifying human behaviors has drawn much attention from game user researchers, as understanding player personalities assists in designing better player experiences. Reviewing the research on human personalities, which is embedded in game research, researchers have used type-based models, such as the Myers-Briggs Type Indicator (MBTI) [[6](#_ENREF_6)], and more recently trait-based models, such as the Five Factor Model (FFM) [[3](#_ENREF_3)]. Type-based models assume that each personality is mutually exclusive. Myers and McCauley [[6](#_ENREF_6)] developed MBTI, using four bipolar axes to distinguish personality types in four dimensions. In each bipolar axis, two opposite psychological types are marked on the ends. The four groups of dimensions are: extraversion and introversion, sensing and intuition, thinking and feeling, and judging and perceiving. Different permutations of these dimensions classify individuals into one of sixteen types. On the other hand, trait-based models emphasize measuring traits, which can be defined as patterns of individual preferences in behavior, thought and emotion[[7](#_ENREF_7)]. The Five Factor Model [[8](#_ENREF_8)] includes five personality traits - *openness*, *conscientiousness*, *extraversion*, *agreeableness*, and *neuroticism*. The FFM is currently a leading model in personality psychology [[3](#_ENREF_3)]. Correlations between players’ gameplay patterns and the Five Factor Model have been an active research area [[9-14](#_ENREF_9)].

In player behavior research focusing on video games, Bartle [[1](#_ENREF_1)] presented a qualitative gamer-personality model with four types (*Achiever*, *Explorer*, *Socializer*, and *Killer*) whilst Yee [[15](#_ENREF_15)] revealed five motivations (*Achievement*, *Relationship*, *Immersion*, *Escapism* and *Manipulation*). Both Bartle and Yee’s models, however, are limited owing to their narrow focus on massively multiplayer games. This has led to the development of a relatively recent model, BrainHex [[16](#_ENREF_16)] that presents seven gamer types (*Achievers*, *Conquerors*, *Daredevils*, *Masterminds*, *Seekers*, *Socializers* and *Survivors*). Founded on neurobiological theories and validated with large number of participants, the BrainHex model attempts to provide a more generalizable typological model across game genres.

Video game user research has focused on classifying players based on their preferences but has not sufficiently accounted for the actual behaviors of players when performing game specific tasks. This paper attempts to focus on and underscore this neglected element. We begin by focusing on spatial exploration, an indispensable component for most digital games.

*2.2 Human exploration and way-finding in the real-world*

Understanding how humans explore and navigate in the real world is a common research topic. Knowledge construction is deemed to be an important aspect for exploration[[17-20](#_ENREF_17)]. In particular, the differences between how people construct navigational knowledge in the form of cognitive maps [[21](#_ENREF_21), [22](#_ENREF_22)] remains an active research area. Lynch [[21](#_ENREF_21)] proposed that the cognitive map for navigation is composed of five components: paths, edges, districts, nodes and landmarks.

The number of choice points, visual access, degree of architectural differentiation and other factors have been identified as affecting how these cognitive maps are created and the ease with which people are able to navigate in new environments [[23-27](#_ENREF_23)]. Although these real-life navigational studies can provide some insight into how people explore virtual environments, our research scopes out a new area for study that investigates the topic in a novel way.

As state-of-art simulation techniques enable virtual environments to be sufficiently similar to real environments, this allows for simulation based experiments and testing of navigational memory. Vaisagh Viswanathan et. al. [[28](#_ENREF_28)] have explored the role of memory in real-life way-finding by investigating user behaviors in their self-developed indoor virtual environment. By contrast, in this paper, we create our environments in Starcraft, a widely played commercial game (as opposed to the task-based virtual environments above) and investigate player in-game exploration behaviors rather than real-life behaviors.

*2.3 Human exploration and way-finding in virtual environments*

Developing analysis tools to investigate players’ behaviors by analyzing gameplay data is a popular way to understand player experience and inform game design in general [[29-31](#_ENREF_29)]. ArcGIS[[3]](#footnote-3) (produced by *Esri Corp.*) was used by Drachen and Canossa [[29](#_ENREF_29)] in a video game context. It enabled researchers to visualize game metrics via multiple facets of data related to spatial environments. Chittaro et al. [[30](#_ENREF_30)] developed a visualization tool named VU-flow, which presents visual components that allow users to observe and extract behavioral patterns from both individuals as well as populations. In another work, Moura et al. [[31](#_ENREF_31)] developed a visualization system that is capable of visualizing players’ actions in a consecutive and active way and this is used to analyze telemetry data, extract gameplay patterns and identify design issues. It also provides protocols to visualize the time spent in each area of the game maps, identify active regions, and extract players’ navigation paths. Although these visualization tools provide a general solution for spatial analysis, they can only serve as a complementary means of understanding human navigation and way-finding behaviors because experimental subjects vary from scene to scene.

In terms of human navigation, Moura and Bartram [[32](#_ENREF_32)] investigated how players responded to different visual way-finding cues in several scenarios: maze, climbing room, waterfall room and exit room, based on a 3D action-adventure game – the Lost Island. They found that proper feedback guidance was strongly needed for navigation and players were very sensitive about missing cues. Another study about developing a visual system for enhancing players’ navigation experience was conducted by Milan et al.[[33](#_ENREF_33)], in which the relationship between visual load, camera and motion attributes was investigated. Moura and Seif El-Nasr [[34](#_ENREF_34)] summarized a set of design techniques that are currently used in the navigation systems of 3D action-adventure games which include three aspects: navigation aids, level design choices affecting navigation and game mechanics related to navigation. Biggs et al. [[35](#_ENREF_35)] also attempted to understand players’ construction and comprehension of small-scale environment patterns in procedural environment generation applications. Their results showed that players who interacted with structured patterns tended to be goal-oriented and preferred to construct cognitive maps. Using a different approach, Badler and Canossa [[36](#_ENREF_36)] designed experiments in a Tropical Island demo to analyze players’ camera movement and gaze displacement. They found that players’ gameplay gaze behaviors resembled those of real-life activities.

In relation to player personalities, much work has been done to analyze exploration behaviors within the framework of FFM. Lankveld et al. [[10](#_ENREF_10), [11](#_ENREF_11)] presented links to preferences for the exploration map with the activity facet of the extraversion type. Yee et al. [[12](#_ENREF_12)] concluded that non-combat exploration and exploration with curiosity behaviors could be mapped to the agreeableness and openness personality traits respectively. Canossa et al. [[13](#_ENREF_13)] introduced the players’ behavior of interacting with doors as a variable into game metrics when conducting a correlation analysis between exploration behaviors and the big five personalities, while Spronck et al. [[14](#_ENREF_14)] located triggers in optional areas of the experimental environments to test the openness of exploration behaviors. Although it appears that current research has discovered several interesting connections between exploration behaviors and players’ personalities, behavioral patterns of exploration remain to be explicitly identified.

 While the exploration of human navigation and way-finding in real-life has been a subject of interest to researchers for some time, it is still, as the above literature review makes manifest, an open area in virtual environments. Research on the spatial-exploration-behaviors of players in video games is not sufficient. Identifying patterns can help us to better understand players’ exploration behaviors. In this paper, we, thereby, extract archetypes from exploration-focused behaviors and compare the traits of these archetypes to the different facets.

**3. Materials and methods**

We captured and analyzed data from participants playing three custom-designed, time-restricted games created on the StarCraft: BroodWar platform. Participants were instructed to perform concurrent think-aloud activities, and verbalize what they were looking at, doing and thinking during the gameplay. The think-aloud data was combined with a video-cued retrospective interview post gameplay to obtain further insights into the participants’ experiences and thought processes. We recorded all participants’ think-aloud and interview videos, and then used NVivo[[4]](#footnote-4) to transcribe and analyze the transcripts. To help contextualize our results, we will briefly describe the StarCraft platform and games we developed.

*3.1 The StarCraft Game*

We chose StarCraft: Brood War as our test-bed due to its well established API and malleability. StarCraft is also representative of the popular RTS game genre. The StarCraft AI Competition, first hosted by the AIIDE Conference in 2010 [[37](#_ENREF_37)], has become a notable test-bed for evaluation of AI agents in academia [[38](#_ENREF_38)].

The goal in a typical RTS game is to destroy the opponents’ bases (structural real estate on the map) so as to conquer the entire play map. Players build and maneuver units to gather resources and go into combat with opposing units, in order to build more base structures and gain control of map regions. StarCraft’s premise is based on fictional interstellar wars where players are required to select a race among three options (Protoss, Terrans, and Zerg) when starting a game. Each race provides the player with different units and strategic options.

The RTS game genre involves players making decisions for both high-level strategies and low-level tactical actions. It generally requires players to have good situational awareness in order to play well. The efficient uncovering of map information and effective use of this information is absolutely crucial to the success of players, which makes spatial exploration a core component of gameplay. Spatial exploration also enables the discovery and management of resources, which are used to either manufacture more units, including production units and combat units, or advanced techniques to enhance combat and general abilities. These resources are usually strategically placed on the maps, but are randomly generated for each new game instance.

The StarCraft provides a 2.5D top-down view as well as an interface that includes a mini-map (bottom-left of Fig. 1) and terrain visuals (the main working window in Fig. 1). This type of interface design can be seen in both early-generations of RTS games and it has been adopted by modern successors as well. It shows an overall view of the game state which allows players to maneuver units at a strategic level. This feature meets our requirement for investigating human-exploration strategies. Moreover, the RTS game genre is the primary application genre which this research attempts to expand upon.

*3.2 Test Game Environments*

To collect detailed representative data about exploration activities, we developed three different game environments: the *pure exploration game*, the *killing game* and the *searching game*. In all the game environments, maps are covered by the fog-of-war – an artificial “fog” that blackens out territory that no units have travelled over yet (Fig. 1).

[Insert Fig. 1 here]

Information about what the terrain looks like, and what items are under the fog is initially hidden from the players. Participants need to explore the environment by navigating a unit with a limited perception range through the unknown areas. These areas are then revealed to players when “perceived” by the game unit as it travels through them. Each game requires players to finish a specific task within a limited time frame.

* In the *pure exploration game*, players are required to explore the whole map as fast as possible within three minutes.
* In the *killing game*, there are 41 opponent space construction vehicles (SCVs) - a basic StarCraft unit - located on the map. Players are required to hunt 20 of the 41 SCVs within five minutes.
* In the *searching game*, participants are required to find the opponent’s base within four minutes. In order to provide them with some guidance in terms of finding the opponent’s base, participants are told that the opponent’s base is located near a mineral site, and that the opponent’s supply depots (basic StarCraft buildings) are distributed around the base area.

For the purposes of the experiment, only a small subset of the StarCraft game mechanics was used. There were no enemies fighting back, no resources had to be gathered by the player and the player did not have to build any units or factories. These simplifications were necessary in order to provide an exploration focus for the experiment. For the *searching* and *pure exploration* games, attacking actions were disabled. For the *killing game*, an on-screen counter showing the number of enemy units the player had to find and kill was added. For all three games, an on-screen timer was placed on the screen to indicate the remaining time left to complete the given task.

The underlying feature of the three games is the common activity of exploring terrain. The *pure exploration game* wasexclusively designed to evaluate the players’ strategies and behaviors in relation to revealing an unknown map. While the *killing game* and the *searching game* work on the basis of exploration, players are encouraged to plan optimal routes to discover more items and to focus on where a specific item is located in the killing and searching game respectively. Even though the ability to explore environments well is central to playing these two games effectively, the extended elements as well as the primary goals for these two games are essentially different. Accordingly, these diverse features can result in different player behaviors.

*3.3 Participants*

Participants were recruited via undergraduate and postgraduate university mailing lists, public social networks and public areas in the university. In total, twenty-five participants (7 females, 18 males) signed up. After consenting to the study, participants filled an online pre-play survey to collect basic demographics like age, gender, gaming interests, gaming habits, and how familiar they were with RTS games and StarCraft in particular. Participants were aged between 20 and 44 (M = 29, SD = 6.01). Except for two participants, most have rich video game experiences. Eleven participants usually play strategy games, ten participants play first-person shooter games, seven participants play sports games, seven participants play role-playing games, four participants play simulation games, seven participants play puzzle games and three participants play social games. Of the twenty-five participants, ten indicated that they were familiar with RTS games, three claimed that they were experienced StarCraft players and four claimed that they could recognize some StarCraft maps. One participant indicated that he plays games for more than 20 hours per week, four participants between 10 to 20 hours, one participant between 5 to 10 hours, seven participants between 1 to 5 hours and twelve participants less than 1 hour per week. The demographic information and gameplay experiences of participants are shown in the Table 1.

[Insert Table 1 here]

*3.4 Procedure*

Participants were scheduled to attend the experiment individually at different times. After a participant completed the survey, the experimenter displayed a game demo to illustrate how to control and navigate game units. The participant was invited to practice control and navigation skills in the demo environment until he/she indicated that they were familiar with the gameplay. Then, the experimenter explained the targets that need to be achieved in each game. After that, participants started to play the games. The order of the three games was randomized for each participant to avoid order effects and counter bias that might otherwise be introduced to the results with a fixed order.

During gameplay, participants were asked to perform the concurrent think-aloud. They were encouraged to describe what strategies they used to play the game and what their instant strategic thoughts and preferences were, and to explain their behaviors to the experimenter. When a participant kept silent for a long time, and if the intent of his / her actions was not apparent to the experimenter, prompting was performed to encourage the participant to verbalize continuously. Short questions like “What are you doing now?”, “What is your strategy at the moment?” were used. After each game was completed, participants filled out a post-game questionnaire, in which they indicated their gameplay behavioral preferences and tendencies. After they filled out the post-game questionnaire, a post-game interview was conducted while watching a video replay of the game they had just completed. Here, participants had an additional opportunity to explain what they were thinking and feeling during gameplay, in case they missed out any important thoughts during the think-aloud. For both the think-aloud and interview, video data was recorded by two cameras: one facing the participant, and the other facing the screen where the actual gameplay or the video replay was running. The data collection of actual in-game behaviors as well as verbal descriptions from the think-aloud and interview aims to answer the research question **Q1**.

*3.5 Thematic Analysis*

Thematic analysis is an established tool of qualitative research [[39](#_ENREF_39)]. Its common approaches are pinpointing, examining and recording themes (patterns) across data sets [[40](#_ENREF_40)]. Themes are defined as patterns within data, which highlight descriptions of common phenomenon that are normally associated with a specific research question [[41](#_ENREF_41)]. In this paper, thematic analysis was used to process both the verbalized think-aloud and interview data. Due to its flexibility in exploring data from a deep and structural perspective, thematic analysis helped us to extract strategic and preference patterns of exploration behaviors as well as structural traits. The results of thematic analysis contributed to answer the **Q2**. Grounded in the typical thematic analysis process [[40](#_ENREF_40)], we applied a four-phase inductive method as follows.

*3.5.1 Develop Proposal Codes and Themes*

In our study, data analysis began at the stage of collecting verbalized think-aloud and interview data, in which the data analyzer observed the entire process of data collection. In our experiment, the analyzer was the same person as the experimenter, participating as they did in the experimental design and conducting the data interpretation and thematic analysis. This arrangement allowed the analyzer to be fully immersed in the data by being involved in the data collection process as well. This, in turn, led to a better understanding of participants’ experiences. It also helped to keep the verbal and transcribed data consistent. We, nonetheless, acknowledge the potential for greater experimental bias. To minimize the possibility of bias, the analyzer was required to meticulously record the data analyzing process, including detailed approaches for handling each part of the data as well as emergent issues and solutions worked out in the regular meetings with the rest of the research team (i.e., the co-authors).

Similar responses were highlighted and noted by the analyzer while the experiments were conducted. After all the participants completed the experiments, the analyzer summarized his notes according to topics related to strategic preferences, reasoning processes and characteristics. These structured topics were used as initial draft themes for the data analysis.

*3.5.2 Data Preparation and Familiarization with Data*

For this phase, we collected verbal data within the think-aloud and interview, and the video records of game replay. The game replay and verbal data was recorded synchronously. This enabled the analyzer to review the audios of either the think-aloud or interview and the game replay videos synchronously, which provided a succinct way of recovering what happened during the experiments. Raw data from audio resources was transcribed into textual files to meet the requirements of marking and coding in the later stages of analysis. The verbal data was transcribed into textual form, along with game situation descriptions, participant behaviors and comments in Nvivo. The analyzer, who was present through all game-play recording, was completely familiar with the data owing to repeated reading in an immersive way.

*3.5.3 Code the Data and Extract Themes*

In this phase, we extracted features from the data into codes. A code refers to “the most basic segment, or element, of the raw data or information that can be assessed in a meaningful way regarding the phenomenon” [[42](#_ENREF_42)]. The coding process mainly focused on the textual data that described the act of exploration. The gameplay videos were used as supplementary content for better understanding the transcripts.

The process of extracting themes began by constructing a hierarchical preliminary theme structure on the basis of the initial theme drafts generated in the first phase. The analyzer encoded the data and categorized them into the relevant potential themes. If there was no corresponding theme, a new theme was created and inserted into the structure. The process continued until all the data was processed.

*3.5.4 Reviewing and Re-Constructing Themes*

This phase started with the analyzer reviewing the themes from the previous phase. It involved the refinement, redefinition, and reorganization of the themes. For example, some of the themes that lacked sufficient support from the data were pruned.

Following this, the themes were reorganized into common aspects of spatial exploration. This resulted in four main themes:

* strategy, which represents what strategies people make in playing the games;
* reasoning, or how they reason about situations and options;
* conception, which represents what spatial conceptions about the environments are mapped in their minds; and
* hesitation, referring to a reluctance to move when encountering certain instances of the game.

Each theme encapsulated common behavioral aspects that participants exhibited in the three exploration games. When reviewing the data sets grouped into these four themes, we further discovered that players had clearly distinguishable preferences. Within each theme, we then embarked on an iterative code-mapping process to re-organize the codes into different groups according to these preferences.

For example, within the theme reasoning, a code-map was generated, structured around sub-themes about what types of options: unexplored areas, paths, targets, and other factors players appear to have considered in making choices (Fig. 2). We merged similar themes and re-structured the code-maps by focusing on the objectives of the types of reasoning participants used, to give us the purpose of participants’ reasoning. The resulting sub-themes of reasoning are: paths, terrain layouts, targets and unexplored areas. The themes that were subject to these sub-themes were more detailed objectives, specific goals and ways of reasoning (Fig. 3).

[Insert Fig. 2 here]

[Insert Fig. 3 here]

Based on the map in Fig. 3, we re-categorized the codes via the ways people do reasoning, in order to distinguish behavior patterns among the themes. In this step, the preferences of methods (e.g. the theme “Special Items” means that people prefer to reason about the options by using their judgment about special items that they are tracking) were converted to be direct subtopics of reasoning, while other factors were grouped within different behavior preferences. We then generated a preference-centered code-map of reasoning (Fig. 4).

[Insert Fig. 4 here]

To get a better idea of our process, we can focus on the re-location of single atomic behavior, e.g. “Barrier – consistency”. This behavior reflects players’ reasoning that barriers exist along the direction from where these barriers are discovered, to the unknown areas they have not visited yet. Based on this, the corresponding behavior, “Following barriers”, comes next, as players explore the barrier limits. This behavior refers to players’ reasoning about terrain and the action of selecting a path for their next move. This behavior is, therefore, organized under the sub-branch “Terrain” of the main branch “Paths” (Fig. 2).

In the Fig. 3, the map was reorganized in an objective-centered fashion, where each sub-branch of “Paths” represented a group of decision factors when players make path-selection decisions. An example of an amendment in this step is the detachment of “Barrier-consistency” from “Terrain” and re-attachment to “Limited View”, as the “Barrier-consistency” which can be regarded as a kind of view limitation. At the end of the process, the map structure facilitates the articulation of player archetypes on the reasoning theme. The main branches are grouped with the consideration preferences (Fig. 4). For example, “Barrier-consistency”, along with the branch “Limited view”, are re-structured. Then, “Barrier-consistency” is renamed as “Following Barriers”, because it represents the decision making and situation-analyzing process better.

By using the same typological methodology, we re-organized the code-maps of the other three themes: strategy, conception and hesitation. Similar sub-themes are found across code-maps. For example, the sub-theme “limited view” exists in the strategy, reasoning and hesitation code-maps.
These sub-themes are identified as players’ preferences within the four aspects of behavior. By grouping these sub-themes across the four maps into four groups, we define four archetypes: *Wanderers*, *Seers*, *Pathers* and *Targeters*, which are comprehensive enough to identify participants’ common behavior patterns. Sub-themes and codes within these four aspects are then regrouped into these four archetype-themes. The characteristics of these archetypes and their performances on the aspects are discussed in the next section.

*3.6 Classification of Gameplay* *Instances*

The archetypes that emerged above depict behavioral traits in various exploration scenarios. The analysis in this phase aims to answer the **Q3**. We categorized all the gameplay instances into the four archetypes to investigate the distribution of the four behavioral types. For reducing bias and concreting the results of classification, we conducted the analysis with two independent coders and assessed the inter-coder reliability (ICR) in the process.

The definitions and traits of the four archetypes were generated via the thematic analysis process described above. The archetypes were discussed and reviewed in group meetings that involved the two coders, in order to generate a set of classification criteria. Then, a set of instances were randomly selected from the entire instance data set as the sample. It contained the gameplay instances of 7 out of 25 participants. The two coders then classified the sample instances independently.

After independent classification was complete, the overall coding agreement and Kappa coefficient [[43](#_ENREF_43)] were calculated to assess the ICR within the sample set. Consequently, the two coders collectively discussed the results with a third researcher to re-assess the classification criteria accordingly. In fact, since all three people agreed on the initial rules, they were directly applied for classification. The overall agreement rating and the Kappa coefficient for this first wave of classification were 85.83% and 0.807 respectively, which provided enough confidence to continue the coding on the basis of existing rules [[44](#_ENREF_44)]. In the next step, coders coded the rest of the 18 participants’ data. Finally, the ICR was assessed over the entire data set by calculating the two coefficients.

**4. Results**

***4.1. Player Exploration Archetypes***

Our findings can basically be derived from the descriptions and characteristics of the four PEAs (*Wanderers*, *Seers*, *Pathers* and *Targeters*) that were generated and evaluated from the procedure described in the prior section.

*4.1.1. Wanderers*

Regardless of the game type, *Wanderers* move around without a definite destination or purpose. *Wanderers* do not have an explicit understanding of their location nor do they have specific plans on how to reach their next destination. They concentrate exclusively on getting around local map regions and discovering items that fall within the immediate cone of the exploration unit’s vision. *Wanderers* prefer local landmarks and terrains, and they use them as references to navigate. For example, a typical *Wanderer*’s preference: “I think I just followed the edge [the terrain boundary that divides the map into regions]. But I didn’t do it on purpose.” (P21 – Interview – *Pure exploration game*) This shows that he had no set targets and that he had minimal awareness of map features.

*4.1.2. Seers*

*Seers* aim to aggressively expand their visibility span when exploring unknown environments. Being able to see as much information as possible is the main priority for *Seers*. They seek to reveal as much of the unexplored map in the quickest time possible. For example, we observed a *Seer* (P11) employing a clockwise circular walking strategy to explore environments efficiently. His actions were supported by his interview statements (*Pure exploration game*): “I referred to the map [overview map] at that point. I headed to the top of the screen. I was on top of this map. I used the clockwise to explore all the area. And I just followed the map down, to the major unexplored area.” He had an explicit global view of the environment as well as eagerness to expand his visual field efficiently.

*4.1.3. Pathers*

The *Pather* archetype is characterized by the elaborately structured cognitive maps of environments. Terrain features, such as high land, low land, ramp, bridges etc., are highlighted, perceived, slotted and grouped by *Pathers*. *Pathers* will categorize a map into known-pattern classes by analyzing its appearance and reasoning about its functional features. Although in most cases the view of the entire environment is not available for players, *Pathers* consistently attempt to keep track of highlighted map features in order to cumulatively construct patterns which are then classified based on their prior map knowledge. An example of a *Pather*’s response is: “At this point, I was confused by the map, because I realized there was a layer. But, I forgot. I completely forgot where the way was.” (P21 – Interview – *Killing game*) When asked by the experimenter on what the ‘layer’ referred to, the participant answered, “The high land. At the point, I realized that this high land was somehow kind of a bridge [linking] to different areas. So I needed to climb, maybe, up and down to find a way out [from areas to the bridge].” This shows that she was trying hard to construct a structured-map representation in her mind.

*4.1.4. Targeters*

The *Targeter* archetype is objective-oriented towards terrain features. Their behaviors appear to have specific targets underpinned by clear tactical plans. *Targeters* seek landmarks, items and any other identified objects that can serve as hints of target locations, such as resources and opponent locations. They keep predicting the locations of these targets, and verifying their predictions. They then adjust their plans with each new discovery. For example, a *Targeter* (P20 – Interview – *Searching game*) said: “I just realized that I was getting close to [the base]. Then I thought it was in the corner, to be honest. Then I thought [that I have] to go and check that corner. I thought [it] may be there, maybe in the small corner that I can’t see. That’s why I explored it and, OH NO, it was not there. Then I went back. Here, I couldn’t believe that I was wrong.” The participant’s disappointment shows her level of confidence about her prediction. When asked by the experimenter to elaborate, she also mentioned: “[The base should be] exactly between these two [mineral sites]. Now, yeah, I began to find [it]. Then I saw this [supply depot]. I thought, OK, it could be something around this area [pointing to the middle black area of the map]. And then I saw a path there.” It appeared that she was keeping track of hints, as well as analyzing them constantly, in order to locate the opponent’s base.

*4.2.* ***Behavioral Aspects of Archetypes***

Within the next section, we describe how the behaviors of the four archetypes differ in terms of the four behavioral aspects: strategy, reasoning, conception and hesitation. For each aspect, the behaviors of each archetype are described. It should be noted that not all the archetypes have corresponding behaviors for all the aspects, which means that for some of the aspects below, not every archetype is described underneath. For example, there is no description of *Targeters* on the strategy aspect, because *Targeters’* strategy behaviors are not explicitly identified according to the data set.

*4.2.1. Strategy*

Different archetypes express their strategies differently based on their preferences.

*Wanderers* do not possess any systematic strategies. At the early stages of exploration, a *Wanderer* is more likely to choose a random direction to move forward. Their typical thought processes are “I have no idea” (P5 – Think aloud – *Pure exploration game*) and “I was just exploring. I had no preferences” (P18 – Interview – *Killing game*). Subsequently, tracking terrain features, e.g., boundaries, is a common type of behavior. A *Wanderer* (P2 – Interview – *Killing game*) described his exploration strategy as: “I don’t know where to go, because I don’t know how to find a path. And there is no way.”

*Seers* keep a global view of the environment. Their general strategies are normally direction-oriented, which include an explicit sequence of exploration to cover different sections of the map. A *Seer* (P4 – Interview – *Killing game*) described his strategy as, “I found [realize] the overview map. I found I was on the top [side of the map]. So I wanted to go down [side of the map] to search another place.” Additionally, this sole focus on map uncovering is also a strategic priority for *Seers* when considering strategies in the *killing game* and the *searching game*, where uncovering unknown terrain is not the main task. For instance, a *Seer* (P11 – Interview – *Searching game*) said, “I continued [using] my clockwise pattern to cover the most areas.”

*Pathers* take advantage of the structure in maps. They normally define enclosing areas where they have already explored, and prefer to uncover a region completely before they move to explore another area. For example, when a *Pather* was asked why he went a certain direction, he replied “Because I thought if I go down [side to the area], I don’t have to like go back.” (P19 – Interview – *Pure exploration game*). Another behavior identified was that they are actively looking for terrain connections among different parts of maps, e.g., “I just want to search a connection between this part and another part.” (P2 – Think aloud – *Pure exploration game*)

*4.2.2. Reasoning*

During the process of exploration, players reasoned about unexplored areas, paths and targets based on what they have already discovered. Different archetypes approach this differently.

*Wanderers* normally choose where to go within the limited local view of the map based on random guesses. For example, we observed a participant who navigated his unit towards the path to the right side of the map. When asked why he didn’t go to the path that leads downwards, he said, “I didn’t see the overview [map] clearly. So I turned right.” (P17 – Interview – *Searching game*)

*Seers* prefer navigational options that can result in larger visible regions. For example, a *Seer* participant explained his choices as, “There is also much area to explore. So I move down [side of the map] for efficiency. So I start going south [down side of the map]. There is no more area to the east [right side of the map].” (P11 – Interview – *Killing game*)

*Pathers* keep a structured representation of the map and a clear prioritized sequence of where to go in strategic order. For example, we observed a *Pather* participant choosing a certain path, as opposed to an alternative path, to an area which she had partially uncovered. When asked about her reasoning, she said, “Because I saw it [the area] from the other side. I couldn’t access it. So I go to that [area] first, clean that area.” (P19 – Interview – *Pure exploration game*)

*Targeters* reason in a way that is consistent with their objective-oriented preferences, i.e., finding key objects of interest such as the opponent’s base. Their reasoning process is anchored on the accumulation of hints from map features in order to predict locations of targets within unexplored areas. For example, when asked about the reasoning on why a *Targeter* participant chose to search in the high platform (which led him to find the opponent base eventually), he replied, “Because, at that point, I think that base is really close. The first time I saw that one ... At the first time I saw this building [supply depot], and after a few seconds I saw another one, I think it’s because these buildings are around the enemy [opponent] base, so I think maybe it’s in the middle. So I go up.” (P13 - Interview – *Searching game*)

*4.2.3. Conception*

Conception here refers to how a player constructs a cognitive representation of the game map, which also varies among different archetypes.

*Seers* apply a direction-based approach in structuring the cognitive map, e.g., segregating a map into the top-left, top-right, bottom-left and bottom-right parts. An example of this type of segregation can be seen in a *Seer* participant’s thought process: “My strategy is just to walk from left [side of the map], and to the right [side of the map]. And up [side of the map] and from right [side of the map] to left [side of the map].”  (P25 – Interview – *Pure exploration game*)

*Pathers* cumulatively maintain a structured cognitive map based on each new acquired knowledge of the environment. They normally have a pre-conceived notion of the layout of the environment, and cumulatively construct the cognitive map by incorporating the gradually acquired spatial knowledge. Topological-map-like structures normally exist in *Pathers*’ minds. For instance, a participant (P3) who preferred to use computer science terminologies (depth-first search and breadth-first search) to describe his exploration behaviors, described his initial strategy in the *killing game* as such (Interview): “I need to search in details, which means I can’t leave any black patches. So, I just go depth-first search. And then, I followed the left edge [the terrain boundary that divides the map into regions] and keep going”. In the *searching game*, he employed both the depth-first search and breath-first search techniques to position the enemy base. He explained (Interview), “I saw a bridge first, so I just go through it, and follow the edge … Actually, this was kind of depth-first search.” When he discovered an enemy cue, he said: “I could see the landmark, which was the oxygen supply [supply depot]. So I thought I should start the breadth-first search now.”

*4.2.4. Hesitation*

A common behavior observed is travelling back and forth in explored areas. The reasons, however, are highly varied, due to diverse situations. We define and classify these kind of behaviors as hesitation. Different archetypes are driven by different motivations to perform hesitations.

*Wanderers* hesitate for two reasons: a lack of specific strategies and unfamiliarity with environments. The combination of these two reasons is especially apparent in the *killing game*. “Why did you keep on moving forward and backward within the areas you have explored?” asked the experimenter. “Because I am sure that I have been here at the first time, and I regarded the fly thing as an enemy [opponent unit]. But I was wrong. I think I didn’t have a CLEAR VISION of the map. I didn’t have some theories about how to explore the new enemies [opponent units]. So, I just moved back and forward.” the participant (P2 – Interview – *Killing game*) said.

*Pathers*’ hesitation behaviors stem from their hesitations in ordering the sequence of visiting points. For instance, one participant (P16 – Interview – *Pure exploration game*) explained his hesitant movements as follows: “I didn’t take the other view - the right side view. I missed one connecting path, so I return there. So I thought maybe if I come back to the same place. Then I would find a way to go to the right [side of the map]. Then I went to up [side of the map] again, I can’t find way to right. I spent some time near here.” When we look at the game replay, we found that he had explored the left part of the map, and was attempting to find a connection to explore the right side.

The *Targeters*’ hesitation in exploring environments with behaviors of walking back and forth is caused by their goal of tracking objects. A typical example is a participant (P20 – Interview – *Searching game*) who gave up moving on his current path and returned to explore repeatedly. The experimenter asked, “Why did you go back?” and the answer was, “Because previously there wasn’t a mineral site nor a lot of places, but, when I saw this one [supply depot], I changed my mind. Because there were more buildings.”

*4.3. Archetypes in Different Instances*

The consensus classification between the two coders is shown in Table 2. With 25 participants, there were 75 gameplay instances in total. The two coders attained consensus categorization in 69 out of the 75 instances. In the *searching game* most players (59% of instances) tend to exhibit the traits of the *Targeter*. In the *killing game*, players were roughly evenly distributed in the *Targeter* (43%) and *Seer* (39%) archetypes respectively. In the *Pure exploration game*, it was interesting that no players exhibited the *Targeter* archetype. In the *Searching game*, most players exhibited the *Targeter* (79%), with a few exhibiting the Seer (14%) archetype.

[Insert Table 2 here]

The classification results in Table 2 produced satisfactory reliability. The reliability measurement consists of an overall agreement rating of 90.82% and a Kappa coefficient of 0.892, based on our inter-coder assessment across the entire data set.

*4.4. Exploration types & demographic types*

*4.4.1. Gender*

Different genders of players express rather different archetypes across the three games, except for the *Targeter* archetype, which we classified a significant portion of both male (34%, n = 17) and female (32%, n = 6) participants as. It is consistent with the prior observation that the *Targeter* archetype represents the majority of overall players across the games. Meanwhile, the *Seer* (36% of male instances, n = 18) and *Wanderer* (37% of the female instances, n = 7) archetypes were the dominant archetypes for males and females respectively (Fig. 5.a).

In Table 1, we can see that six of the seven female participants played games for less than one hour per week, and one of them played games for ten to twenty hours per week. This presents a possibility that low gameplay proficiency may have an effect on the results for analyzing the gender factor. The population of female players (one person P7) who comparatively played lots of hours per week is too small to analyze. In Fig. 5.b, hence, the archetype distribution is compared across genders with same level of gameplay time by eliminating instances where the gameplay hours are more than one. Interestingly, the *Seer* (33% of male instances, n = 5) and *Wanderer* (44% of the female instances, n = 7) archetypes still dominate for male and female groups respectively (Fig. 5.b).

[Insert Fig. 5 here]

*4.4.2. Gameplay hours*

We compared the proportion of participants for each archetype based on the number of hours played per week (Fig. 6). The most glaring observation is that 91% of participants who play games for less than one hour per week are *Wanderers*, which shows that being unfamiliar with gameplay forges *Wanderers* (Fig. 6). This is consistent with the notion that *Wanderers* possess the least “gamer-savvy” attributes, i.e., they are the least strategic and do not give deep thought to the exploration task, a game feature which is central to many modern video games.

We also compared the proportion of participants across archetypes for each category of weekly gameplay hours. Here we observe that 50% of participants who spend 1-5 hours per week on playing games are *Seers*, while 63% of those who spend more than 5 hours are *Targeters* (Fig. 7). This, again, is consistent with the fact that more avid gamers (who spend more time each week) tend to exhibit more elaborate behaviors (i.e., those characterized by *Seers* and *Targeters*) that involve deeper analysis for their resulting actions. It is also interesting to note that the *Pather* archetype lends itself well to more avid gamers, but it is exhibited to a lesser extent in our study.

[Insert Fig. 6 here]

[Insert Fig. 7 here]

*4.4.3 Real-life Navigation Abilities*

Within the pre-game questionnaires, we employed three Likert scale questions to evaluate people’s navigation experience in real-life. They are:

1. I keep a clear egocentric distance and direction of my home in my mind, every time I leave home;
2. I am easily disoriented in an unfamiliar environment; and
3. I have a good spatial memory of places, where I have been to.

These questions serve to evaluate the three key aspects of spatial navigation abilities: distance estimation [[45-47](#_ENREF_45)], spatial orientation [[48](#_ENREF_48), [49](#_ENREF_49)] and spatial memory [[50](#_ENREF_50)]. Previous research has focused on developing evaluation scales to test these abilities respectively. Instead of combining them into a comprehensive version, we evaluated participants’ navigation abilities via the three questions in the pre-play questionnaire, which helps participants to concentrate on game playing sessions without too many distractions. The summarized scores of the three questions are shown in Table 3:

[Insert Table 3 here]

It can be seen that the participants who exhibit the *Wanderer* archetype have the poorest real-life navigation abilities (M = 9.91, SD = 1.76), while participants who exhibit the *Targeter* archetype have the best real-life navigation abilities (M = 11.17, SD = 2.55). This might imply that, other than gameplay experience affecting their behaviors in exploration, real-life navigation abilities might also play a part in explaining the behaviors participants exhibit, e.g., poorer real-life navigation relates well to more non-systematical exploration behaviors typical of the *Wanderer* archetype. In one example, a *Wanderer* (P22 – Interview – *Pure exploration game*), who marked 10 in the real-life navigation ability testing, ignored a bridge, which was explicitly shown in her main view. She explained the reason why she ignored it as: “Maybe I thought that’s the same bridge, the one that I found in the beginning.”

*4.5. Preferences for Different Terrain Features*

In the post-game questionnaire, participants were also evaluated on their preferences to seek and follow the four types of environmental features present in the game: (1) open space; (2) edges such as walls, obstacles, cliffs and riversides; (3) connections such as connecting paths, bridges and narrow ramps; and (4) landmarks, such as buildings, creatures and other special items. Their responses are summarized. The means and standard deviations are calculated and listed in the Table 4:

[Insert Table 4 here]

From Table 4, it can be seen that *Wanderers* have the strongest preference for connections (M =3.73, SD = 0.72). *Pathers* have the strongest preference for edges (M = 4.04, SD = 0.82). *Targeters* have strong preferences for both open spaces (M = 3.65, SD = 0.88) and landmarks (M = 3.54, SD = 1.09). *Seers* have strong preferences for both open spaces (M = 3.67, SD = 1.15) and connections (M = 3.76, SD = 0.78).

The strongest preferences of each archetype were all consistent with the think-aloud responses of participants classified into that archetype, e.g., for the *Pather* archetype, P15 (Think aloud – *Pure exploration game*), whose preference value to edges is 5, said “I suspect that there was a big ocean there. I am gonna check this. Try to find way to here. There might be a lake here. I suggest it's a lake.” This provides additional confidence that these are the behavioral tendencies distinguishable between the different archetypes we have uncovered in this paper.

**5. Discussion**

*5.1. Mapping with General Gamer Types*

Even though the four archetypes we discovered were based on our unique study environments aimed at investigating exploration behaviors, it is interesting to note that they are relevant to other more general gamer types devised in prior research [[4](#_ENREF_4)]. The connections between our four archetypes and Nacke’s types are described below:

* The *Wanderer* can be connected to Nacke’s *Seeker* and *Survivor* types. The *Seekers*’ preference of seeking instant and easy enjoyment from the environment could map to the *Wanderers*’ characteristics of exploring local items. In relation to Nacke’s *Survivor* type, *Wanderers*’ negative fear emotions may motivate players to focus exclusively on their immediate localities and not see or plan for the broader exploration task.
* The *Seer* can be connected to Nacke’s *Seeker* and *Daredevil* types. The *Seer* is similar to the *Seeker* as both of them have interests in the environments themselves. Unlike the *Wanderer* archetype, in which players’ behaviors can be associated with a sense of being lost, the *Seer* archetype tends to be more aggressive and risk-taking. This element coincides with the characteristics of the *Daredevil* type.
* The *Pather* can be connected to Nacke’s *Seeker* and *Mastermind* types. The *Pather* has similar characteristics as the *Seeker* but with the addition of maintaining a structured mental map. On the other hand, the *Pather*’s preferences for making elaborate strategies to reveal the structure of virtual environments could be mapped to the *Mastermind* type.
* The *Targeter* can be connected to Nacke’s *Achiever* and *Mastermind* types. The *Targeter* is similar to the *Achiever* as the objects that *Targeters* hunt for are similar to the goals that *Achievers* attempt to complete. The *Targeter* also prefers to reason about acquiring information for discovering the target items, which maps to the characteristics of enjoying solving puzzles in the *Mastermind* type.

A player may exhibit several types of exploration behaviors based on game environments and tasks. The summarized connections help to better understand the four behavioral types discovered in map exploration, and provide a lens to predict possible exploration behaviors that specific Nacke’s player traits may lead to. Factors that determine a specific type of exploration behavior are discussed below.

*5.2. Different Archetypes for Different Games*

We found that the archetypes exhibited by a participant might not be consistent across all three exploration games. In further analysis of these instances, it was apparent that participants who didn’t exhibit consistent archetypes in all three types of games possessed multiple archetypes themselves. They expressed one dominant archetype, alongside other minor archetypes in different games.

Game mechanics could be one vital element that led to this common variation. For example, when observing P6’s (Interview - *Seer*) gameplay, whenever he avoided narrow paths he aggressively expanded his map viewing area in the *killing game*, saying, “My main attention at this point was to EXPLORE ALL [emphasis added] the high ground. So I just continue walk on the high ground.” Interestingly, he also exhibited the *Targeter* archetype along with the *Seer* archetype in playing the *killing game*. He said, “I think, at the point, I realized that SCVs are near minerals,” when he reviewed the early stages of playing, which potentially indicates that he extracted the knowledge of positioning targets very quickly. Later on, instead of continuing to explore the remaining parts of a region, where he had already revealed part of it, he gave that up and moved on to other regions, in which he explained: “I realized it was too narrow for minerals.”

In contrast, whilst in the *searching game*, his *Targeter* archetype dominated behaviors (Interview): “At this point, I was around here, and I saw a supply depot. I was not sure whether it [the target enemy base] was going to this part [the highland at the top of the map] or that one [the high land in the middle part of the map]. Before going further down, I thought I’d have to check.” His explanation of his behaviors indicates that he was sensitive to the cues, and made substantial reasoning of the target location. These are typical behaviors of a *Targeter*.

In this example, we discovered that P6 possessed two archetypes - the *Seer* and the *Targeter*, which emerge in varying intensities in the participant’s behaviors in different games (the *killing game* – *Seer*, the *pure exploration game* – *Seer*, and the *searching game* - *Targeter*). The differing game goals in the three game types (e.g., seeking targets was the primary goal in the *searching game*) led to different dominant archetypes observed in the players across the games. It should be noted that some of these game goals might occur in more than one game type, however, the primary goal for each game remains explicitly different, which facilitated the differing behaviors observed across the games. For example, seeking targets was an explicit primary goal of the *searching game*; players in the *killing game* had to hunt for targets as well, however, in this case it was an implicit goal compared to the primary goal of destroying these targets. Moreover, different game mechanics (e.g., sparse distribution of enemy units in the *killing game*) also contributed to the variation in gameplay across the three game types.

*5.3. Different Archetypes in One Game*

As mentioned in section 5.2, we noticed that a participant might significantly exhibit more than one archetype in a single gameplay instance. For instance, when P8 was playing the *killing game*, he, sometimes showed obvious effort in recognizing the map structure: “Because mostly the parts of the map are downside, so I tried to go to…”, and also manifested explicit attempts at finding opponent units, “I thought, when I was playing some games, I saw enemies are always hiding in some corners.” (Interview). This shows some traits of a *Pather*. However, his dominant behaviors were classified as a *Seer*, as they employed a general mapping strategy, “Maybe go upside. Cross the whole upstairs, upside and downside. And explore the whole area”, and prefers to explore open spaces, “Just go explore the open space … To explore [the dark area].” This might be attributed to studies that have shown that players’ mostly exhibit multiple personal characteristics in games, such as emotions, play skills, social preference and obsessive tendencies [[2](#_ENREF_2)]. It was even rare that a player exclusively possesses one single trait in playing one type of game. This phenomenon appears to surface in our findings as well, however, through our analysis, we do find that we are able to confidently identify a dominant archetype in most cases. The archetype table (Table 2) lists the eventual dominant archetypes derived from our coding process.

*5.4. Player demographic may affect archetype*

As shown in the Results section, player demographics like gender, weekly gameplay hours and real-life navigational abilities appear to have an effect on the exploration behaviors, i.e., the player’s archetype. Many of these findings appear to conform logically to the archetype behaviors. For example, participants who play less hours and are less familiar with games, as well as those with lesser real-life navigational abilities, tend to be *Wanderers*. However, these relationships are not conclusive as they were not the primary focus of this research, and further research needs to be done to establish these relationships. We suggest this as possible future work.

*5.5. Preferences for Terrain Features*

In our results, we found that strategic preferences on environmental features support the exploration behavior characteristics of each archetype. For example, *Wanderers* prefer connections, which provides them with an easy way to find visiting spots, as they do not have a systematic strategy for exploration. In contrast, we found that *Pathers* prefer edges the most, which fits their typical behavior of paying more attention to the structural definition of terrain features.

5.6 Benefits to Game Design

 The findings in the study will benefit game design, especially the design of game maps and navigation systems. The four exploration types reveal how players mentally map game environments, how they make strategies to find ways, and differences in their behaviors. The discovered knowledge enables game designers to produce user-centered navigation-assistant systems. For example, since *Seers* have a direction-based mental map, game designers could create mutual-mapping compasses for the window of mini-map view and the main window respectively. They could also develop an assist mechanism which can automatically generate the structure of discovered areas of the map to enhance *Pathers’* ability of structuring game environments.

 Our research can also help designers produce more immersive game maps. Taking the *Targeters’* feature as an example, their reasoning of environments and way-finding relies on the key items found. This requires map designers to place conspicuous and informative items, which act as important navigation guidance aside from other existing mechanisms, in the maps.

 The enhancements of game design suggested above not only provide a better navigation experience for *Seers*, *Pathers*, and *Targeters*, but also stimulate *Wanderers* to learn to use external tools to explore. According to the findings about hesitation behaviors, the improvements might also be expected to reduce players’ hesitation when exploring maps to improve the flow experience.

**6. Limitations**

The experiment was conducted on three types of customized-developed exploration games. Unlike standard StarCraft games, these games are exclusively built on the three basic components of exploration. The players’ motivations of exploration tend to be directly generated from the goals of exploration games. In standard StarCraft games, players are motivated by the real-time desires from gameplay, in which behaviors are influenced by other gameplay factors. This potential limitation is a barrier for this research to understand players’ exploration behaviors in actual standard StarCraft games, in which exploration activities only act as a component. StarCraft provides a 2.5D top-down environment. It has a broad visual range for players which enable them to make groups of navigation behaviors easier than in a 3D environment. Players may also have different visual points in 2.5D and 3D environments. Given that, whether the knowledge discovered in this study is applicable in 3D environments still needs to be verified via further research.

Another potential limitation is that the experiment data is not suitable for conducting comprehensive quantitative analysis. Even though we found that players’ demographic backgrounds and preferences to terrain features affect archetypes, the scale of the collected data set is not sufficient for high statistical reliability. Furthermore, we ran one-way ANOVA tests to analyze how real-life navigation abilities impact archetypes as well as the preferences of archetypes to terrain features by generating p-values via the SPSS[[5]](#footnote-5) software. After reviewing the tests, however, we found the calculation method was not reliable in this case, because of the extreme differences of group sizes that broke the homogeneity assumption of the ANOVA test [[51](#_ENREF_51)].

The process of classifying gameplay instances into archetypes is also a limitation for future researchers wishing to repeat this work in other genres. When categorizing an instance into an archetype, the think-aloud, interview as well as in-game data were comprehensively collected and analyzed. This requires coders to meticulously observe and read players’ behaviors and statements within the context of the genre across the data set. Due to the complexity and variability of behaviors and responses, we also found that it was overly challenging to code the data in a quantifiable manner. Hence possible future work would be to investigate better ways of collecting and coding such data.

The participants are normally invited from within the university. Their occupations are all the same as they are all students, even though they register in different faculties and enroll in different programs. This fact indicates that the knowledge about human exploration that we gained in this study might not be directly regarded as the common law of exploration behaviors for people from different occupational backgrounds. However, it is common and widely-accepted research practice that university students are used in experiments across many domains.

**7. Conclusion**

In this paper, we presented a study that examined the game exploration traits of 25 players playing three types of custom-designed exploration games on the StarCraft: Brood War platform. By using thematic analysis on both concurrent think-aloud and video-cued retrospective interviews, we uncovered four behavioral aspects - strategy, reasoning, conception and hesitation - that provided several angles from which to understand exploration activities in a virtual game world.

By distinguishing behaviors according to the four behavioral aspects, we further showed that players can exhibit one or more of four player exploration archetypes, or PEAs, that represent different explorative archetypes, i.e., *Wanderers*, *Seers, Pathers* and *Targeters*. Inter-coder classification analysis was also conducted to identify each gameplay instance into a certain archetype. The results also show that the dominant archetypes for participants vary in different game types.

Analyzing the relationships between the behaviors in the derived archetypes and the behaviors inferred from the survey responses, we found that gender, weekly gameplay time and real-life navigation ability had significant effects on the eventual archetypes into which we classified players. Additionally, participants’ preferences for different terrain features, which we collected from the survey responses, match the traits of the archetypes corresponding to each player. The small size of the participant group is the major limitation of the research.

Our future work will address the development of this research from several angles. First, further studies could be conducted in generating large-scale quantitative proof of behavior differences or of the existence of actual clusters of behaviors. Second, since the experiments were conducted in safe virtual environments, introducing risk factors (such as enemies who are capable of fighting against players) into the games could contribute towards the identification of behavioral patterns in relation to exploring dangerous virtual environments. Finally, rather than using the experimental games that were designed to encourage participants to actively explore unknown environments, a further study could allow players to explore maps under standard game conditions.

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**Table 1** Demographic information and gameplay experience of participants

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ID | Gender | Age | Hours | Game types usually played | Familiarity with RTS games | Experience of StarCraft | Recognition of StarCraft maps |
| P1 | M | 33 | 10 - 20 | FPS, Strategy, RPG, Simulations, Puzzle, CB, Sports, RFS | 5 | 3 | 4 |
| P2 | M | 28 | < 1 | Sports | 1 | 1 | 1 |
| P3 | M | 27 | 1 - 5 | Strategy, Puzzle | 5 | 3 | 2 |
| P4 | M | 29 | < 1 | FPS | 5 | 1 | 2 |
| P5 | F | 27 | < 1 | None | 1 | 1 | 1 |
| P6 | M | 21 | 5 - 10 | FPS, Strategy, CB, PBG | 5 | 5 | 5 |
| P7 | F | 35 | 10 - 20 | Strategy, RPG, Simulations | 5 | 4 | 2 |
| P8 | M | 35 | 1 - 5 | Strategy, RPG | 3 | 2 | 3 |
| P9 | M | 22 | 10 - 20 | FPS, Strategy, W&T | 5 | 3 | 3 |
| P10 | M | 26 | < 1 | CB, PBG, RLS | 1 | 1 | 4 |
| P11 | M | 20 | 1 - 5 | FPS, Strategy, Simulations, Puzzle, PBG | 4 | 2 | 2 |
| P12 | F | 24 | < 1 | RPG, Puzzle | 2 | 1 | 2 |
| P13 | M | 23 | 10 - 20 | FPS, RPG, Sports, RLS | 5 | 1 | 1 |
| P14 | M | 25 | > 20 | FPS, Strategy, RPG, PBG | 5 | 5 | 5 |
| P15 | M | 44 | 1 - 5 | RPG | 3 | 1 | 2 |
| P16 | M | 30 | < 1 | FPS | 1 | 1 | 1 |
| P17 | M | 27 | 1 - 5 | Sports | 3 | 1 | 1 |
| P18 | F | 22 | < 1 | Simulation, Puzzle, CB | 1 | 1 | 1 |
| P19 | F | 32 | < 1 | Strategy, CB, Social | 1 | 1 | 1 |
| P20 | M | 36 | < 1 | FPS, Puzzle, W&T, CB, Sports | 2 | 1 | 1 |
| P21 | F | 27 | < 1 | Puzzle | 2 | 1 | 2 |
| P22 | F | 28 | < 1 | Social, Sports | 1 | 1 | 1 |
| P23 | M | 33 | < 1 | Strategy | 3 | 2 | 1 |
| P24 | M | 39 | 1 - 5 | FPS, Puzzle, Sports, RLS | 2 | 1 | 1 |
| P25 | M | 23 | 1 - 5 | Strategy, Social | 5 | 2 | 2 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| FPS | First – person Shooters | RPG | Role-playing Games | CB | Chance - based |
| PBG | Physical Board Games | RLS | Real-life Sports | W&T | Word & Trivia |

**Table 2** Archetype classification of participants for each game type.

1. Archetype distributions in each game type.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Pure Exploration Game | Killing Game | Searching Game |
| Wanderer | P5, P18, P21, P22 | P2,P18 | P10, P17, P18, P22, P23 |
| Pather | P1, P2, P3, P7, P9, P13, P15, P16, P19, P20, P23 | P3, P21 | P8 |
| Targeter |  | P1, P7, P9, P10, P14, P15, P17, P20, P22, P24 | P1, P5, P6, P7, P9, P13, P14, P15, P19, P20, P21, P24, P25 |
| Seer | P4, P6, P8, P11, P12, P14, P17, P24, P25 | P4, P6, P8, P11, P12, P13, P16, P23, P25 | P4, P11, P12 |

1. Categorization of each participant in different games.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Pure exploration game | Killing game | Searching game |
| P1 |  |  |  |
| P2 |  |  |  |
| P3 |  |  |  |
| P4 |  |  |  |
| P5 |  |  |  |
| P6 |  |  |  |
| P7 |  |  |  |
| P8 |  |  |  |
| P9 |  |  |  |
| P10 |  |  |  |
| P11 |  |  |  |
| P12 |  |  |  |
| P13 |  |  |  |
| P14 |  |  |  |
| P15 |  |  |  |
| P16 |  |  |  |
| P17 |  |  |  |
| P18 |  |  |  |
| P19 |  |  |  |
| P20 |  |  |  |
| P21 |  |  |  |
| P22 |  |  |  |
| P23 |  |  |  |
| P24 |  |  |  |
| P25 |  |  |  |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Wanderer |  | Seer |  | Pather |  | Targeter |  | None |

**Table 3** Means and standard deviations of the total scores representing participants’ real-life navigation abilities. The total scores are a sum of 3 Likert scale (1-5) items (max score of 15).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Wanderer | Pather | Targeter | Seer |
| Means | **9.91** | 10.93 | **11.17** | 10.38 |
| Standard Deviation | **1.76** | 2.09 | **2.55** | 2.27 |

**Table 4** Means and standard deviations of the evaluations of participants’ preferences to different terrain features.

|  |
| --- |
| **Mean** |
|  | Open Spaces | Edges | Connections | Landmarks |
| Wanderer | 3.09 | 2.68 | **3.73** | 3.18 |
| Pather | 3.36 | **4.04** | 3.79 | 2.50 |
| Targeter | **3.65** | 3.07 | 3.46 | **3.54** |
| Seer | **3.67** | 3.60 | **3.76** | 2.88 |
| **Standard Deviation** |
|  | Open Spaces | Edges | Connections | Landmarks |
| Wanderer | 1.22 | 1.12 | **0.72** | 1.06 |
| Pather | 1.22 | **0.82** | 0.80 | 1.21 |
| Targeter | **0.88** | 0.95 | 0.80 | **1.09** |
| Seer | **1.15** | 1.00 | **0.78** | 1.08 |

**Fig. 1**. The entire environment is covered by the fog-of-war (black shadows). The global map – down-left, the information window – down-middle, the control panel – right-down and the middle – the window of main view.

**Fig. 2.** Initial codes map for the reasoning theme.

**Fig. 3.** Objective-centered structure of the reasoning map.

**Fig. 4.** Preference-centered structure of the reasoning map.

**Fig. 5.** Relation between gender groups and the archetypes.

1. Original data
2. Data with the elimination of some participants’ data whose gameplay hours are more than one

**Fig. 6.** Relation between weekly gameplay hours and the archetypes – grouped by types.

**Fig. 7.** Relation between weekly gameplay hours and the archetypes – grouped by playing time.

1. <http://thatgamecompany.com/games/journey/> (19/09/2016) [↑](#footnote-ref-1)
2. <http://us.blizzard.com/en-us/games/sc/> (19/09/2016) [↑](#footnote-ref-2)
3. <https://www.arcgis.com/features/> (19/09/2016) [↑](#footnote-ref-3)
4. <http://www.qsrinternational.com/products_nvivo.aspx> (19/09/2016) [↑](#footnote-ref-4)
5. <http://www.ibm.com/analytics/us/en/technology/spss/> (19/09/2016) [↑](#footnote-ref-5)