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Research into the Relationship between Personality and Behavior in Video Games, Based on Mining Association Rules

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Abstract: Nowadays, people have started to spend more and more time using the Internet, which has a crucial impact on people's lives. Individual personality type is often the main factor dictating the various behaviors that people carry out, and it dominates their activities when socializing, communicating, and making choices in the virtual world. This study is dedicated to uncovering how the six dimensions of personality traits relate to players' in-game behavior. This research is divided into two studies. Study 1 uses the K-means method to classify players in "Clash of Kings", an online strategy video game, according to their activities. Using apriori algorithm, this research analyzes the correlation between in-game behavior and personality. In Study 2, the correlations are validated. In conclusion, not all personality traits are related to in-game behaviors. Players with high extraversion demonstrate more killings and attacks in games. Conscientiousness is negatively related to deaths. Emotionality shows strong extremes. The highest or lowest emotionality scores are associated with killings and attacks, while players with moderate emotionality will behave irregularly. Honesty/humility, agreeableness, and openness to experience are not predictive of in-game behaviors. For game manufacturers, players' personality traits can be inferred through their corresponding in-game behaviors, to use in order to carry out targeted promotions.

Keywords: personality; in-game behavior; association rule; HEXACO; online video game

MSC: 68W01

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1. Introduction

The availability of mobile internet, as a hybrid of mobile communication, has changed human lifestyles and behaviors. People are used to spending more time on mobile devices, whether shopping online, communicating on social networks, or playing online video games. Tom Wijman, Newzoo's Games Market Consultant, offered the view that mobile games would continue to be the largest segment of digital game revenue, following 10 years of double-digit growth [1]. Since video games allow players to have several playing choices and permit relatively free interactions by simulating the real world, millions of game players are taking more time to indulge in game-playing [2,3]. Therefore, it is interesting to study how people behave when participating in games.

In summary, video games can influence a player's individual personality. Playing a game lowers friendship quality [4]. The mode in which friends play a video game and the behavior displayed during gaming influence friendship quality [5]. Conversely, playing collaborative games partially increases cooperation in prosocial people by facilitating their trust in their gaming partners [6]. However, previous studies have paid more attention to the influence that video games have had on players' social activities, such as cooperation, interaction, and other prosocial behaviors. Instead, this research looks at the relationship between a player's behavior within a strategy game, "Clash of Kings" (COK), and their own personality characteristics.

Therefore, we raise the following three research questions:

RQ1: In COK, could all 13 items of the players' recorded data or just some of the items represent the player's in-game behavior?

Players in MUDs (multiuser domains) are first divided into four types: killers, achievers, explorers, and socializers [7]. Worth and Book [8] created a behavior questionnaire and conducted a principal component analysis. They presented six behavior scales in "World of Warcraft" (WOW), i.e., player-versus-player, social player-versus-environment, working, helping, immersion, and core content. In this research, we obtain those items that could mainly represent players' behavior by means of correlation analysis between the items and the player's game level.

RQ2: In COK, what are the players' behaviors, and what patterns of behavior exist within different player groups?

As presented earlier, personality traits were correlated with certain exploration behaviors. As seen in "Second Life", higher conscientiousness is related to moving around more often and visiting more zones [9]. Since different video games provide different choices, exploratory acts might not be the most common choice in many other games. In our research, the entirety of players of COK is clustered according to their in-game behaviors. After figuring out players' representational items, cluster analysis is applied to generate the different groups of players.

RQ3: In video games, how do personality traits correlate with in-game behaviors?

The well-known Big Five or five-factor personality model (B5/FFM: openness to experiences, conscientiousness, extraversion, agreeableness, and emotional stability) is utilized in many gaming studies [10–13]. Since HEXACO personality model (HEXACO: honesty/humility, emotionality, extraversion, agreeableness, conscientiousness, openness to experience) constitutes a viable alternative to B5/FFM and also predicts several personality traits that cannot be explained in B5/FFM, including the relationship of personality factors with the theoretical biologists' constructs of reciprocal and kin altruism and the patterns of sex differences in personality traits, the HEXACO personality model is used to measure participants' personality in this research [14].

The main goal of this research is to find the association between in-game behavior and personality. This research is divided into two studies, in which we have gone into more detail. In Study 1, we collected players' in-game behavior data in "Clash of Kings" (COK), which is an online warfare strategy video game developed by ELEX. We clustered players into different groups through K-means. Then, we distributed questionnaires to players to collect their HEXACO personality traits, after which we analyzed the correlation between personality and in-game behavior through apriori algorithm. Study 1 conducted a fundamental analysis to study the relationship between in-game behavior and personality in COK, which was in the form of a pre-analysis. Based on the association rules obtained in Study 1, Study 2 collected data from several other games, including mobile games, MOBA games, stand-alone action games, and other types of games, to verify the results in Study 1. Besides this, a self-reported method [4] was introduced, using questionnaires to understand the players' self-evaluation of their game performance (mainly in terms of killings, deaths, and attacks). Overall, Study 1 provided a fundamental analysis, depicting the players' types and the basic correlation between personality and in-game behavior. Afterward, Study 2 verified the results in study 1. The framework is shown in Figure 1.

In the following framework, Section 2 will introduce the literature background, Sections 3 and 4 will introduce Study 1 and Study 2, respectively, in detail, Section 5 will show the discussion, and Section 6 will draw conclusions from the current research.

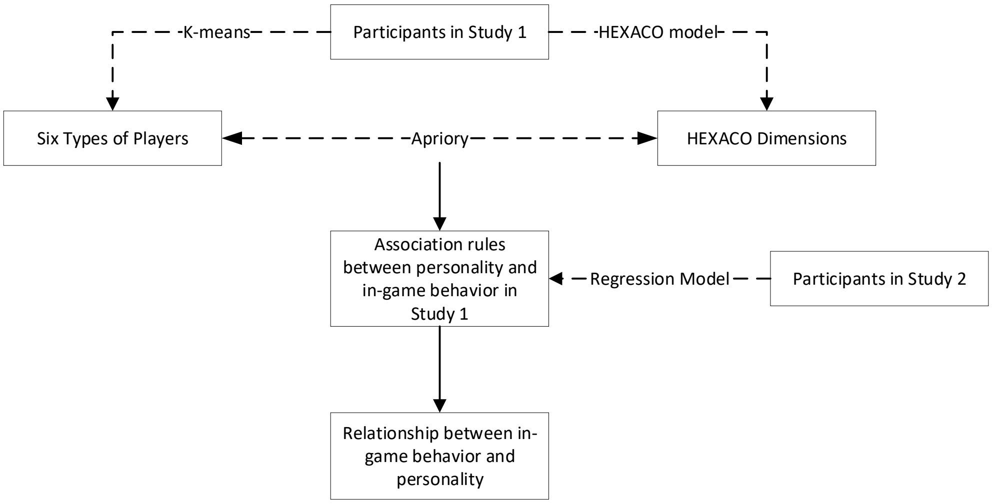


Figure 1. Research framework.

2. Literature Review

2.1. In-Game Behavior

In-game behavior refers to players' performance during games, including completing game tasks, interacting with other players, etc. Social interaction acts as a critical motivation for playing online games. Some players engage in in-game intra-group aggressive behavior, such as swearing at, ignoring, and sabotaging their teammates [15]. Different players have different in-game behaviors. Potard et al. [16] clustered video game user behavior into four profiles: casual, challenge, hardcore, and arousal. Bayraktar and Amca [17] believed that people's habits and personality could impact their behaviors in games. In "World of Warcraft" (WOW), players' behaviors are affected by gender, age, and personality [9]. In "League of Legends" (LoL), personality and behavior are highly entangled [18]. In first-person shooting (FPS) games, participants have different preferences for gaming acts, based on their personality traits [4]. Specifically, men prefer player-versus-player activities, while women and older players tend to prefer to explore video game environments [19]. Previous studies gave some hints as to the major dimensions of in-game acts from the point of view of game-playing motivations [20,21]. Other studies have tried to create and analyze the responses to a questionnaire measuring self-reported in-game behaviors [8]. Other studies have indicated that players' in-game behaviors were consistent with real-world behaviors [17,22]. In turn, players repeatedly exposed to video games suffer changes in cognition and particular personality traits in real life [23].

2.2. Personality-Behavior Correlations

Some researchers have found that a player's personality was associated with game motivation and the extent of time spent playing [24]. In many cases, particular personality–behavior correlations are found in games [25–27]. High levels of depressive symptoms and neuroticism could be identified as significant predictor variables regarding problematic gaming habits [28]. The Big Five model has been used to measure player behavior and personality modeling for interactive storytelling in games [29]. Some research [9] has focused on "Second Life", using the Big Five personality model to study players' behavior, and the results have illustrated that some exploration behaviors are related to personality traits. Likewise, based on HEXACO (honesty/humility, emotionality, extraversion, agreeableness, conscientiousness, and openness to experience), some studies have shown that players' in-game behavior might be predictable with personality analysis [8,30]. For instance, player-versus-player activities are relevant to low-level honesty/humility and high-level psychopathic traits [8]. It is revealed that neuroticism is significantly and positively correlated with aggressive behavior, whereas it is negatively and significantly correlated with agreeableness [20]. In addition, a study on two violent action video games indicated that people with more aggressive personalities tended to demonstrate more aggressive acts [31], while an extrovert is more likely to plan or criticize, resulting in fewer attacks [32]. Players with more aggressive behavior in the game are more aggressive and less prosocial in real life [4]. Psychopathy is positively correlated with cheating and negatively correlated with altruism in the game [33]. Meanwhile, players with low agreeableness will play violent video games more often [34]. Low agreeableness is associated with disordered gaming in terms of social interaction [35]. Extraversion is associated with problematic game use [36]. Competitive motivation is a personal factor predicting trait aggression [37]. Recently, growing evidence has suggested that justified game violence decreases the feelings of guilt caused by in-game immoral behavior [38]. Overall, it appears that one's favored role in a video game relates to certain personality traits.

However, certain studies came to different conclusions. Some scholars have conducted research among WOW players, and the results showed no significant correlation between players' personality and their gaming behaviors [39]. However, its sample size was too small, and the behavioral data might not be reliable. Actually, under the protection of an anonymous environment, people tend to behave in a way that they rarely do in the real world, for example, harassment, without any consequence [40]. Moreover, harmful behaviors are evoked in games, such as cheating, deception [41], and aggression [42].

Different video games give players different choices, and research focusing on WOW or other massively multiplayer online role-playing games cannot represent all video games. Therefore, further studies need to be conducted to reveal the correlation between in-game behavior and players' personality,

3. Study 1

In Study 1, we aim to discuss players' performance in COK and explore the association rules between in-game behavior and personality, starting with identifying which items of the players' recorded data could represent the player's in-game behavior. Players in COK collect resources, train their armies, develop technology, form alliances, and finally fight for the thrones. Fortunately, the players' main record data is open in COK, including 13 variables: battlesWin, battlesLose, attacksWin, attacksLose, defensesWin, detectNum, armyKill, armyDead, armyCure, cityDestroyed, trapPower, Power and buildingPower. Only some of the 13 variables in COK record data are useful to indicate the players' in-game behavior. After a brief correlation analysis between the 13 items and the players' level of achievement in COK, three items, killings (armyKill), deaths (armyDead), and attacks (attacksLose plus attacksWin), which are most strongly associated with each player's ability and level, are selected to study their in-game behavior. Participants are divided into six groups, according to the in-game behavior records of these three variables. Combined with players' HEXACO personality data, players' personality traits from the different groups are displayed. Some correlations between personality traits and in-game behaviors emerge; we used apriori algorithm to study the specific association rules between players' personalities and in-game behavior.

3.1. Materials and Methods

3.1.1. Sample

The sample contains two parts. The first part comprises the complete players' records in the COK server, including 13 items: battlesWin, battlesLose, attacksWin, attacksLose, defensesWin, detectNum, armyKill, armyDead, armyCure, cityDestroyed, trapPower, Power and buildingPower. Most of these items are easy to understand. For example, battlesWin means the number of victorious battles. Some items might be obscure, such as Power, buildingPower and trapPower, representing the player's comprehensive combat effectiveness, fighting power in terms of urban defense, and trap-making capability, respectively. For the first part of the data, 91,222 players' records were collected; after removing invalid records with 0-value items, such as 0-valued armyKill or armyDead, 8248 players' records remained. In addition, we deleted those players with a game level under VIP10, since it only takes a few hours of gameplay for COK players to upgrade to VIP10. Players at a level higher than VIP36 were also deleted as they are then very powerful and can behave arbitrarily. Finally, 4702 players' records were selected, ranging from VIP10 to VIP36.

The second part is mainly drawn from the HEXACO-60 questionnaire investigation, by which we obtained the participants' personality traits; additionally, their COK record data were required for analyzing their in-game behaviors. HEXACO has been used to uncover the relationship between personality traits and consumer video game engagement [43], which is a commonly used method to measure personality traits [44]. For the second part, we published the HEXACO-60 questionnaire (in simplified Chinese, referring to the 60-item version) on WJX.CN (https://www.wjx.cn/jq/7755587.aspx (accessed on 12 December 2017)), which is a short personality inventory based on the HEXACO Personality Inventory—Revised (HEXACO-PI-R), which measured the six dimensions of the HEXACO model of personality structure. Then, we invited more than 300 COK players (VIP10-36) to participate in the test by sending them the questionnaire link via dialogs within COK. HEXACO-60 is formed from 60 items in six scales, each scale containing 10 items [44]. Compared with HEXACO-PI-R, HEXACO-60 is quicker to complete. The details of HEXACO-60 inventory are listed in the Appendix in Ashton's research [44]. Participants' personality traits are generated from HEXACHO-60, which has been used in many different studies [8,45]. In HEXACO-60, participants were asked to score items from 1 to 5, where 5 meant "strongly agree with" and 1 meant "strongly disagree with". As each scale included 10 items, the participants' scores for one scale might reach the highest level of 50 and the lowest level of 10. The participants were promised a cash reward of RMB 60 after completing the questionnaire. Nevertheless, we only received 113 valid responses. The time spent by participants in filling in the questionnaire varied tremendously, ranging from 80 to 6203 s, with an average of 459s. Participants could receive an extra RMB 20 as a reward after giving us access to their gaming records in COK. Before putting the data into the experimental analysis, we carefully checked the records, after which only 50 participants' personality traits and gaming records remained. Some participants spent less than 3 min, which was suspected to be a random response. The initial sample comprised n = 67 players. In addition, 17 participants were deleted because of an unreasonable response time or 0-valued variables, such as armyKill or armyDead. The effective sample comprised n = 50 participants, of whom 58% were male. The players' ages ranged from 18 to 32, and the average was 24.72 (SD = 19.68). Of these, 43.2% of players reported that they were still students. We have obtained the consent of the subjects, and their privacy rights were observed. Ethical approval for the survey was obtained from the university.

Data analysis was conducted using Stata SE and MATLAB. In addition to the descriptive statistics, we also calculated the support, confidence, and lift of the association rules.

3.1.2. Methods

K-Means

The clustering method has become well-known in the broad scientific community of statistics, data analysis, and applications. The broad applicability of cluster algorithms, such as K-means, in many clustering application areas can be attributed to their implementation simplicity and low computational complexity [46]. K-means is also used to assist empirical study [47]. In addition, K-means could offer a useful option for choosing a fantasy sports team or identifying similar players, based on player statistics.

The K-means algorithm aims to divide M points in N dimensions into K clusters so that the within-cluster sum of squares is minimized [48]. The algorithm requires as input a matrix of M points in N dimensions and a matrix of K initial cluster centers in N dimensions. The steps of K-means are as follows:

1. Determine the number Nc of clusters K.

To set Nc, the number of clusters, $r = \left[\sum_i^{Nc} \sum_{x \in C_i} dist(x, c_i)^2\right] / \sum_{i \neq j} dist\left(c_i, c_j\right)^2$ is used, which is referred to as distortions, where c_i is i-th cluster's centroid, and $x \in C_i$

indicates an individual, x, in the i-th cluster, C_i. The lower the distortion, the tighter the cluster members, and the higher the distortion, the looser the cluster structure. When seeking the appropriate number of clusters, r needs to be smaller.

2. Choose cluster centers randomly.
3. Assign all points to the closest cluster center.
4. Recalculate the updated center for all clusters.
5. Repeat Step 3 and Step 4 until the cluster centers remain the same and the data points are stable.

In Study 1, we collect data on the different behaviors of players and cluster them in terms of the behavioral dimensions of the players.

Apriori Algorithm

The apriori algorithm is one of the methods used to find association rules. It has become the most influential association rule algorithm in data mining by which to extract valuable information, knowledge, and patterns from massive data [49]. Association rules are "if–then rules" with two measures that quantify the rule's support and confidence for a given data set. Recently, a new measure, named "lift", has been proposed to test the significance of rules. Association rules originated in market-basket analysis and are now one of the most popular tools used in data mining.

Apriori analysis operates in two stages. In the first stage, all item sets with minimum support (frequent-item sets) are generated. This phase utilizes the downward closure property of support. In other words, if an item set of size k is a frequent-item set, then all the item sets below this $(k-1)$ size must also be frequent-item sets. Using this property, candidate item sets of size k are generated from the set of frequent-item sets of size $(k-1)$ by imposing the constraint that all subsets of size $(k-1)$ of any candidate item set must be present in the set of frequent-item sets of size $(k-1)$. The second phase of the algorithm generates rules from the set of all frequent item sets [50].

Once the final results are available, the validity of the results is usually assessed using the following three dimensions: confidence, support, and lift. The notion of *P(X)* represents the proportion of times that set X appears in a transaction set, τ. *P(X,Y)* represents the proportion of times that sets X and Y coincide in the transactions. Thus, $P(X|Y) = \frac{P(X,Y)}{P(X)}$ represents the proportion of times that set Y appears in all sets involving set X. Based on the above definition, the functions are defined as follows.

(1) Support

The support, *s(I)*, of an item is the percentage of records containing I. The support for the association rule $X \Rightarrow Y$ is the percentage of transactions that contain both item sets, X and Y, among all transactions, which represents the conditional probability of finding Y, given X. The association is of frequency when its support is greater than the minimum support threshold, MinSup. It is given by:

$$s(X \rightarrow Y) = P(X, Y).$$

(2) Confidence

The confidence for the rule $X \Rightarrow Y$ is the percentage of transactions that contain item set Y among transactions that contain item set X. It is given by: $c(X \rightarrow Y) = s(X \rightarrow Y)/s(X)$.

(3) Lift

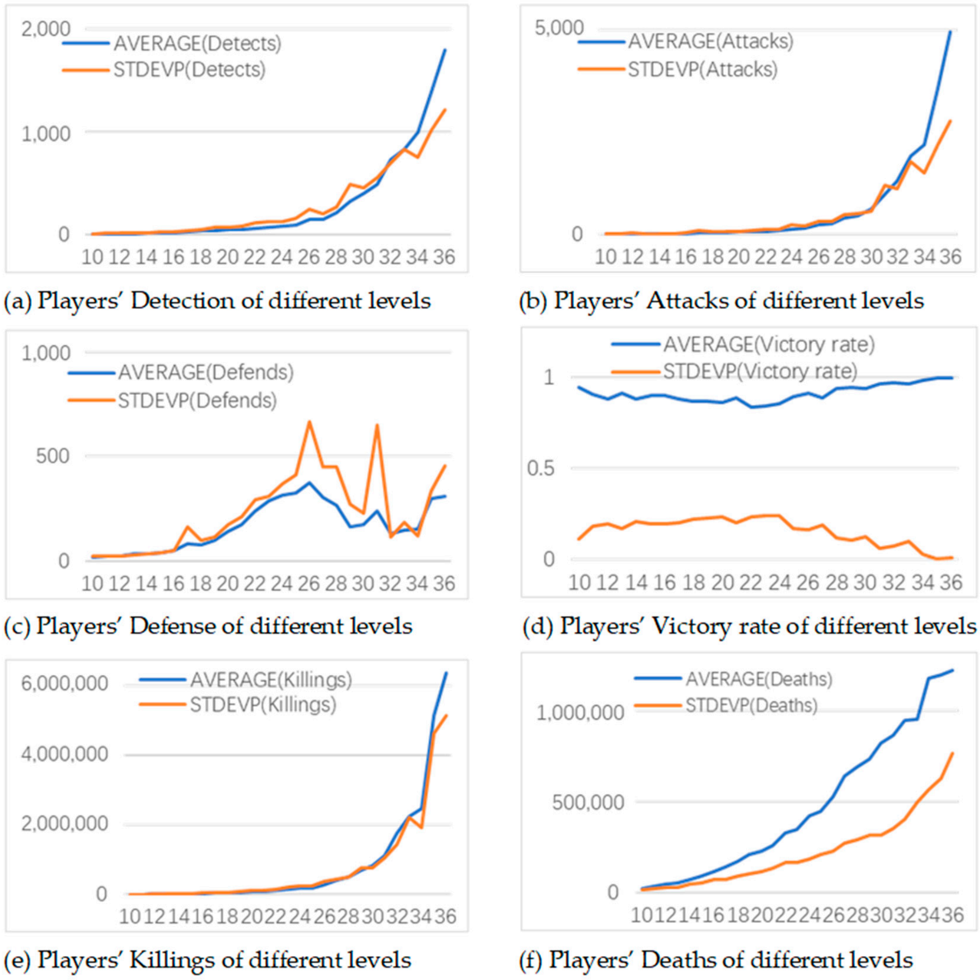
The "lift" value measures the significance of a rule, which represents the distance between *P(Y | X)* and *P(B)*. "Lift" is the rise in probability of having *{Y}* with the knowledge of *{X}* being present, over the probability of having *{Y}* without any knowledge about the presence of *{X}*. When "lift" is greater than 1, this means that X and Y are positively related. It is given by:

$$\mathrm{L}(\mathrm{X} \to Y) = \frac{c(X \to Y)}{P(Y)} = \frac{P(X, Y)}{P(X)P(Y)}$$

3.2. Results

3.2.1. Players' Behaviors in COK

In COK, a war-strategy mobile game, players need to spy on their enemies before an attack. After a few rounds of fighting between the two sides, the side with fewer injuries wins, and the winners receive booty as their reward. In Figure 2, we explored how players' in-game behaviors varied according to the players' game level, including detection, attacks, defense, victory rate, killings, and deaths.



(a) Players' Detection of different levels (b) Players' Attacks of different levels
(c) Players' Defense of different levels (d) Players' Victory rate of different levels
(e) Players' Killings of different levels (f) Players' Deaths of different levels

Figure 2. Six kinds of players' in-game behaviors, varying according to their level, ranging from 10.

To better study players' in-game behaviors, the in-game primary data should be selected to describe the players' acts. Defense varied irregularly, while victory was basically unchanged. Furthermore, with the players upgrading, players' value in terms of detection, defense, killings, and deaths change obviously and regularly, while their values in terms of detection and attacks were almost the same. The correlation coefficient between detection and attacks is over 0.989, which is in accordance with the reality that players would detect enemies before an attack was mounted. After a brief correlation analysis between the 13 items and players' levels in COK, three items that were most strongly associated with players' ability and level, including killings (armyKill), deaths (armyDead), and attacks (attacksLose plus attacksWin), were selected to study the in-game behavior. Overall, killings, deaths, and attacks (KDA) were taken as the players' three principal in-game behaviors in COK, represented as (killings, deaths, attacks), indicating the number of kills, deaths, and attacks experienced by the players in the game.

Figure 3 shows how r changes with Nc (abscissa axis). In Figure 3, when Nc is 6, r is very small, and with the Nc value growing, r varies little. Accordingly, Nc is determined to be 6.

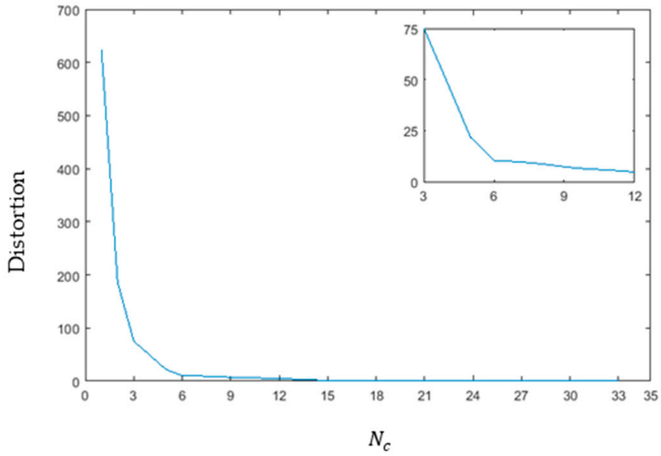


Figure 3. The distortion in k-means results under a different cluster number, N_c.

Based on the players' information (killings, deaths, attacks), players from the first part could be clustered into six in-game behavior types through K-means clustering, which correspond to six kinds of in-game behavior modes. Table 1 shows the players' performance in terms of the information (killings, deaths, attacks) for six groups.

Table 1. KDA performance of the different behavior groups.

Group	(Killings, Deaths, Attacks)	Number
$G1^{COK}$	(Low, Middle, High)	110
$G2^{COK}$	(High, Middle, High)	132
$G3^{COK}$	(Low, High, Low)	377
$G4^{COK}$	(Low, Low, Low)	1923
$G5^{COK}$	(Low, Middle, Low)	1430
$G6^{COK}$	(Middle, Middle, Middle)	730

Notes. G1–6 stands for Groups 1–6. The superscript "COK" means the data here is based on the COK server data.

In order to analyze the levels of different groups, the line chart is shown in Figure 4.

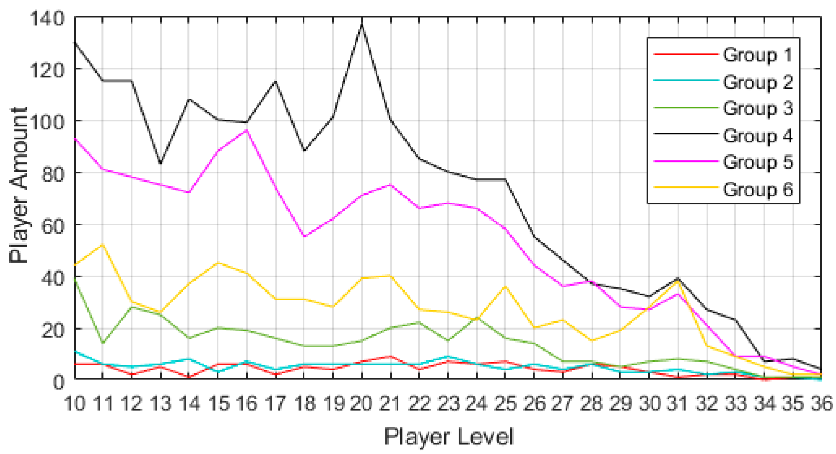


Figure 4. How players in the different groups are distributed, with the level.

Visibly, in $G3^{COK}$ to $G6^{COK}$, with the levels getting higher, players are becoming fewer, but in $G1^{COK}$ and $G2^{COK}$, the number of players differs little among the different levels. Accordingly, we set up a hypothesis that player type influences the relationship between player level and player number. In MATLAB, the null hypothesis of the crosstab function is independent in each dimension. Thus, the distribution of the different groups is different. The distribution of players with low or middle attacks ($G3^{COK}$–$G6^{COK}$) is consistent (p-value = 0.0059) with the rule that low-level players are more common and high-level players are less common. While the distribution of players with high attacks ($G1^{COK}$–$G2^{COK}$) is independent of level (p-value = 0.9451), since the distribution of high-level players is the same as that of low-level players, this leads to an assumption that attack behaviors might be a pivotal and sensitive factor by which to classify players, as it has an impact on the relationship between player level and player amount.

3.2.2. Personality Traits

Since players in the first part could be divided into six groups, for the players who participated in the HEXACO-60 questionnaires, normalized values (killings, deaths, attacks) in the second part are used to divide the players into six groups, based on the centroids of K-means clusters from the first part of the data. The classification is displayed in Figure 5. To better illustrate the three-dimensional effect, three points are marked with dotted lines.

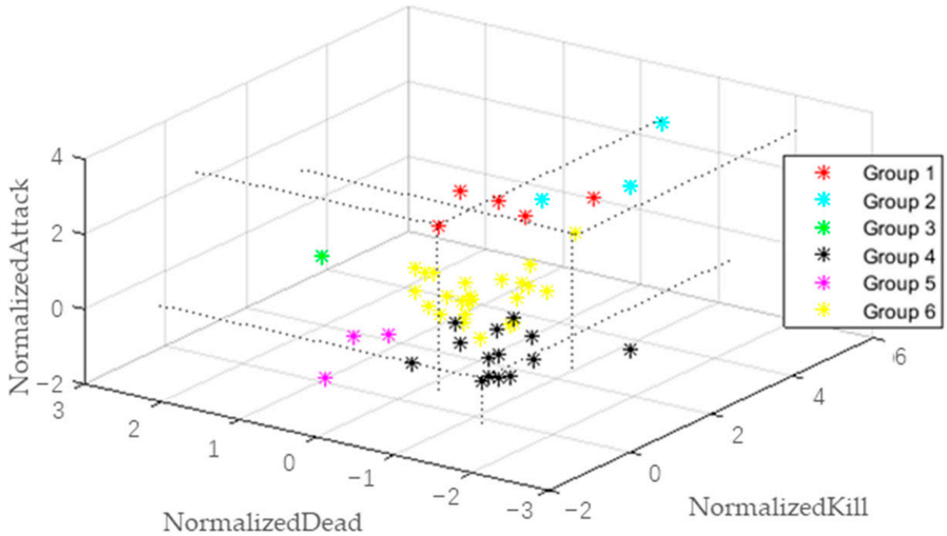
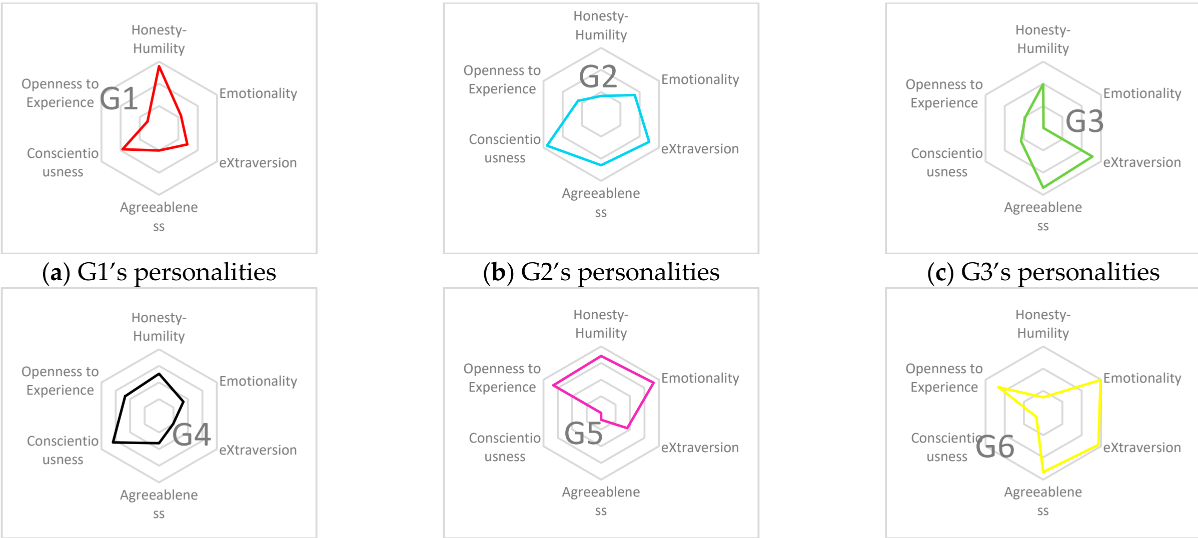


Figure 5. Classification of HEXACO-60 participants, based on the centroids of the K-means clusters.

By observing how players from six different behavior groups scored for the six personality traits (HEXACO), we could better understand the finding that players of different groups have different personality traits. The HEXACO scores of every group, presented in the form of radar charts, can be seen in Figure 6, which clearly shows that players' personality scores differ greatly among the different groups. For example, in Group 1, the openness to experience score is relatively low and the honesty/humility score is high, while in Group 6, both honesty/humility and conscientiousness are low. In contrast, openness to experience, emotionality, extraversion, and agreeableness are high.

Table 2 shows players' fuzzy descriptions (honesty/humility, emotionality, extraversion, agreeableness, conscientiousness, and openness to experience) in the six groups.



(**a**) G1's personalities (**b**) G2's personalities (**c**) G3's personalities
(**d**) G4's personalities (**e**) G5's personalities (**f**) G6's personalities

Figure 6. HEXACO scores of six groups, G1–G6, shown in radar charts.

Table 2. Players' personality orientation for each HEXACO dimension.

Group	**(H,E,X,A,C,O)**
G1^{Q}	(Low, Middle, High, Low, Low, Low)
G2^{Q}	(Middle, High, High, High, Middle, Middle)
G3^{Q}	(Low, High, Middle, Low, Middle, Low)
G4^{Q}	(Middle, High, High, Middle, Middle, Middle)
G5^{Q}	(Low, Middle, High, Middle, Middle, Middle)
G6^{Q}	(Middle, High, Middle, Middle, Middle, Low)

Notes. G1–6 stands for Groups 1–6. The superscript "Q" means the data here is based on the players from whom we derived their personality traits and in-game behavior records from questionnaires. *H*, *E*, *X*, *A*, *C*, *O* represent honesty/humility, emotionality, extraversion, agreeableness, conscientiousness, and openness to experience, respectively.

3.2.3. Association Analysis

For better analyzing the associations between players' personality and in-game behavior, we applied data fuzzification on HEXACO dimensions and in-game behavior records. In HEXACO dimensions, the following scales were used to evaluate individuals: 1 = scores very low; 2 = scores low; 3 = scores medium; 4 = scores high; 5 = scores very high. As for in-game behavior records, we used 2 scales (1 and 2) to describe the frequency of behavior is low or high in COK. Table 3 showed 26 association rules between players' personality and in-game behavior. In association rules, we set Min (Support) to 0.1, Confidence, 0.5, and Lift, 1.

Table 3. Association rules between personality traits and in-game behaviors in Study 1.

No.	**LHS**	**RHS**	**Support**	**Confidence**	**Lift**
1	E = 1	Attacks =1	0.11	0.61	1.22
2	X = 3		0.13	0.58	1.16
3	O = 3		0.19	0.58	1.16
4	E = 1	Attacks = 2	0.13	0.57	1.15
5	O = 2		0.21	0.55	1.11
6	A = 2&X = 2		0.11	0.59	1.19
7	A = 2&O = 2		0.11	0.59	1.19
8	H = 2&O = 2		0.11	0.60	1.20
9	C = 2&O = 2		0.11	0.57	1.14

Table 3. *Cont.*

No.	LHS	RHS	Support	Confidence	Lift
10	X = 2&H = 2	Deaths = 1	0.12	0.68	1.36
11	C = 2&H = 2		0.14	0.60	1.19
12	X = 1	Deaths = 2	0.10	0.57	1.15
13	H = 1&O = 2		0.10	0.56	1.13
14	A = 2&H = 1		0.11	0.61	1.23
15	X = 1	Killings = 1	0.11	0.59	1.18
16	E = 3		0.14	0.63	1.26
17	A = 2		0.24	0.56	1.12
18	A = 2&X = 2		0.12	0.65	1.29
19	A = 2&H = 2		0.11	0.59	1.18
20	A = 2&C = 2		0.13	0.56	1.13
21	E = 1	Killings = 2	0.14	0.62	1.25
22	X = 3		0.19	0.57	1.16
23	A = 3		0.23	0.58	1.18
24	H = 2		0.26	0.56	1.12
25	A = 3&H = 2		0.14	0.66	1.33
26	A = 3&C = 2		0.11	0.64	1.29

Notes. In LHS, 1 = scores very low; 2 = scores low; 3 = scores medium; 4 = scores high; 5 = scores very high. In RHS, 1 = the frequency of a behavior is low; 2 = the frequency of a behavior is high. *H*, *E*, *X*, *A*, *C*, *O* represent honesty/humility, emotionality, extraversion, agreeableness, conscientiousness, and openness to experience, respectively.

3.3. Discussion

In Study 1, we defined "behavior" in COK to understand how people perform in COK and to measure the players' performance. Considering all the eliminated record data, in which players have no records of killings, deaths, or attacks, it is concluded that most players chose a conservative strategy in COK, opting for self-development with more in-game exploration, rather than expanding solely by plundering resources from enemies. The results in Study 1 show that players in COK could be clustered into six groups, depending on their different behaviors. As seen in Table 1, players belonging to the 6 groups perform differently in terms of (killings, deaths, attacks). High, middle, and low were used as fuzzy descriptions of (killings, deaths, attacks).

Four brief laws were drawn up, based on Tables 1 and 2: (1) when honesty/humility is low, the number of killings is low and of deaths is not low; (2) when extraversion is high, the number of deaths is not high; (3) agreeableness and killings are positively correlated; (4) when openness to experience is low, the number of killings is not high and of deaths is not low. Note that when agreeableness is low, openness to experience is low, as well as honesty/humility, which means that agreeableness conforms to laws (1) and (4). Interestingly, when players score low in agreeableness, openness to experience, or honesty/humility, their fighting style will be inefficient since they will kill fewer enemies but suffer more injuries.

The results also show the association rules between in-game behavior and personality. According to Table 3, we obtained scores corresponding to in-game behavior and personality, as shown in Table 4.

The numbers in Table 4 represent the scores of the corresponding personality traits. We can see that in-game behaviors and personality traits are partially correlated. We can draw several conclusions from Table 4: (1) the numbers vary from 1 to 3 in terms of the association rules, which confirms that most players tend toward conservative administration in COK and self-development with more in-game exploration. (2) A higher number of killings is associated with a lower emotionality score; a lower number of killings is associated with a higher emotionality score. In other words, players with lower emotionality values show more killings, while players with higher emotionality values show fewer killings. Emotionality has a converse trend in terms of attacks. (3) Honesty/humility is negatively related to deaths, which is similar to the results in Table 2. (4) When extraversion is low, killings and attacks are low. However, the situation is the opposite in terms of deaths. (5) Agreeableness and killings are positively correlated, which could confirm the results drawn from Table 2. (6) Openness to experience and attacks are negatively correlated. These results suggest that certain personality traits are associated with in-game behaviors.

Table 4. Scores of the six personality traits in terms of in-game behaviors.

	H	E	X	A	C	O
Killings = 1		3	1, 2	2		
Killings = 2		1	3	3		
Deaths = 1	2		2		2	
Deaths = 2	1		1	2		2
Attacks = 1		3	1			3
Attacks = 2	2	1	2	2	2	2

Notes. In-game behaviors: 1 = the frequency of a behavior is low; 2 = the frequency of a behavior is high. Regarding the personality traits scores, 1 = scores very low; 2 = scores low; 3 = scores medium; 4 = scores high; 5 = scores very high. *H*, *E*, *X*, *A*, *C*, *O* represent honesty/humility, emotionality, extraversion, agreeableness, conscientiousness, and openness to experience, respectively.

4. Study 2

In Study 1, it could be concluded that parts of the personality traits are related to the participants' in-game behavior, which is in accordance with the previous research [30]. Although the association rules discovered in Study 1 have a high confidence score (above 55%), we still suspect that this might be due to the impact of small-scale sampling. Therefore, in Study 2, we examined new samples and tested the results in Study 1.

4.1. Materials and Methods

4.1.1. Sample

To verify the findings in Study 1, we re-collected the data. This sample comprised n = 297 participants. However, 28 participants were excluded from the analyses due to their not meeting the inclusion criteria (e.g., non-eligible age, invalid response time, not playing video games). Among the final effective participants, there were n = 269 participants. Of these, 128 were male (47.6%). The participants were between 21 and 55, and the average age was 23.9 years (SD = 5.332). In total, 81.9% of the participants had played games for more than one year. As for gaming frequency, 43.8% of the players played at least 3 times a week. In total, 76.1% of the players played games to entertain themselves and pass the time, which is similar to the conclusion in Study 1 that most players chose a conservative strategy in COK. What is interesting in the responses is the players' self-evaluation of their in-game behaviors. In terms of players' performance in the game, they rated their probability of killing high, with most of them scoring above 50 (mean = 60.9, SD = 18.4, 25th percentile = 50); 72.5% of failure assessments were between 20 and 60 points, and 72.5% of players rated their probability of failure at between 20% and 60% (mean = 43.7, SD = 17.3, 25th percentile = 35); in addition, 56.7% players rated their probability of aggressive behavior at between 41 and 80% (mean = 60.8, SD = 21.9, 25th percentile = 47). We have obtained the subjects' consent, and their privacy rights have been observed. Ethical approval for the survey was obtained from the university.

Further data analysis was conducted using Stata SE. Pearson's correlations between HEXACO traits and in-game behaviors were computed. Three regression models were run, with killings, deaths, and attacks as dependent variables, and with frequency as a control variable.

New questionnaires, including questions about in-game behaviors and personality traits, were issued. Before that, we conducted a preliminary experiment among 10 people on a small scale to collect their opinions and further revise the questionnaire to create the final version. First, we collected the player's basic personal information. Then we asked the participants whether they would play online games or stand-alone games in their daily lives, then we listed the most common types of games for them to choose from. Afterward, they were asked about the frequency and level of playing games, as well as relevant information about their behavior in games. The questionnaire also surveyed the participant's HEXACO-60 personality traits. Since some privacy would be given in the HEXACO personality questionnaire to ensure authenticity, we published the new HEXACO-60 questionnaire (in simplified Chinese, referring to the 60-Item version) on WJX.CN (https://www.wjx.cn/vj/Y4Bihiy.aspx (accessed on 16 December 2019)), and distributed the questionnaire to 297 students and their families at school. The entire questionnaire has 80 questions, and we promised to give RMB 10 as a reward to players who completed it, far less than they received in Study 1. In Study 2, there were more players compared to Study 1, since most of them were students at school who were more willing to participate in the research questionnaires and answer questions that might be related to privacy. In the end, we obtained 269 valid questionnaires for Study 2.

4.1.2. Methods

From the results of Study 1, we believed that there might be a relationship between the three kinds of behavior in the game and the six personality traits of HEXACO. Since the frequency of playing video games is positively related to the aggression, winning, and helping scale in-game [30], we took frequency (*Fre*) as the control variable:

$$\text{Killings} = \beta_{11}H + \beta_{12}E + \beta_{13}X + \beta_{14}A + \beta_{15}C + \beta_{16}O + \alpha_{11}Fre + C_1 + \varepsilon_1 \quad (1)$$

$$\text{Deaths} = \beta_{21}H + \beta_{22}E + \beta_{23}X + \beta_{24}A + \beta_{25}C + \beta_{26}O + \alpha_{21}Fre + C_2 + \varepsilon_2 \quad (2)$$

$$\text{Attacks} = \beta_{31}H + \beta_{32}E + \beta_{33}X + \beta_{34}A + \beta_{35}C + \beta_{36}O + \alpha_{31}Fre + C_3 + \varepsilon_3. \quad (3)$$

In the above models, killings, deaths, and attacks represented the number of kills, deaths, and attacks of the player in the game, respectively. *H*, *E*, *X*, *A*, *C*, and *O* represent the six dimensions of the HEXACO personality traits. *Fre* is a control variable, representing how often the player plays the game. We used (1), (2), and (3) to verify the relationship between personality traits—killings, deaths, and attacks in games.

4.2. Results in Study 2

Table 5 describes the correlation between in-game behaviors and the six personality traits of HEXACO. The relationship between the three behaviors when in-game is highly correlated. Obviously, the number of killings is negatively correlated with that of deaths (r = −0.413, p = 0.0000); the number of attacks is positively correlated with that of killings (r = 0.5022, p = 0.0000), and negatively correlated with that of deaths (r = −0.1871, p = 0.0021), which means that if players show more aggressive behavior in the game, they are likely to kill more enemies in battle. At the same time, it is less likely that they will lose the battle. These results imply that if we wanted to win in the game, we could take the "active attack" approach. In addition, there is also a relationship between personality traits, such as the positive relationship between honesty/humility and agreeableness. This might be inconsistent with the conclusion of the previous study that there is a significant negative correlation between aggressiveness and honesty/humility [30].

Table 5. Correlations between in-game behaviors and personality traits.

Variables	Killings	Deaths	Attacks	H	E	X	A	C	O
Killings	1.000								
Deaths	−0.413 ***	1.000							
Attacks	0.502 ***	−0.187 **	1.000						
H	0.159 **	−0.152 *	0.119	1.000					
E	−0.066	−0.035	−0.031	−0.008	1.000				
X	0.229 ***	−0.087	0.203 ***	0.212 ***	−0.132 *	1.000			
A	0.217 ***	−0.067	0.101	0.267 ***	−0.099	0.441 ***	1.000		
C	0.144 *	−0.187 **	0.085	0.245 ***	−0.118	0.376 ***	0.290 ***	1.000	
O	0.108	−0.184 **	0.060	0.319 ***	−0.016	0.383 ***	0.276 ***	0.329 ***	1.000

Notes. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. *H*, *E*, *X*, *A*, *C*, *O* represent honesty/humility, emotionality, extraversion, agreeableness, conscientiousness, and openness to experience, respectively.

Multiple regression analyses for in-game behaviors are presented in Table 6. The player's killings value is positively correlated with extraversion; the deaths value is negatively correlated with conscientiousness; the attacks value is positively correlated with extraversion. As for the game frequency of the player, frequency is negatively correlated with the number of killings.

Table 6. Regression model, predicting the in-game behaviors.

Dependent Variable	**Killings**			**Deaths**			**Attacks**		
Independent Variables	**B**	**β**	**SE**	**B**	**β**	**SE**	**B**	**β**	**SE**
H	0.117	0.110	0.069	−0.0917	−0.092	0.066	0.108	0.101	0.070
E	−0.019	−0.017	0.065	−0.0550	−0.055	0.061	0.00524	0.005	0.066
X	0.167 *	0.157	0.076	0.0134	0.013	0.072	0.219 **	0.207	0.077
A	0.132	0.124	0.073	0.0178	0.018	0.069	0.00435	0.004	0.074
C	0.0477	0.045	0.071	−0.146 *	−0.147	0.068	0.0105	0.010	0.073
O	−0.0269	−0.025	0.072	−0.121	−0.122	0.068	−0.0505	−0.048	0.0732
Frequency	−0.0906 *	−0.0850	0.067	0.0292	0.029	0.063	−0.0678	−0.064	0.068
Constant	0.365		0.174	−0.204		0.165	0.2894		0.176

Notes. ** $p < 0.01$, * $p < 0.05$. H, E, X, A, C, O represent honesty/humility, emotionality, extraversion, agreeableness, conscientiousness, and openness to experience, respectively.

4.3. Discussion

The results of Study 2 showed that there was a correlation between in-game behavior and personality. However, only part of the rules could be verified. Taking the control variable into consideration, only two dimensions (extraversion and Consciousness) of HEXACO personality traits correlated with one or two kinds of in-game behaviors. Extraversion correlated positively with killings and attacks. Conscientiousness negatively relates to deaths. Interestingly, there is no correlation between the other four behaviors and the player's in-game behaviors. Under normal circumstances, the other four personality traits may affect the players' state when they are playing the game and, thus, have an influence on their in-game behavior, which may differ from the above conclusions. Possibly, players could then maybe realize the difference between their virtual and real lives; they may take steps that they will not take in their daily lives to avoid exposing themselves in games.

5. General Discussion

In this research, we have explored the relationship between personality traits and in-game behaviors. We collected data on players' in-game behaviors from COK and other video games by self-evaluation in the questionnaire, then adopted HEXACO to establish the personality traits of players. We applied the association rules and linear models to fit our data and describe the relationships between personality traits and in-game behaviors.

5.1. In-Game Behaviors

The relationship between in-game behaviors and the game level implies that only (killings, deaths, attacks) vary regularly with the level of players, so we chose (killings, deaths, attacks) as the three dimensions by which to measure the in-game behaviors. Study 1 carried out cluster analysis among all players in the whole COK server. The players were clustered into six in-game behavior groups through K-means, where, accordingly (killings, deaths, attacks) manifested as (Low, Middle, High), (High, Middle, High), (Low, High, Low), (Low, Low, Low), (Low, Middle, Low), and (Middle, Middle, Middle). Based on the in-game performance, most players chose a conservative strategy in COK, as in self-development with more in-game exploration, rather than expanding only by plundering resources from enemies.

5.2. Association between In-Game Behaviors and Personality Traits

The association relationship between players' in-game behaviors and their personality traits was disclosed. Then, considering the frequency, we tested the relationship via linear models in Study 2. In addition, when we analyzed the in-game behavior-personality relationship, behavioral data, and HEXACO scores were consistently one-to-one matched, guaranteeing our study's reliability. Obvious clues as to the association between in-game behavior and real personality exist according to the results, and the clues have been exhibited step-by-step from different perspectives:

(1) Personality trait scores of players from different in-game behavior groups

Through personality traits descriptions of all six in-game behavior groups, it is evident that players with different behavior records have different scores in the HEXACO personality test, as shown in Table 2.

(2) Players' behavior distribution, according to the perspective of HEXACO dimensions.

Fuzzy correlation is generalized through Tables 1 and 2. For instance, when agreeableness is low, openness to experience is low, as is honesty/humility. Interestingly, when players score low in agreeableness, openness to experience, or honesty/humility, their fighting style is inefficient since they kill fewer enemies but are more likely to die.

(3) Association analysis of players' personality traits and behaviors

We conducted a regression analysis between personality traits and in-game behaviors. In Figure 7, the results indicate that people with a high extraversion value show more killings and attacks in video games. Extraversion indicates how outgoing and how social a person is [51]. Previous studies showed that participants who are likely to attack in games scored higher than others in terms of extraversion [4], which is similar to our results. Conscientiousness represents how organized, self-disciplined, and dutiful a person is [9]. Conscientiousness is negatively related to deaths in video games, similar to the results that individuals with higher conscientiousness might be less likely to have conflicts with others [24]. The lack of a significant relationship between the other four domains and in-game behaviors (i.e., honesty/humility, emotionality, agreeableness, and openness to experience) indicates that although players could feel a psychological connection to their game character, the scope of this link was limited. While emotionality and openness to experience were not statistically significant predictors of in-game behaviors, players with high emotionality and openness to experience showed more attacks in games, according to Table 4. In addition, emotionality showed a strong correlation with in-game behavior, based on the association rules, which might mean that the in-game behavior of players with more extreme emotional expressions was obvious. In contrast, the in-game behavior of players with medium emotionality was less regular and might be more chaotic. In other words, when emotionality is extremely high or low, the players' killings and attacks are more affected; when it is medium, there is no discernible difference in the in-game behavior. However, honesty/humility, agreeableness, and openness to experience did not show a strong relationship with in-game behavior. The main reason for this might be the limitations of the game rules. In most video games, manufacturers tend to focus on the activities of the players that could lead to specific results (i.e., seek, battle, attack). At the same time, art appreciation (openness to experience) or honesty (honesty/humility) are hard to demonstrate. The results of Study 1 and Study 2 indicate that not all the HEXACO personality traits are related to in-game behavior.

The comparison between attacks and killings is worth mentioning. On the one hand, there is a significant positive correlation between the two (as shown in Table 5). On the other hand, both attacks and killings were positively related to extraversion. The results show that killings usually accompany attacks, and attacks often lead to more killings, which is as expected and is consistent with reality.

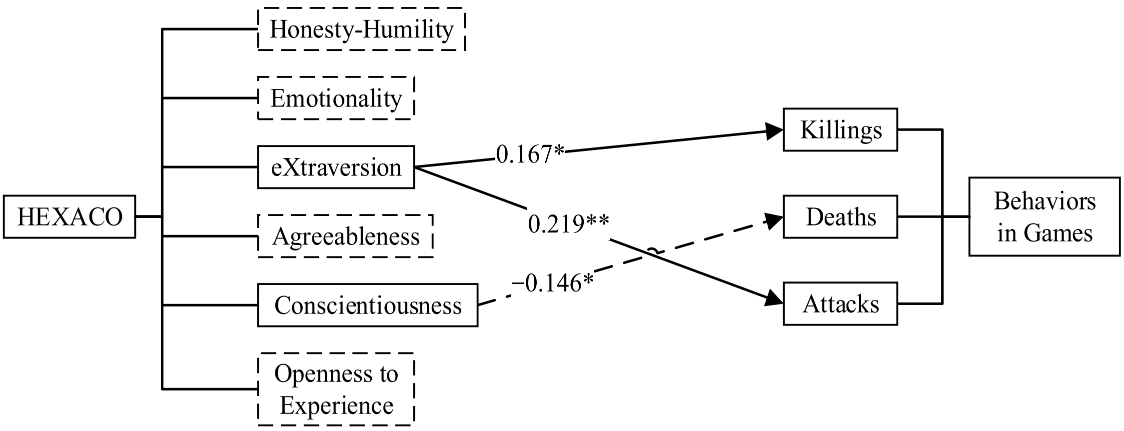


Figure 7. The results of the regression analysis, showing that the personality traits were partly related to in-game behaviors. The significant positive associations were indicated by solid black arrows, the significant negative association were indicated by a dashed black arrow. Honesty/humility, emotionality, agreeableness, and openness to experience, which had no correlation to any in-game behaviors, are indicated by a dotted box. Notes. ** $p < 0.01$, * $p < 0.05$.

For the different results of Study 1 and Study 2, we have the following explanations. (1) Study 1 and Study 2 collected data from different samples. In Study 1, we collected data on players' in-game behaviors from the COK server, which were drawn from a wide range. We did not limit the age, gender, occupation, etc., of our participants, and randomly sent questionnaires to them to ascertain their personality traits. In Study 2, most of the participants were familiar to us since we mainly distributed questionnaires to students and related personnel at school to collect data; they were more concentrated in terms of age and occupation. (2) The games targeted in the two studies were different. Study 1 was only tested for COK, while Study 2 extended the game to more console games and mobile online games. (3) The performance data in Study 1 were obtained through objective data in the game, such as the number of kills and deaths. However, the in-game behavior data were collected through self-evaluation via the questionnaire in Study 2, which might lead to deviations due to the player's impressions and memory. (4) Study 1 adopted apriori algorithm. The conclusions obtained in this way only inform us of the probability that a player with certain personality traits will manifest a certain kind of behavior simultaneously. Study 2 adopts regression analysis, which pays more attention to the trend between personality traits and in-game behaviors. Therefore, the conclusions drawn from the two studies may be different.

6. Conclusions

6.1. Main Findings

This research has revealed the relationship between in-game behavior and personality in COK and has verified the association rules, based on an additional dataset. The research is divided into two studies: Study 1 defined the "in-game behavior" in COK and selected the most representative activities. Players could be divided into six categories based on their value (killings, deaths, attacks) in the game. Besides, associations of personality traits and in-game behaviors are revealed. Study 2 tested the association rules drawn in Study 1.

Based on the analysis in Study 1 and Study 2, only part of the HEXACO model is related to in-game behavior. People with high extraversion show more killings and attacks in games. Conscientiousness is negatively related to deaths in video games. Emotionality shows a correlation relationship with killings and attacks. When emotionality is extremely high, the players are likely to show more killings and attacks. By contrast, players show fewer killings or attacks when their emotionality is low. However, when emotionality is medium, the player's behavior is vague and is not easily distinguishable. Apart from that, the other dimensions of personality (honesty/humility, agreeableness, openness to experience) do not show any correlation with in-game behavior. These results may be significant in understanding the individual differences in gaming and may have great significance for game manufacturers and players.

Our study contributes to both the related theories and practice. Firstly, the research expands the in-game behavior–personality association relationship, based on a new game, COK, in a novel way. According to the cluster analysis of enormous behavioral data (the behavior records of a player from the whole server, in the first part of the data), we obtained the players' classification basis (centroids of the clustering results), which makes the classification of participants valid, objective, and reliable. Secondly, we investigated the relationship between the player's personality traits and their in-game behaviors. Personality traits are partially related to in-game behaviors. Only extraversion and conscientiousness are significantly related to in-game behaviors. Emotionality shows a correlation relationship with killings and attacks. Generally, our research is a complement to the in-game behavior–personality relationship study, which shows that personality is a factor that developers should take into consideration in game design and game development. Game players could also develop strategies by understanding their own personality traits, to achieve a better gaming experience.

6.2. Limitations and Future Directions

Limitations also exist in our study. Firstly, this study only considers three principal behaviors in games, and the rest is unknown. Although it might be concluded that the three in-game behaviors are associated with real personality traits, this does not mean that all the behaviors are identical. How the less commonly performed acts are related to personality is unknown, while those less frequently performed acts might appear more casually or compulsively. Few considerations as to secondary or inconspicuous behaviors are presented in gaming studies. It might be a promising study topic for us to understand better how players act and how to better design an attractive game by revealing the relationship between less common behaviors and natural personality. Secondly, the small size of the sample is another limitation. A more extensive and more diverse dataset will be required. COK is a worldwide game, but we mainly distributed our personality questionnaires in China. Thus, the demographics of participants need to be more universally balanced. For future work, we will improve the recruitment of participants to have broader samples. However, we have finally obtained association rules between personality traits and in-game behaviors, proving that it is feasible to use our study method for other kinds of games, such as adventure games.

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