Table of Contents

Table of Figures

Table of Appendices

Executive Summary

This report contains four main sections, starting with (i) understanding the dataset and pre-processing the variables, (ii) investigating in variables association, (iii) identifying natural groupings of players, and (iv) recognizing key variables that affect player's expert level.

A six-step approach was employed for each analysis, starting from defining the objective and establishing the research design. Since all the statistical methods heavily rely on assumptions that could potentially result in biased outputs, assumptions to specific techniques were thoroughly checked. Following this, analyses were carried out to the dataset, results were then interpreted and validated.

After the datatypes of variables were corrected, Factor Analysis were used to identify hidden factors related to the player's characteristics. The variables were grouped into five factors, which significantly differ from one another and were meaningfully interpreted. Using these factors, the hierarchical and non-hierarchical Cluster Analysis were computed to identify six clusters of players, with a five-factor score. The characteristics that distinguish players in all the six clusters were interpreted. Further in the report, Multiple Regression Analysis and Multiple Discriminant Analysis were leveraged to identify NumberOfPACs as the imperative variable with positive correlation to the player's expert level.

1 Introduction

The given dataset describes some players of Skill Craft video game. This data analysis has many practical applications. For example, a team entering a gaming competition could be interested in specific areas to focus on practising in order to up their game. It may also help the game company to identify target players (clusters) for marketing campaigns.

2 Skill Craft data: Understanding the dataset, variables and pre-processing

Data pre-processing is a crucial step to a comprehensive data analysis. It begins with identifying the correct datatype of each variable. As "GameID" is unique to each player, it is the primary key and nominal. "LeagueIndex" is an ordinal variable with 7 levels and specifies the expert level from "Bronze" to "Professional". The variables "Age", "HoursPerWeek" and "TotalHours" are integers; thus, the "decimals" column in SPSS is 0. All other variables are continuous numbers, whose type and scale are defined as "Numeric" and "Measure" in SPSS. All datatypes were revised by characteristics (see Appendix A.1).

In the second step, one missing value was detected in the "TotalHours" column for player 1064. Since the results of different techniques cannot be interrupted by missing values, this will be explained respectively in subsequent sections.

Both boxplot (in Appendix A.2) and Mahalanobi's Distance (in Appendix A.3) were applied to check outliers. Because the mean value and variance between variables are discrete, this will give rise to several outliers. Therefore, Mahalanobi's Distance was used for cross-validation. In this large dataset, if Mahalanobi's Distance is greater than 4, it might be a potential outlier. In the end, there are 11 outliers (see Appendix A.4) and approach to handling outliers will be discussed for each question.

3 Data Investigation

3.1 Connection between different variables (Question 3)

3.1.1 Objective

In order to find the data structure and interrelationships among variables, exploratory factor

analysis was applied to separate variables into a few factor groups. The goal is to appropriately interpret factors with reasonable underlying relationships of variables.

3.1.2 Designing of factor analysis

This dataset includes 697 observations and 19 metric variables. Referring to the result from 2 Skill Craft data: Understanding the dataset, variables and pre-processing, one missing value has been found; however, no missing value will be removed if factor groups are interpretable. Since there is no distinction for dependent and independent variables in factor analysis, all of the attributes will be considered as characteristics to divide into factor groups and 11 outliers were found. Based on the validation requirement, removing outliers and testing subset are the two key validation processes in the following steps.

3.1.3 Assumptions

If correlations between variables were not high enough, it is challenging to divide them into corresponding groups. Therefore, multicollinearity is desirable in factor analysis and four rules of thumb provide criterion to check whether this dataset is fit for factor analysis.

First of all, the p-value is significantly less than 0.05 and the value of KMO is greater than 0.5 (see Appendix B.1). Secondly, the number of correlation greater than 0.3 should account for a substantial amount. Correlation Matrix in Appendix B.2 demonstrates that 59 pairs satisfy the correlation requirement and occupies approximately one-third of 171 pairs in total. Moreover, both partial correlation and Measure of Sampling Accuracy (MSA) achieves by inspecting anti-image matrices in Appendix B.3. Merely one diagonal element violates the rule that individual correlations should be more than 0.5. For off-diagonal elements, values should be less than 0.7. Otherwise, they will fail to abide by the partial correlation standard. It is acceptable to have only five pairs with larger correlations. All in all, factor analysis is well suited and would be beneficial to adopt for this dataset.

3.1.4 Deriving factors and assessing

If five factors were used without rotation, the total variance explained using the maximum likelihood approach will be notably less than the principal component for around 10% (see Appendix C.1). Furthermore, the extraction of the principal component could take more variables into account for at least 50% of the variance explained (see Appendix C.2). Thus, the principal component extraction method was chosen.

Deciding the factor number on two primary reasons will be the issue discussed in the next phase. Firstly, five factors could explain more than 60% of the variance, and secondly, all of the top five factors are with eigenvalue exceeding one (see Appendix C.1).

Although using five factors is applicable, consideration of alternative factor numbers is called for to confirm the best structure had been identified. As a result (see Appendix C.1 and C.2), those tables present that the variance explained rise mildly by raising another factor. The stability to divide groups with the same variables is one of the checking points to select factor numbers. It will be further elaborated in the following interpretation part.

3.1.5 Interpretation

Based on Appendix C.4, no significant loading exists on “MinimapRightClicks” and “ComplexAbilitiesUsed”. Besides, cross-loading happened on “TotalHours”, “ActionsInPAC”, and “TotalMapExplored” before rotation. Hence, a summary of the factor matrix (see

Appendix C.3) displays the factor loadings with various rotation methods such as Varimax, Oblimin, Quartimax, Equamax, and Promax.

For five factors, nearly all variables are high loadings except for "WorkersMade", and the results are similar in both five and six factors. Nevertheless, the main difference is that the group components cannot be consistently categorized through different rotations and fail to maintain stability among the six factors. While the output of five factors delivers consistency, stability, no variables with insignificant loadings or extremely low commonalities, and even cross-loadings, Varimax and Equamax consider all variables; nonetheless, Varimax outweighs Equamax because Varimax has the higher correlations between factors and variables. Grouping variables into five factors by Varimax is the optimal way at this stage.

Varimax					
	Component				
	1	2	3	4	5
LeagueIndex	0.773				
Age					0.657
HoursPerWeek				0.793	
TotalHours				0.716	
APM	0.843				
SelectByHotkeys	0.728				
AssignToHotkeys	0.734				
UniqueHotkeys	0.572				
MinimapAttacks					0.577
MinimapRightClicks			0.608		
NumberOfPACs	0.836				
GapBetweenPACs	-0.639				
ActionLatency	-0.802				
ActionsInPAC			0.856		
TotalMapExplored		0.588			
WorkersMade			0.501		
UniqueUnitsMade		0.675			
ComplexUnitsMade		0.81			
ComplexAbilitiesUsed		0.776			

component 1	LeagueIndex	Proficiency
	APM	
	SelectByHotkeys	
	AssignToHotkeys	
	UniqueHotkeys	
	NumberOfPACs	
	GapBetweenPACs	
	ActionLatency	
component 2	TotalMapExplored	Strategy
	UniqueUnitsMade	
	ComplexUnitsMade	
	ComplexAbilitiesUsed	
component 3	MinimapRightClicks	Reaction Speed
	ActionsInPAC	
	WorkersMade	
component 4	HoursPerWeek	Spending Time
	TotalHours	
component 5	Age	Age
	MinimapAttacks	

Figure 1. Interpretation Table (5 Factors, Varimax Rotation, with Outliers)

Interpretation has an indispensable role to play in factor analysis, and all variables are summarized into five components in Figure 1. Factor 1 contains variables such as "LeagueIndex", "APM", "SelectByHotkeys", "AssignToHotkeys", "UniqueHotkeys", "NumberOfPACs", "GapBetweenPACs", and "ActionLatency". Proficiency is representative of Factor 1. Whether the gamers are familiar with manipulations in games is decisive. Factor 2 with "TotalMapExplored", "UniqueUnitsMade", "ComplexUnitsMade", "ComplexAbilitiesUsed" could be interpreted as a strategy. Unique soldiers, complex instructions, and map exploration for specific reason are the keys to success. Factor 3 is a composite of "MinimapRightClicks", "ActionsInPAC", and "WorkersMade". It might be problematic to use a mini-map to move or attack because a mini-map is tiny and deteriorates incorrect click probability to the false position. Consequently, it is difficult to swiftly respond or accurately act to incidents without outstanding reaction speed. Factor 4, which includes "HoursPerWeek" and "TotalHours", specifies the spending time on the video game. Factor 5 is the trickiest one with two seemingly irrelevant attributes "Age" and "MinimapAttacks". "Age" is not highly correlated to other variables and it might be a potential issue in this dataset. It is preferable to reach an expert for assistance to explain whether "Age" and "MinimapAttacks" are relevant.

3.1.6 Validation

Owing to identify influential outliers, validation through removing outliers was attempted to decide if removing outliers will enhance stability by examining factor matrix. Apart from the slight increase in correlations between factors and attributes, the output (see Appendix D.1) resembles that of Appendix C.3. No changes in interpretation should be revised because of the same components within five-factor groups when outliers were not removed.

On the other hand, observations were randomly selected at 70% of the full dataset as a new

subset to validate the stability of model. Five factors, principal component extraction, no outliers, and Varimax rotation method were set up (see Appendix D.2). It adequately splits variables into five groups and the group components are as same as the analysis in Appendix D.1. Even though the correlation of "MinimapAttacks" and factor 5 is about 0.475, the result seems fit, and the stability virtually exists in this dataset.

3.1.7 Additional use

The final result of factor analysis was used before clustering for identifying the sets of players.

3.1.8 Conclusion

In conclusion, the stability, eigenvalues, factor loadings, cross-loadings, interpretation of factors, and many possible triggers were considered in factor analysis. Ultimately, the best combination of five factors was selected, eliminating outliers, the extraction method of principal component, and the Varimax rotation could sufficiently and systematically categorize data and identify the underlying structure of the dataset.

3.2 Identifiable sets of players (Question 2)

3.2.1 Problem Definition

The purpose of this problem is to identify sets or groups of players within the given data. Although players are assigned to seven expert levels, such an index cannot reflect all their group features. Therefore, Cluster Analysis was carried out to identify their characteristics.

In the given dataset, 19 variables were adopted to conduct cluster analysis apart from "GameID", because it is assumed that this variable cannot indicate any features of game players.

3.2.2 Pre-analysis Decisions

As mentioned in data preparation (Part 2), there is one missing value in the dataset. The observation was kept testing whether the missing value would affect the result. During the process of detecting outliers (see Appendix A.4), 11 observations were found and were kept in the first trial and in analysis including Factor Analysis, hierarchical and non-hierarchical cluster analysis. Finally, it was found that a cluster contains only two observations (see Appendix E.1), meaning that the outliers have a significant influence on the result. Therefore, the final analysis was conducted without the 11 outliers.

3.2.3 Check Assumptions and Standardize the Data

After checking the assumptions of multicollinearity in Question 3 (see Appendix B.2), multicollinearity was found in the data, which may have significant impact on the cluster analysis result. In such case, the result of factor analysis (see Part 3.1.5) can be applied here to remove the correlation between variables as it will be convenient to interpret the clustering result based on the factor analysis.

From factor analysis' outcome (see Part 3.1.4), the first 5 FACs, whose eigenvalue is greater than 1, were chosen to carry out further cluster analysis. Data standardization is not required since the variables generated by factor analysis are homoscedastic.

3.2.4 Choose Similarity Measure and Create Clusters

Due to the advantages of combining hierarchical and non-hierarchical procedures, both methods were applied to decide an appropriate cluster. Due to the 5 FACs are continuous variables, squared Euclidean distance was chosen as the distance measure.

By trying different linkage methods, it was found that most methods except for "furthest neighbour" lead to one cluster containing more than 90% of observations. Therefore, the "furthest neighbour" method was chosen.

3.2.5 Execute Cluster, Compare Results and Choose Solution

The result of carrying hierarchical technique is as following.

Agglomeration Schedule

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage	Diff. between Coef.	No. of cluster
	Cluster 1	Cluster 2		Cluster 1	Cluster 2			
675	5	6	28.333	664	657	676		10
676	5	15	36.043	664	668	679	7.710	9
677	21	24	36.636	670	662	679	0.593	8
678	2	3	37.721	672	661	681	1.085	7
679	5	21	48.954	676	677	681	11.233	6
680	1	4	49.836	671	667	683	0.882	5
681	2	5	57.265	678	679	682	7.429	4
682	2	8	68.118	681	674	684	10.853	3
683	1	7	77.991	680	673	684	9.873	2
684	1	2	100.305	683	682	0	22.314	1

Figure 1. The Agglomeration Schedule of Hierarchical Method

It is apparent that six clusters can be set since the difference between coefficients (11.233) is the highest in Figure 2. After confirming the number of clusters, k-means was used as the non-hierarchical solution and reset the initial cluster centres by calculating the solution chosen from hierarchical cluster results (see Appendix E.2). The result is as follows.

Cluster 4 has the leading number of observations (260), follows by Cluster 1 (141) and Cluster 2 (125). Meanwhile, 83 observations are assigned to Cluster 5, 59 observations belong to Cluster 3 and Cluster 6 has 17 observations (see Appendix E.3). In Appendix E.5, the table illustrates the cluster membership for each observation except outliers.

According to Final Cluster Center Table (see Appendix E.4), Cluster 1 has the highest value (1.11) of FAC 1, and Cluster 2 has the largest (1.17) of FAC 3. Meanwhile, Cluster 3 is affected more by FAC 4 (2.23), while Cluster 4 lies in the middle. FAC 2 has a great impact (1.82) on Cluster 5. Cluster 6 is heavily influenced by FAC 4 (1.54) and FAC 5 (2.76).

The ANOVA table (see Appendix E.6) illustrates that all FACs have significance ($p < 0.0001$) in determining cluster solutions for each player. Consequently, "Distances between Final Cluster Centres" (see Appendix E.7) demonstrates that the distance between Cluster 5 and Cluster 6 is the highest (4.333), which means that they have the highest divergence. Meanwhile, Cluster 2 and Cluster 3 are more similar than others because of the distances at 1.897.

3.2.6 Validate and Profile Cluster Solution

3.2.6.1 Validate

To validate the clustering result, 477 samples were randomly selected, which is around 70% of the population. The subset's cluster result was then compared with the total dataset's, 415 observations (87.2%) were allocated to the same cluster, meaning that the cluster solution is stable (Appendix E.8 & E.9).

3.2.6.2 Profile Cluster Solution

Based on the table "Final Cluster Centres" (see Appendix E.4) and "Scatter Plots" (see Figure 4 & Appendix E.10), the characteristics of each cluster can be described. Considering our results in Question 3 (Part 3.1.5), the brief interpretation of all clusters is as following (Figure 3).

Clusters	Interpreted Group	Distinguishable Features
Cluster1	Semi Advanced Players	Medium high expert level; Prefer fast game strategy
Cluster2	Common Middle Players	Medium in most factors
Cluster3	Loyal Players	Spend long time playing the game
Cluster4	Common Players	Medium and low level in most factors
Cluster5	Late Strategy Players	Prefer late game strategy
Cluster6	Old and Loyal Players	Old in age; Spend long time playing the game

Figure 3. Interpretation of Every Cluster

Cluster 1 is interpreted as semi-advanced players because the majority of them are in medium-high expert level. This group of players also prefer fast game strategy, where players will not spend time exploring the map or making advanced weapons but focus on defeating enemies as soon as possible using whatever weapons they have.

Cluster 2, the common middle players, includes individuals who are mostly medium in most factors, meaning that they are not as professional as players in cluster 1 but are better than common players.

Cluster 3 is regarded as a group of loyal players who spend a long time playing this game. They are likely to have started playing the game since it was first released. However, they are average in other factors.

Cluster 4 has the greatest number of observations. Players who belong to this cluster are in medium and low level in most factors. Players in this cluster are treated as common players, who play this game for leisure.

Cluster 5 includes players who prefer the late-game strategy. It means that players tend to develop their economy and resource first, such as soldiers, weapons and map exploration, before attacking their enemies. Therefore, this cluster is called late strategy players.

With the least number of players, ***Cluster 6*** is a group of aged players who spend long time playing the game like the players in Cluster 3. Thus, this cluster is defined as old and loyal players.

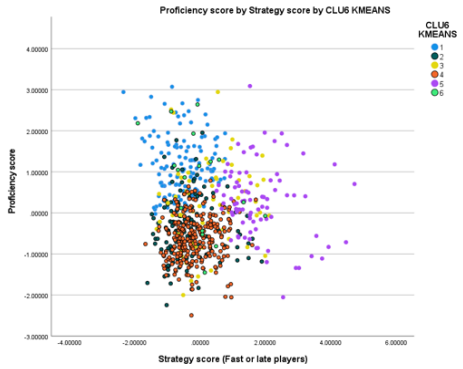

Figure 4. Scatter Plot of Proficiency Score by Strategy Score

3.2.7 Conclusion

hierarchical and non-hierarchical Cluster methods were combined to examine possible groupings of players. Six clusters were created by using the 5-factor scores generated in Question 3 after removing outliers. The cluster solution is stable. Meanwhile, the characteristics of players in these six clusters can be further interpreted.

4 Improve players' expert level (Question 1)

4.1 Objective

We are interested to know the key variables that significantly impact in predicting a player's expert level. The dependent variable is LeagueIndex and all the 18 variables are predictor variables, "GameID" does not contribute to the analysis. The objective of both the techniques is the same and the further steps are detailed below for each method.

4.2 Multiple Regression Analysis

4.2.1 Research Design

After removing the missing value (GameID 1064) and outliers as discussed previously, there are a total of 684 observations, which is more than the minimum requirement of 50 to carry out Multiple Regression (MR). The ratio of observations to variables is 39 to 1, which is greater than the required ratio of 15 to 1 for MR. The analysis was carried out with and without the outliers and model performance was checked.

4.2.2 Assumptions Check

Histograms and p-p plots were plotted for all the predictor variables (see Appendix F). Few variables like "UniqueHotKeys", "NumberOfPACs", show a fair normal distribution. As the other variables have a biased distribution, the normality assumption is not satisfied. We ran the initial analysis without transforming the variables. Examining the correlation matrix (see Appendix G), there are several correlations > 0.3, there is a multi-collinearity problem. The VIF values of APM, SelectByHotkeys and NumberOfPACs is very high (>10), tolerance is quite low (<0.01). As APM is highly correlated with many variables, we ran the analysis with and without APM.

We notice that all the scatter plots of the independent variables have a structure since the output variable is a nominal one. This is a violation of the assumption. Initially, we performed simple linear regression on all the 18 predictor variables to predict LeagueIndex individually, NumberOfPACs is the most significant variable (see Appendix H).

4.2.3 Regression Model and Assessing overall model fit

R^2 is the squared correlation (R) between the observed values of expert level and the level predicted by the model. From model summary (see Figure 5 & Appendix I), we can say that the variables together explain 65.7% of the variance in expert level.

S.No.	Variables	Method	Adj. R^2	Important variables
1	All 18 independent variables	Forced	0.648	AssignToHotkeys, NumberOfPACs
2	APM dropped	Forced	0.648	NumberOfPACs, AssignToHotkeys
Outliers removed				
S.No.	**Variables**	**Method**	**Adj. R^2**	**Important variables**
3	All 18 independent variables	Forced	0.657	APM, AssignToHotkeys
4	APM dropped	Forced	0.656	NumberOfPACs, AssignToHotkeys
5	APM dropped	Stepwise	0.657	ActionLatency, NumberOfPACs
5	Final model - Only important variables	Stepwise	0.657	ActionLatency, NumberOfPACs

Figure 5. Comparation of different regression analyses

For the Diagnostics check for the final model in Figure 6, firstly, the residuals have a fairly normal distribution. Secondly, there is multicollinearity in the dataset, the VIF for all the final predictor variables <10. Besides, for Homoscedastic of errors, there is no pattern in the scatter plot of error term and the predicted values of dependent variable, that suggest homoscedacity. The linear graph could be due to the dependent variable being categorical, rather than numeric and continuous. Finally, for Uncorrelated errors, Durbin Watson coefficient is 2.046, close to 2. Hence, the residual errors seem to be slightly correlated.

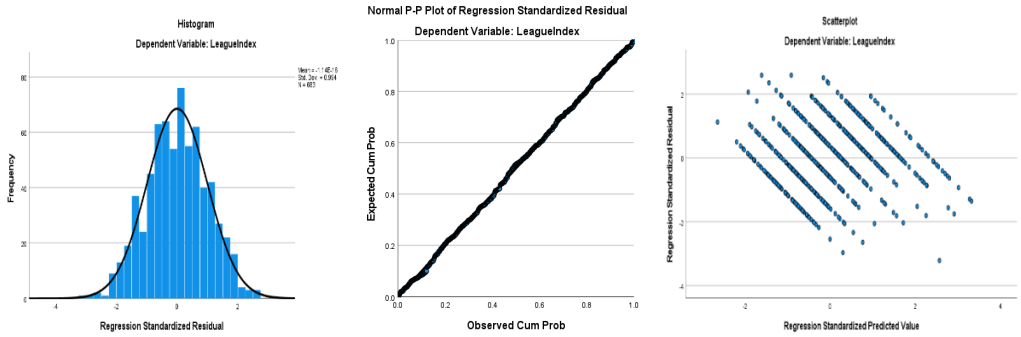

Figure 6. Residual plots of regression analysis

4.2.4 Interpretation

Based on the standardised beta values in Figure 7, the most important variables that affect the expert level are ActionLatency, followed by NumberOfPACs. We can interpret the results as follows.

1. ActionLatency (b = -0.015, β = -0.187, t=-3.911, p<0.05) – As the player's ActionLatency i.e., his reaction time to the first action increases, his LeagueIndex decreases
2. NumberOfPACs (b = 316.872, β = 0.179, t=4.028, p<0.05) – The β value indicates that as NumberOfPACs per timestamp increase for a player, his LeagueIndex improves

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
8	(Constant)	2.669	0.464		5.751	0.000		
	ActionLatency	-0.015	0.004	-0.187	-3.911	0.000	0.219	4.566
	AssignToHotkeys	1465.582	254.380	0.172	5.761	0.000	0.564	1.773
	TotalHours	0.000	0.000	0.145	5.722	0.000	0.784	1.276
	SelectByHotkeys	65.760	12.905	0.143	5.095	0.000	0.637	1.570
	MinimapAttacks	1716.326	331.220	0.124	5.182	0.000	0.879	1.137
	WorkersMade	356.614	86.316	0.103	4.131	0.000	0.805	1.243
	NumberOfPACs	316.872	78.665	0.179	4.028	0.000	0.255	3.916
	GapBetweenPACs	-0.010	0.003	-0.110	-3.487	0.001	0.504	1.985

a. Dependent Variable: LeagueIndex

Figure 7. Coefficients of final model

4.2.5 Validation

To counter the normality problem, we used log transformations on "Age", "HoursPerWeek", "TotalHours", "SelectByHotkeys", "GapbetweenPACs", "Workersmade", "Minimaprightclicks" and Square root transformation on "MinimapAttacks", "ComplexUnitsMade", "ComplexAbilitiesUsed". The rest of the variables remain the same. There is still a multicollinearity problem (see Appendix G), and the VIF for "UniqueUnitsMade" (VIF=95.35) and "RootComplexUnitsMade" (VIF=94.9). We will run the analysis with and without these variables.

S.No.	Variables	Method	Adj. R2	Most important variable	Beta value
3	All 18 independent variables	Forced	0.697	RootComplexUnitsMade	-0.758
4	APM dropped	Forced	0.694	RootComplexUnitsMade	-0.751
5	Dropping RootComplexUnitsMade as it's VIF is high	Forced	0.688	LogTotalHours, NumberOfPACs	0.225 0.218
5	Final model - Only important variables	Forward	0.689	NumberOfPACs	0.213

Figure 8. Regression analysis with transformed variables

The normal distribution has improved than before. The VIF for all these predictor variables is < 10, but there are correlation values > 0.3. there is no pattern in the scatter plot of error term and the predicted values of dependent variable, that suggest homoscedastic. The linear graph could be due to the dependent variable being categorical, rather than numeric and continuous. Durbin Watson coefficient is 2.046 (close to 2), the residual errors are uncorrelated.

The important variables from the final model are listed below. NumberOfPACs has the highest beta value, the most important feature affecting the player's LeagueIndex. The most important variables that significantly affect the expert level have not changed.

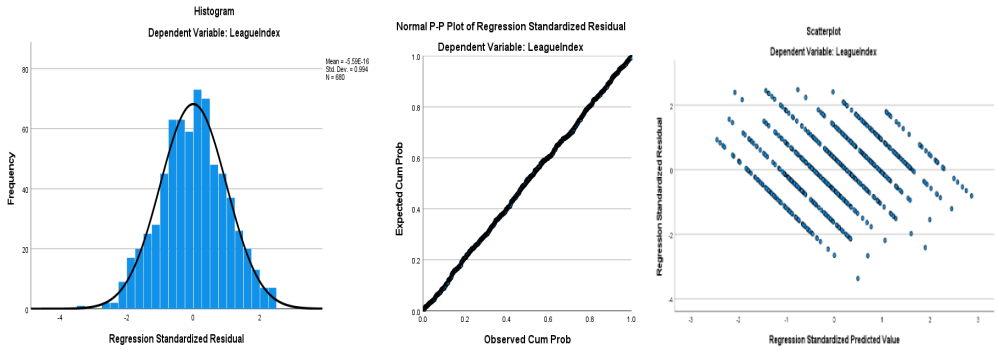

Figure 9. Residual plots of validation analysis

Coefficients[a]								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
8	(Constant)	6.173	0.860		7.176	0.000		
	NumberOfPACs	361.722	74.562	0.205	4.851	0.000	0.265	3.777
	LogSelectByHotkeys	0.593	0.103	0.181	5.743	0.000	0.474	2.111
	LogTotalHours	0.760	0.096	0.198	7.930	0.000	0.755	1.325
	LogGapBetweenPACs	-1.145	0.290	-0.120	-3.953	0.000	0.516	1.940
	RootMiniMapAttcks	38.871	6.891	0.132	5.641	0.000	0.856	1.169
	AssignToHotkeys	1017.385	263.534	0.119	3.861	0.000	0.493	2.027
	LogWorkersMade	0.676	0.209	0.083	3.228	0.001	0.721	1.387
	ActionLatency	-0.010	0.004	-0.121	-2.646	0.008	0.224	4.455
a. Dependent Variable: LeagueIndex								

Figure 10. Coefficients of validation model

To further validate the model (5), we split the data into training and test data with 50/50 ratio. R^2 for the testing set (unselected) is $(0.786)^2$ is 61.7%, for training set (selected) is 68.9%. The difference between them is 7.2%, which is greater than recommended 2%. On contrary, we notice from the coefficient matrix that all the variables significantly affect the expert level

(Appendix J).

4.3 Multiple Discriminant Analysis

Discriminant Analysis is to determine group membership of samples from dependent predictor by finding the linear combinations of the independent variables (Brown, 1998). Our objective is to determine the attributes that affect the players' expert level and understand the difference between different expert groups.

4.3.1 Data Selection

Players are spread into seven different expert levels ranging from "1" or "Bronze" to "7" or "Professional". The data is exclusive (Each player belongs to only one level) and exhaustive (there are only 7 levels and data represents all the existing levels). The ratio of observations over independent variables is 684: 18, which meets the minimum ratio requirement of Multiple Discriminant Analysis (MDA). However, there is an ill-conditioned problem for variable "APM" (see Appendix K). APM stands for Actions Per Minute, which explains the cognitive ability of the players. It is highly correlated by other variables such as "UniqueHotkeys", which also captures the player's cognitive abilities. Hence, dropping "APM" would be necessary for further analyses.

4.3.2 Assumptions

Based on previous studies by Eisenbeis (1978), five assumptions are required by MDA application: (1) multivariate normality, (2) absence of outliers, (3) no multicollinearity, (4) homoscedasticity and (5) homogeneity of variance-covariance matrices. In this case, most of the assumptions are violated (see Appendix L). Only half of the variables follow normal distribution. The outliers were removed as mentioned in data preparation (see Part 2). There are multicollinearity problems (see Appendix L.2). As variance of each group has significant difference (see Appendix L.3), the homoscedasticity assumption is violated. Finally, Box'M test shows the assumption of homogeneity of variance-covariance is also violated, $p < 0.01$ (see Appendix L.4). This analysis was estimated with comparison to the evaluation results as follows.

4.3.3 Model estimation

To discover the best classification performance in MDA (see Appendix M), seven expert levels were combined into three groups. The criterion of grouping is based on the group centroids (see Appendix N) and the classification accuracy can be improved by obtaining the best subset of relevant predictors (Iduseri& Osemwenkhae, 2018). In this case, grouping seven different expert levels into three groups gives the best performance (see Figure 11).

Summary of Classification results

		7 expert levels	4 expert levels	3 expert levels
Include 'APM'	selected original correctly classified	40.40%	69.60%	81.60%
	unselected original correctly classified	35.80%	71.00%	78.80%
	cross-validated correctly classified	35.50%	67.10%	81.00%
Remove 'APM'	selected original correctly classified	45.50%	73.00%	85.00%
	unselected original correctly classified	34.20%	68.40%	77.70%
	cross-validated correctly classified	40.20%	72.00%	83.70%

In this table, **7 expert levels** is same as the original grouping as in 'LeagueIndex'.
For **4 expert levels**, we group 'Bronze', 'Silver' and 'Gold' as level 1, 'Platinum' as level 2, put 'Diamond' and 'Master' together as level 3, and 'professional' as level 4.
For **3 expert levels**, we group 'Bronze' to 'Platinum' as level 1, 'Diamond' and 'Mater' as level 2 and 'professional' as level 3

Figure 11. Comparation of different grouping methods

4.3.4 Model fit and interpretation

The Canonical Discriminant Functions are

$$f_1(x) = -6.115 + 0.001x_1 + 85.989x_2 + 1645.543x_3 + 3319.394x_4 + 1030.493x_5 + 0.012x_6 + 0.173x_7 + 25.386x_8 - 0.057x_9 \quad (1)$$

$$f_2(x) = -4.364 + 0.02x_2 - 152.306x_3 + 4773.693x_4 + 0.005x_5 + 0.047x_6 - 0.122x_7 - 759.339x_8 - 4327.571x_9 \quad (2)$$

where x_1 is 'TotalHours', x_2 is 'SelectByHotkeys', x_3 is "AssignToHotKeys", x_4 is "MinimapAttacks", x_5 is "NumberOfPACs", x_6 is "ActionLatency", x_7 is "ActionInPAC", x_8 is "WorkersMade", x_9 "UniqueUnitsMade". Two discriminant functions are explaining 100% variances, 92% are explained by function (1), 8% are explained by function (2). Wilks' Lambda test denote that function (1) and (2) both significantly distinguish the differences between groups of expert levels.

Based on classification results in Figure 12, the accuracy of correctly classifying is 85%. The right scatter plot in Figure 12 classifies the different groups based on the two Canonical Discriminant Functions, three groups with their centroid are separated by the colour blue, red and green. Misclassifications are shown in the scatter plot, the number of misclassified cases is displayed in the result tables, for instance, there are 23 players of group 1 that are incorrectly predicted into group 2. Players will classify into the groups with higher classification scores (see Appendix O), which might incur misclassifications.

Classification Results[a,b,d]

			League Index	Predicted Group Membership			
				1	2	3	Total
Cases Selected	Original	Count	1	301	23	0	324
			2	41	105	4	150
			3	0	6	12	18
		%	1	92.9	7.1	0	100
			2	27.3	70	2.7	100
			3	0	33.3	66.7	100
	Cross-validated[c]	Count	1	299	25	0	324
			2	44	102	4	150
			3	0	7	11	18
		%	1	92.3	7.7	0	100
			2	29.3	68	2.7	100
			3	0	38.9	61.1	100
Cases Not Selected	Original	Count	1	116	9	1	126
			2	19	28	7	54
			3	0	7	6	13
		%	1	92.1	7.1	0.8	100
			2	35.2	51.9	13	100
			3	0	53.8	46.2	100

a. 85.0% of selected original grouped cases correctly classified.
b. 77.7% of unselected original grouped cases correctly classified.
c. Cross validation is done only for those cases in the analysis.
d. 83.7% of selected cross-validated grouped cases correctly classified.

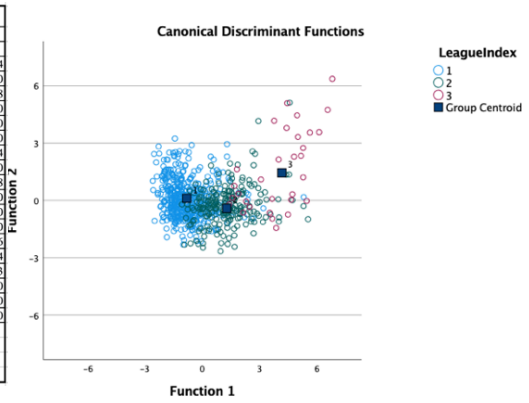

Figure 12. Classification Results from Discriminant Functions

From the effect of attributes in Figure 14, "NumberOfPACs" is the most important variable and positively relates to the expert levels. Second important variable is "Total Hours". That means that the speed of actions and the total playing hours of players spent on both highly affects players' expert level. Likewise, most of the variables are positively related to players' expert levels except "UniqueUnitMade".

Summary of important variables

	with 'APM'						without 'APM'					
Importance	7 experts levels	Standardized Canonical Discriminant	4 experts levels	Standardized Canonical Discriminant	3 experts levels	Standardized Canonical Discriminant	7 experts levels	Standardized Canonical Discriminant	4 experts levels	Standardized Canonical Discriminant	3 experts levels	Standardized Canonical Discriminant
1	APM	0.588	APM	0.509	APM	0.436	NumberOfPACs	0.483	NumberOfPACs	0.679	NumberOfPACs	0.743
2	MinimapAttacks	0.339	NumberOfPACs	0.446	NumberOfPACs	0.375	TotalHours	0.352	TotalHours	0.372	TotalHours	0.349
3	AssignToHotkeys	0.299	MinimapAttacks	0.349	MinimapAttacks	0.336	SelectByHotkeys	0.341	AssignToHotkeys	0.3	MinimapAttacks	0.321
4	ActionLatency	-0.284	AssignToHotkeys	0.233	AssignToHotkeys	0.276	AssignToHotkeys	0.326	MinimapAttacks	0.298	AssignToHotkeys	0.28
5	TotalHours	0.257	TotalHours	0.228	TotalHours	0.243	MinimapAttacks	0.282	SelectByHotkeys	0.276	SelectByHotkeys	0.275
6	ActionsInPAC	-0.252	ActionLatency	0.139	Workersmade	0.126	GapBetweenPACs	-0.192	ActionsInPAC	0.244	ActionsInPAC	0.232
7	Workersmade	0.139	ComplexUnitsMade	-0.108	HoursPerWeek	-0.017	ActionsInPAC	0.102	ActionLatency	0.097	ActionLatency	0.2
8	HoursPerWeek	-0.016	Workersmade	0.081	ActionLatency	-0.016	WorkersMade	0.085	HoursPerWeek	-0.071	UniqueUnitsMade	-0.102
9	/	/	/	/	GapBetweenPACs	-0.192	HoursPerWeek	-0.063	UniqueUnitsMade	-0.054	WorkersMade	0.014
10	/	/	/	/	/	/	/	/	WorkersMade	0.048	/	/

Figure 13. Importance of variables

4.3.5 Model validation

Many studies adopt leave-one-out cross-validation to evaluate the performance of a classification algorithm (Wong, 2015). In this case, results from cross-validation are similar to the original (see Figure 13), it correctly classified 83.7% of total cases.

4.4 Conclusion

In this part, Regression Analysis and Discriminant Analysis were used to discover the imperative variables that might affect players' expert levels and their importance. Chiefly, most of the attributes are positively related to expert levels, higher speeds of every action such as assigning to Hotkeys and attacking actions on Mini-map will lead to a higher expert level. Besides, "NumberOfPACs" is an important variable based on both methods. Therefore, players with higher numbers of possessing and actions per timestamp will have a higher level, which indicates that players need to focus on quicker possessing and actions during the game, which is beneficial to improving their expert levels.

5 Summary

To summarize, prior to handling with any specific problems, understanding data structure is critical. The given dataset was thoroughly inspected through factor analysis and five factor groups were generated with stability and reasonable interpretations. Based on the result of that, five groups were used in clustering players by characteristics. Eventually, six groups were identified and effectively separated gamers into corresponding groups. The attribute that is decisive for classifying the expert level was identified through Regression and Discriminant analysis. These two techniques indeed provided useful information of which the variable 'NumberOfPACs' has a noticeable impact on expert level with positive correlation.

6 References

1. Altman, Edward I & Eisenbeis, Robert A, 1978. Financial Applications of Discriminant Analysis: A Clarification. Journal of financial and quantitative analysis, 13(1), pp.185–195.
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3. Iduseri, A & Osemwenkhae, J E, 2018. A New Approach for Improving Classification Accuracy in Predictive Discriminant Analysis. Annals of data science, 5(3), pp.339–357.
4. Mihalovič, Matúš 2016. Performance comparison of multiple discriminant analysis and logit models in bankruptcy prediction. Economics & sociology, 9(4), pp.101–118.
5. Wong, Tzu-Tsung, 2015. Performance evaluation of classification algorithms by k-fold and leave-one-out cross validation. Pattern recognition, 48(9), pp.2839–2846.

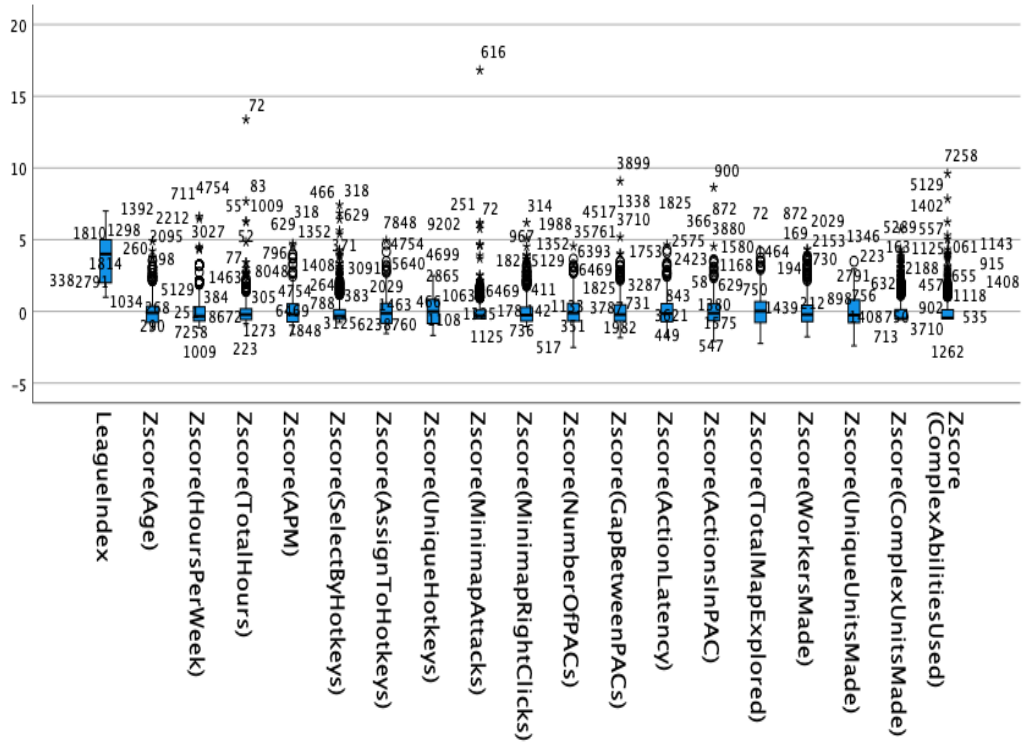
7 Appendices

Appendix A – Data preparation

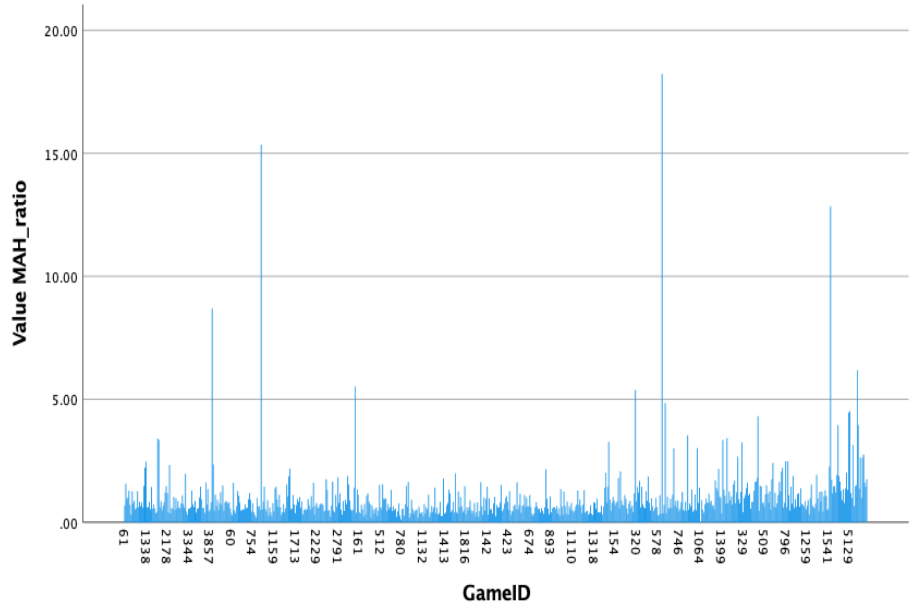
A.1 Variable Review in SPSS

	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
1	GameID	Numeric	4	0		None	None	8	Right	Nominal	Input
2	LeagueIndex	Numeric	1	0		None	None	8	Right	Ordinal	Input
3	Age	Numeric	2	0		None	None	8	Right	Scale	Input
4	HoursPerWeek	Numeric	2	0		None	None	8	Right	Scale	Input
5	TotalHours	Numeric	5	0		None	None	8	Right	Scale	Input
6	APM	Numeric	8	5		None	None	8	Right	Scale	Input
7	SelectByHotkeys	Numeric	11	4		None	None	17	Right	Scale	Input
8	AssignToHotkeys	Numeric	11	4		None	None	17	Right	Scale	Input
9	UniqueHotkeys	Numeric	2	0		None	None	8	Right	Scale	Input
10	MinimapAttacks	Numeric	11	4		None	None	16	Right	Scale	Input
11	MinimapRightClicks	Numeric	11	4		None	None	20	Right	Scale	Input
12	NumberOfPACs	Numeric	11	9		None	None	14	Right	Scale	Input
13	GapBetweenPACs	Numeric	8	4		None	None	8	Right	Scale	Input
14	ActionLatency	Numeric	8	4		None	None	8	Right	Scale	Input
15	ActionsInPAC	Numeric	7	4		None	None	8	Right	Scale	Input
16	TotalMapExplored	Numeric	2	0		None	None	8	Right	Scale	Input
17	WorkersMade	Numeric	10	3		None	None	13	Right	Scale	Input
18	UniqueUnitsMade	Numeric	2	0		None	None	8	Right	Scale	Input
19	ComplexUnitsMade	Numeric	11	4		None	None	18	Right	Scale	Input
20	ComplexAbilitiesUsed	Numeric	10	3		None	None	22	Right	Scale	Input

A.2 Boxplot – z-score



A.3 Mahalanobi's Distance



A.4 Outliers

GameID	MAH_1	MAH_ratio
616	328.29116	18.24
900	276.28554	15.35
72	231.13564	12.84
3899	156.48858	8.69
7258	111.27669	6.18
83	99.48543	5.53
318	96.81833	5.38
629	87.28560	4.85
5129	81.55378	4.53
4754	80.21701	4.46
466	77.65490	4.31

Appendix B – Assumption of Factor Analysis

B.1- KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.752
Bartlett's Test of Sphericity	Approx. Chi-Square	7787.445
	df	171
	Sig.	0.000

B.2 Correlation Matrix

Correlation Matrix

		League Index	Age	Hours Per Week	Total Hours	APM	Select By Hotkeys	Assign To Hotkeys	Unique Hotkeys	Minimap Attacks	Minimap Right Clicks	Number Of PACs	Gap Between PACs	Action Latency	Actions In PAC	Total Map Explored	Workers Made	Unique Units Made	Complex Units Made	Complex Abilities Used
Correlation	LeagueIndex	1.000	-0.137	0.250	0.476	0.730	0.549	0.614	0.362	0.376	0.281	0.702	-0.569	-0.703	0.154	0.336	0.421	0.212	0.235	0.223
	Age	-0.137	1.000	-0.205	-0.034	-0.201	-0.114	-0.119	0.008	0.061	-0.046	-0.179	0.127	0.241	-0.084	-0.013	-0.108	0.011	-0.100	-0.073
	HoursPerWeek	0.250	-0.205	1.000	0.462	0.295	0.258	0.211	0.125	0.091	0.070	0.254	-0.172	-0.238	0.070	0.106	0.111	0.098	0.078	0.030
	TotalHours	0.476	-0.034	0.462	1.000	0.408	0.312	0.309	0.200	0.256	0.112	0.418	-0.285	-0.390	0.054	0.230	0.218	0.156	0.143	0.106
	APM	0.730	-0.201	0.295	0.408	1.000	0.808	0.610	0.387	0.312	0.362	0.749	-0.616	-0.776	0.407	0.302	0.511	0.176	0.257	0.203
	SelectByHotkeys	0.549	-0.114	0.258	0.312	0.808	1.000	0.528	0.365	0.193	0.120	0.520	-0.329	-0.464	0.119	0.179	0.280	0.108	0.139	0.102
	AssignToHotkeys	0.614	-0.119	0.211	0.309	0.610	0.528	1.000	0.467	0.278	0.183	0.579	-0.442	-0.534	0.099	0.261	0.307	0.165	0.249	0.228
	UniqueHotkeys	0.362	0.008	0.125	0.200	0.387	0.365	0.467	1.000	0.191	0.108	0.427	-0.201	-0.342	-0.051	0.327	0.188	0.297	0.179	0.145
	MinimapAttacks	0.376	0.061	0.091	0.256	0.312	0.193	0.278	0.191	1.000	0.216	0.269	-0.259	-0.265	0.120	0.248	0.125	0.138	0.073	0.061
	MinimapRightClicks	0.281	-0.046	0.070	0.112	0.362	0.120	0.183	0.108	0.216	1.000	0.231	-0.289	-0.302	0.358	0.157	0.269	0.133	0.122	0.121
	NumberOfPACs	0.702	-0.179	0.254	0.418	0.749	0.520	0.579	0.427	0.269	0.231	1.000	-0.540	-0.833	-0.141	0.479	0.354	0.318	0.282	0.257
	GapBetweenPACs	-0.569	0.127	-0.172	-0.285	-0.616	-0.329	-0.442	-0.201	-0.259	-0.289	-0.540	1.000	0.688	-0.363	-0.099	-0.348	-0.067	-0.117	-0.152
	ActionLatency	-0.703	0.241	-0.238	-0.390	-0.776	-0.464	-0.534	-0.342	-0.265	-0.302	-0.833	0.688	1.000	-0.179	-0.386	-0.404	-0.249	-0.276	-0.260
	ActionsInPAC	0.154	-0.084	0.070	0.054	0.407	0.119	0.099	-0.051	0.120	0.358	-0.141	-0.363	-0.179	1.000	-0.112	0.357	-0.099	0.079	0.058
	TotalMapExplored	0.336	-0.013	0.106	0.230	0.302	0.179	0.261	0.327	0.248	0.157	0.479	-0.099	-0.386	-0.112	1.000	0.100	0.579	0.334	0.284
	WorkersMade	0.421	-0.108	0.111	0.218	0.511	0.280	0.307	0.188	0.125	0.269	0.354	-0.348	-0.404	0.357	0.100	1.000	0.087	0.185	0.099
	UniqueUnitsMade	0.212	0.011	0.098	0.156	0.176	0.108	0.165	0.297	0.138	0.133	0.318	-0.067	-0.249	-0.099	0.579	0.087	1.000	0.381	0.330
	ComplexUnitsMade	0.235	-0.100	0.078	0.143	0.257	0.139	0.249	0.179	0.073	0.122	0.282	-0.117	-0.276	0.079	0.334	0.185	0.381	1.000	0.615
	ComplexAbilitiesUsed	0.223	-0.073	0.030	0.106	0.203	0.102	0.228	0.145	0.061	0.121	0.257	-0.152	-0.260	0.058	0.284	0.099	0.330	0.615	1.000

B.3 Anti-image Matrices

Anti-image Matrices

		League Index	Age	Hours Per Week	Total Hours	APM	Select By Hotkeys	Assign To Hotkeys	Unique Hotkeys	Minimap Attacks	Minimap Right Clicks	Number Of PACs	Gap Between PACs	Action Latency	Actions In PAC	Total Map Explored	Workers Made	Unique Units Made	Complex Units Made	Complex Abilities Used
anti-imge Correltion	LegueIndex	0.953	0.007	0.045	-0.215	-0.057	-0.025	-0.216	0.017	-0.168	-0.041	-0.029	0.124	0.113	0.043	-0.038	-0.124	0.005	0.022	-0.043
	ge	0.007	0.714	0.197	-0.121	0.060	-0.059	0.030	-0.079	-0.099	-0.030	-0.035	0.074	-0.139	-0.031	-0.043	-0.008	-0.037	0.042	0.011
	HoursPerWeek	0.045	0.197	0.771	-0.407	-0.007	-0.030	-0.030	-0.002	0.031	0.000	-0.023	0.002	-0.034	-0.024	0.025	0.050	-0.056	-0.002	0.049
	TotlHours	-0.215	-0.121	-0.407	0.859	0.008	-0.007	0.033	0.019	-0.094	0.051	-0.042	-0.018	0.015	-0.013	-0.023	-0.027	0.003	-0.020	0.009
	PM	-0.057	0.060	-0.007	0.008	0.653	-0.919	0.084	-0.013	-0.125	-0.139	-0.798	-0.055	0.138	-0.866	0.021	-0.183	0.077	-0.060	0.094
	SelectByHotkeys	-0.025	-0.059	-0.030	-0.007	-0.919	0.538	-0.154	-0.036	0.126	0.165	0.681	0.004	-0.147	0.758	0.015	0.179	-0.064	0.061	-0.068
	ssignToHotkeys	-0.216	0.030	-0.030	0.033	0.084	-0.154	0.927	-0.267	-0.075	0.011	-0.139	0.084	-0.038	-0.092	0.018	-0.020	0.075	-0.073	-0.051
	UniqueHotkeys	0.017	-0.079	-0.002	0.019	-0.013	-0.036	-0.267	0.925	-0.023	0.002	-0.026	-0.029	-0.006	0.029	-0.073	-0.037	-0.142	0.010	0.022
	Minimpttcks	-0.168	-0.099	0.031	-0.094	-0.125	0.126	-0.075	-0.023	0.855	-0.076	0.095	0.067	-0.068	0.077	-0.133	0.092	-0.008	0.031	0.031
	MinimpRightClicks	-0.041	-0.030	0.000	0.051	-0.139	0.165	0.011	0.002	-0.076	0.923	0.027	-0.008	-0.041	-0.033	-0.022	-0.013	-0.072	0.034	-0.029
	NumberOfPCs	-0.029	-0.035	-0.023	-0.042	-0.798	0.681	-0.139	-0.026	0.095	0.027	0.656	0.133	0.264	0.873	-0.138	0.030	-0.053	0.026	-0.087
	GpBetweenPCs	0.124	0.074	0.002	-0.018	-0.055	0.004	0.084	-0.029	0.067	-0.008	0.133	0.905	-0.314	0.203	-0.217	-0.048	0.013	-0.087	0.022
	ctionLtency	0.113	-0.139	-0.034	0.015	0.138	-0.147	-0.038	-0.006	-0.068	-0.041	0.264	-0.314	0.937	0.037	0.066	-0.059	0.014	0.009	0.026
	ctionsInPC	0.043	-0.031	-0.024	-0.013	-0.866	0.758	-0.092	0.029	0.077	-0.033	0.873	0.203	0.037	0.249	-0.049	-0.005	-0.029	0.011	-0.097
	TotlMpExplored	-0.038	-0.043	0.025	-0.023	0.021	0.015	0.018	-0.073	-0.133	-0.022	-0.138	-0.217	0.066	-0.049	0.835	0.088	-0.427	-0.064	-0.016
	WorkersMde	-0.124	-0.008	0.050	-0.027	-0.183	0.179	-0.020	-0.037	0.092	-0.013	0.030	-0.048	-0.059	-0.005	0.088	0.922	-0.039	-0.070	0.063
	UniqueUnitsMde	0.005	-0.037	-0.056	0.003	0.077	-0.064	0.075	-0.142	-0.008	-0.072	-0.053	0.013	0.014	-0.029	-0.427	-0.039	0.796	-0.163	-0.091
	ComplexUnitsMde	0.022	0.042	-0.002	-0.020	-0.060	0.061	-0.073	0.010	0.031	0.034	0.026	-0.087	0.009	0.011	-0.064	-0.070	-0.163	0.767	-0.533
	ComplexbilitiesUsed	-0.043	0.011	0.049	0.009	0.094	-0.068	-0.051	0.022	0.031	-0.029	-0.087	0.022	0.026	-0.097	-0.016	0.063	-0.091	-0.533	0.737

a. Measures of Sampling Adequacy(MSA)

Appendix C – Comparation of results for Factor Analysis (5 factors)

C.1 Total Variance Explained (5 factors vs. 6 factors)

Total Variance Explained Summary

Factor	Initial Eigenvalues			Extraction Method - **Principal Component**					
				5 Factors			6 Factors		
	Total	% of Variance	Cumulative %	Extraction Sums of Squared Loadings			Extraction Sums of Squared Loadings		
				Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.394	33.655	33.655	6.394	33.655	33.655	6.394	33.655	33.655
2	1.983	10.438	44.093	1.983	10.438	44.093	1.983	10.438	44.093
3	1.410	7.421	51.514	1.410	7.421	51.514	1.410	7.421	51.514
4	1.183	6.225	57.739	1.183	6.225	57.739	1.183	6.225	57.739
5	1.137	5.983	63.721	1.137	5.983	63.721	1.137	5.983	63.721
6	0.938	4.937	68.658				0.938	4.937	68.658
Factor	Initial Eigenvalues			Extraction Method - **Maximum Likelihood**					
				5 Factors			6 Factors		
	Total	% of Variance	Cumulative %	Extraction Sums of Squared Loadings			Extraction Sums of Squared Loadings		
				Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.394	33.655	33.655	3.501	18.425	18.425	5.671	29.848	29.848
2	1.983	10.438	44.093	3.067	16.143	34.568	1.178	6.199	36.046
3	1.410	7.421	51.514	1.434	7.547	42.115	0.994	5.230	41.277
4	1.183	6.225	57.739	1.384	7.282	49.396	1.454	7.653	48.930
5	1.137	5.983	63.721	0.592	3.114	52.510	0.611	3.218	52.147
6	0.938	4.937	68.658				0.504	2.652	54.799

C.2 Communalities (5 factors vs. 6 factors)

Communalities

Extraction Method - Principal Component						Extraction Method - Maximum Likelihood					
5 Factors			6 Factors			5 Factors			6 Factors		
	Initial	Extraction		Initial	Extraction		Initial	Extraction		Initial	Extraction
LeagueIndex	1.000	0.718	LeagueIndex	1.000	0.720	LeagueIndex	0.657	0.607	LeagueIndex	0.657	0.721
Age	1.000	0.556	Age	1.000	0.714	Age	0.117	0.063	Age	0.117	0.067
HoursPerWeek	1.000	0.698	HoursPerWeek	1.000	0.749	HoursPerWeek	0.248	0.114	HoursPerWeek	0.248	0.126
TotalHours	1.000	0.620	TotalHours	1.000	0.631	TotalHours	0.312	0.189	TotalHours	0.312	0.236
APM	1.000	0.876	APM	1.000	0.896	APM	0.972	0.987	APM	0.972	0.999
SelectByHotkeys	1.000	0.554	SelectByHotkeys	1.000	0.720	SelectByHotkeys	0.906	0.999	SelectByHotkeys	0.906	0.984
AssignToHotkeys	1.000	0.580	AssignToHotkeys	1.000	0.612	AssignToHotkeys	0.522	0.435	AssignToHotkeys	0.522	0.554
UniqueHotkeys	1.000	0.480	UniqueHotkeys	1.000	0.523	UniqueHotkeys	0.327	0.272	UniqueHotkeys	0.327	0.306
MinimapAttacks	1.000	0.554	MinimapAttacks	1.000	0.568	MinimapAttacks	0.188	0.140	MinimapAttacks	0.188	0.221
MinimapRightClicks	1.000	0.494	MinimapRightClicks	1.000	0.551	MinimapRightClicks	0.260	0.260	MinimapRightClicks	0.260	0.264
NumberOfPACs	1.000	0.830	NumberOfPACs	1.000	0.878	NumberOfPACs	0.928	0.981	NumberOfPACs	0.928	0.999
GapBetweenPACs	1.000	0.571	GapBetweenPACs	1.000	0.621	GapBetweenPACs	0.572	0.499	GapBetweenPACs	0.572	0.547
ActionLatency	1.000	0.768	ActionLatency	1.000	0.840	ActionLatency	0.826	0.805	ActionLatency	0.826	0.802
ActionsInPAC	1.000	0.746	ActionsInPAC	1.000	0.794	ActionsInPAC	0.838	0.917	ActionsInPAC	0.838	0.854
TotalMapExplored	1.000	0.637	TotalMapExplored	1.000	0.681	TotalMapExplored	0.492	0.689	TotalMapExplored	0.492	0.689
WorkersMade	1.000	0.437	WorkersMade	1.000	0.439	WorkersMade	0.351	0.318	WorkersMade	0.351	0.327
UniqueUnitsMade	1.000	0.622	UniqueUnitsMade	1.000	0.634	UniqueUnitsMade	0.420	0.522	UniqueUnitsMade	0.420	0.516
ComplexUnitsMade	1.000	0.717	ComplexUnitsMade	1.000	0.764	ComplexUnitsMade	0.423	0.610	ComplexUnitsMade	0.423	0.687
ComplexAbilitiesUsed	1.000	0.649	ComplexAbilitiesUsed	1.000	0.710	ComplexAbilitiesUsed	0.388	0.572	ComplexAbilitiesUsed	0.388	0.513

C.3 Factor Matrix with Rotation (5 factors vs. 6 factors)

Varimax					
	Component				
	1	2	3	4	5
LeagueIndex	0.77				
Age					0.66
HoursPerWeek				0.79	
TotalHours				0.72	
APM	0.84				
SelectByHotkeys	0.73				
AssignToHotkeys	0.73				
UniqueHotkeys	0.57				
MinimapAttacks					0.58
MinimapRightClicks			0.61		
NumberOfPACs	0.84				
GapBetweenPACs	-0.6				
ActionLatency	-0.8				
ActionsInPAC			0.86		
TotalMapExplored		0.59			
WorkersMade			0.5		
UniqueUnitsMade		0.68			
ComplexUnitsMade		0.81			
ComplexAbilitiesUsed		0.78			

Oblimin					
	Component				
	1	2	3	4	5
LeagueIndex	0.75				
Age				0.68	
HoursPerWeek					0.82
TotalHours					0.73
APM	0.84				
SelectByHotkeys	0.77				
AssignToHotkeys	0.75				
UniqueHotkeys	0.59				
MinimapAttacks				0.57	
MinimapRightClicks			0.59		
NumberOfPACs	0.83				
GapBetweenPACs	-0.7				
ActionLatency	-0.8				
ActionsInPAC			0.87		
TotalMapExplored		0.52			
WorkersMade					
UniqueUnitsMade		0.64			
ComplexUnitsMade		0.85			
ComplexAbilitiesUsed		0.81			

Quartimax					
	Component				
	1	2	3	4	5
LeagueIndex	0.82				
Age					0.66
HoursPerWeek				0.77	
TotalHours				0.68	
APM	0.9				
SelectByHotkeys	0.75				
AssignToHotkeys	0.75				
UniqueHotkeys	0.57				
MinimapAttacks					0.58
MinimapRightClicks				0.58	
NumberOfPACs	0.86				
GapBetweenPACs	-0.7				
ActionLatency	-0.8				
ActionsInPAC			0.85		
TotalMapExplored		0.56			
WorkersMade					
UniqueUnitsMade		0.66			
ComplexUnitsMade		0.8			
ComplexAbilitiesUsed		0.77			

Equamax					
	Component				
	1	2	3	4	5
LeagueIndex	0.68				
Age					0.59
HoursPerWeek				0.83	
TotalHours				0.72	
APM	0.74				
SelectByHotkeys	0.69				
AssignToHotkeys	0.68				
UniqueHotkeys	0.56				
MinimapAttacks					0.64
MinimapRightClicks			0.62		
NumberOfPACs	0.78				
GapBetweenPACs	-0.6				
ActionLatency	-0.7				
ActionsInPAC			0.85		
TotalMapExplored		0.57			
WorkersMade			0.55		
UniqueUnitsMade		0.65			
ComplexUnitsMade		0.83			
ComplexAbilitiesUsed		0.79			

Promax					
	Component				
	1	2	3	4	5
LeagueIndex	0.77				
Age					0.74
HoursPerWeek				0.89	
TotalHours				0.75	
APM	0.86				
SelectByHotkeys	0.82				
AssignToHotkeys	0.78				
UniqueHotkeys	0.63				
MinimapAttacks					0.6
MinimapRightClicks			0.64		
NumberOfPACs	0.87				
GapBetweenPACs	-0.68				
ActionLatency	-0.82				
ActionsInPAC			0.89		
TotalMapExplored		0.5			
WorkersMade					
UniqueUnitsMade		0.64			
ComplexUnitsMade		0.92			
ComplexAbilitiesUsed		0.88			

Varimax	
component 1	**component 2**
LeagueIndex	TotalMapExplored
APM	UniqueUnitsMade
SelectByHotkeys	ComplexUnitsMade
AssignToHotkeys	ComplexAbilitiesUsed
UniqueHotkeys	
NumberOfPACs	**component 4**
GapBetweenPACs	HoursPerWeek
ActionLatency	TotalHours
component 3	**component 5**
MinimapRightClicks	Age
ActionsInPAC	MinimapAttacks
WorkersMade	

Oblimin	
component 1	**component 2**
LeagueIndex	TotalMapExplored
APM	UniqueUnitsMade
SelectByHotkeys	ComplexUnitsMade
AssignToHotkeys	ComplexAbilitiesUsed
UniqueHotkeys	
NumberOfPACs	**component 4**
GapBetweenPACs	Age
ActionLatency	MinimapAttacks
component 3	**component 5**
MinimapRightClicks	HoursPerWeek
ActionsInPAC	TotalHours

Quartimax	
component 1	**component 2**
LeagueIndex	TotalMapExplored
APM	UniqueUnitsMade
SelectByHotkeys	ComplexUnitsMade
AssignToHotkeys	ComplexAbilitiesUsed
UniqueHotkeys	
NumberOfPACs	**component 4**
GapBetweenPACs	HoursPerWeek
ActionLatency	TotalHours
component 3	**component 5**
MinimapRightClicks	Age
ActionsInPAC	MinimapAttacks

Equamax	
component 1	**component 2**
LeagueIndex	TotalMapExplored
APM	UniqueUnitsMade
SelectByHotkeys	ComplexUnitsMade
AssignToHotkeys	ComplexAbilitiesUsed
UniqueHotkeys	
NumberOfPACs	**component 4**
GapBetweenPACs	HoursPerWeek
ActionLatency	TotalHours
component 3	**component 5**
MinimapRightClicks	Age
ActionsInPAC	MinimapAttacks
WorkersMade	

Promax	
component 1	**component 2**
LeagueIndex	UniqueUnitsMade
APM	ComplexUnitsMade
SelectByHotkeys	ComplexAbilitiesUsed
AssignToHotkeys	TotalMapExplored
UniqueHotkeys	
NumberOfPACs	**component 4**
GapBetweenPACs	HoursPerWeek
ActionLatency	TotalHours
component 3	**component 5**
MinimapRightClicks	Age
ActionsInPAC	MinimapAttacks

Varimax						
	Component					
	1	2	3	4	5	6
LeagueIndex	0.744					
Age						0.818
HoursPerWeek					0.821	
TotalHours					0.703	
APM	0.843					
SelectByHotkeys	0.771					
AssignToHotkeys	0.742					
UniqueHotkeys	0.587					
MinimapAttacks			0.493			
MinimapRightClicks		0.68				
NumberOfPACs	0.786					
GapBetweenPACs	-0.6					
ActionLatency	-0.75					
ActionsInPAC		0.783				
TotalMapExplored			0.73			
WorkersMade		0.504				
UniqueUnitsMade			0.662			
ComplexUnitsMade				0.841		
ComplexAbilitiesUsed				0.816		
component 1		**component 3**				
LeagueIndex		MinimapAttacks				
APM		TotalMapExplored				
SelectByHotkeys		UniqueUnitsMade				
AssignToHotkeys						
UniqueHotkeys		**component 4**				
NumberOfPACs		ComplexUnitsMade				
GapBetweenPACs		ComplexAbilitiesUsed				
ActionLatency						
		component 5				
component 2		HoursPerWeek				
MinimapRightClicks		TotalHours				
ActionsInPAC						
WorkersMade		**component 6**				
		Age				

Oblimin						
	Component					
	1	2	3	4	5	6
LeagueIndex	0.74					
Age				0.816		
HoursPerWeek					0.85	
TotalHours					0.694	
APM	0.836					
SelectByHotkeys	0.765					
AssignToHotkeys	0.739					
UniqueHotkeys	0.587					
MinimapAttacks						-0.65
MinimapRightClicks						-0.51
NumberOfPACs	0.805					
GapBetweenPACs	-0.66					
ActionLatency	-0.78					
ActionsInPAC			0.899			
TotalMapExplored						-0.51
WorkersMade						
UniqueUnitsMade		0.492				
ComplexUnitsMade		0.886				
ComplexAbilitiesUsed		0.859				
component 1		**component 3**				
LeagueIndex		ActionsInPAC				
APM						
SelectByHotkeys		**component 4**				
AssignToHotkeys		Age				
UniqueHotkeys		ComplexAbilitiesUsed				
NumberOfPACs						
GapBetweenPACs		**component 5**				
ActionLatency		HoursPerWeek				
		TotalHours				
component 2						
UniqueUnitsMade		**component 6**				
ComplexUnitsMade		MinimapAttacks				
ComplexAbilitiesUsed		MinimapRightClicks				
		TotalMapExplored				

Quartimax						
	Component					
	1	2	3	4	5	6
LeagueIndex	0.823					
Age						0.802
HoursPerWeek					0.81	
TotalHours					0.658	
APM	0.9					
SelectByHotkeys	0.725					
AssignToHotkeys	0.754					
UniqueHotkeys	0.564					
MinimapAttacks				0.612		
MinimapRightClicks			0.527			
NumberOfPACs	0.856					
GapBetweenPACs	-0.69					
ActionLatency	-0.85					
ActionsInPAC			0.869			
TotalMapExplored				0.568		
WorkersMade	0.49					
UniqueUnitsMade		0.514		0.514		
ComplexUnitsMade		0.844				
ComplexAbilitiesUsed		0.818				
component 1		**component 3**				
LeagueIndex		MinimapRightClicks				
APM		ActionsInPAC				
SelectByHotkeys						
AssignToHotkeys		**component 4**				
UniqueHotkeys		MinimapAttacks				
NumberOfPACs		TotalMapExplored				
GapBetweenPACs		UniqueUnitsMade				
ActionLatency						
WorkersMade		**component 5**				
		HoursPerWeek				
component 2		TotalHours				
UniqueUnitsMade						
ComplexUnitsMade		**component 6**				
ComplexAbilitiesUsed		Age				

Promax						
	Component					
	1	2	3	4	5	6
LeagueIndex	0.708					
Age						0.892
HoursPerWeek					0.84	
TotalHours					0.677	
APM	0.868					
SelectByHotkeys	0.938					
AssignToHotkeys	0.811					
UniqueHotkeys	0.686					
MinimapAttacks			0.543			
MinimapRightClicks		0.699				
NumberOfPACs	0.737					
GapBetweenPACs	-0.55					
ActionLatency	-0.67					
ActionsInPAC		0.846				
TotalMapExplored			0.773			
WorkersMade						
UniqueUnitsMade			0.736			
ComplexUnitsMade				0.809		
ComplexAbilitiesUsed				0.788		
component 1		**component 3**				
LeagueIndex		MinimapAttacks				
APM		TotalMapExplored				
SelectByHotkeys		UniqueUnitsMade				
AssignToHotkeys						
UniqueHotkeys		**component 4**				
NumberOfPACs		ComplexUnitsMade				
GapBetweenPACs		ComplexAbilitiesUsed				
ActionLatency						
		component 5				
component 2		HoursPerWeek				
MinimapRightClicks		TotalHours				
ActionsInPAC						
		component 6				
		Age				

C.4 Factor Matrix without Rotation

Component Matrix[a]					
	Component				
	1	2	3	4	5
LeagueIndex	0.833				
Age				0.681	
HoursPerWeek					0.649
TotalHours	0.509				0.589
APM	0.888				
SelectByHotkeys	0.647				
AssignToHotkeys	0.726				
UniqueHotkeys	0.533				
MinimapAttacks				0.539	
MinimapRightClicks	0.412		0.426		
NumberOfPACs	0.850				
GapBetweenPACs	-0.655				
ActionLatency	-0.852				
ActionsInPAC		-0.570	0.601		
TotalMapExplored	0.514	0.574			
WorkersMade	0.511				
UniqueUnitsMade	0.414	0.634			
ComplexUnitsMade	0.405	0.487	0.502		
ComplexAbilitiesUsed		0.479	0.467		
Extraction Method: Principal Component Analysis.					
a. 5 components extracted.					

Component Matrix[a]						
	Component					
	1	2	3	4	5	6
LeagueIndex	0.833					
Age				0.681		
HoursPerWeek					0.649	
TotalHours	0.509				0.589	
APM	0.888					
SelectByHotkeys	0.647					0.406
AssignToHotkeys	0.726					
UniqueHotkeys	0.533					
MinimapAttacks				0.539		
MinimapRightClicks	0.412		0.426			
NumberOfPACs	0.850					
GapBetweenPACs	-0.655					
ActionLatency	-0.852					
ActionsInPAC		-0.570	0.601			
TotalMapExplored	0.514	0.574				
WorkersMade	0.511					
UniqueUnitsMade	0.414	0.634				
ComplexUnitsMade	0.405	0.487	0.502			
ComplexAbilitiesUsed		0.479	0.467			
Extraction Method: Principal Component Analysis.						
a. 6 components extracted.						

Appendix D – Model validation

D.1 Factor Matrix without Outliers (5 factors)

Varimax	Component				
	1	2	3	4	5
LeagueIndex	0.765				
Age					0.677
HoursPerWeek				0.85	
TotalHours				0.74	
APM	0.832				
SelectByHotkeys	0.752				
AssignToHotkeys	0.754				
UniqueHotkeys	0.582				
MinimapAttacks					0.588
MinimapRightClicks			0.643		
NumberOfPACs	0.833				
GapBetweenPACs	-0.601				
ActionLatency	-0.775				
ActionsInPAC			0.862		
TotalMapExplored		0.623			
WorkersMade			0.504		
UniqueUnitsMade		0.712			
ComplexUnitsMade		0.793			
ComplexAbilitiesUsed		0.767			
component 1	**component 2**				
LeagueIndex	TotalMapExplored				
APM	UniqueUnitsMade				
SelectByHotkeys	ComplexUnitsMade				
AssignToHotkeys	ComplexAbilitiesUsed				
UniqueHotkeys					
NumberOfPACs	**component 4**				
GapBetweenPACs	HoursPerWeek				
ActionLatency	TotalHours				
component 3	**component 5**				
MinimapRightClicks	Age				
ActionsInPAC	MinimapAttacks				
WorkersMade					

Oblimin	Component				
	1	2	3	4	5
LeagueIndex	0.719				
Age				0.69	
HoursPerWeek					0.894
TotalHours					0.753
APM	0.803				
SelectByHotkeys	0.792				
AssignToHotkeys	0.778				
UniqueHotkeys	0.62				
MinimapAttacks				0.593	
MinimapRightClicks			0.645		
NumberOfPACs	0.816				
GapBetweenPACs	-0.584				
ActionLatency	-0.737				
ActionsInPAC			0.877		
TotalMapExplored		0.569			
WorkersMade					
UniqueUnitsMade		0.692			
ComplexUnitsMade		0.824			
ComplexAbilitiesUsed		0.801			
component 1	**component 2**				
LeagueIndex	TotalMapExplored				
APM	UniqueUnitsMade				
SelectByHotkeys	ComplexUnitsMade				
AssignToHotkeys	ComplexAbilitiesUsed				
UniqueHotkeys					
NumberOfPACs	**component 4**				
GapBetweenPACs	Age				
ActionLatency	MinimapAttacks				
component 3	**component 5**				
MinimapRightClicks	HoursPerWeek				
ActionsInPAC	TotalHours				

Quartimax	Component				
	1	2	3	4	5
LeagueIndex	0.822				
Age					0.68
HoursPerWeek				0.83	
TotalHours				0.699	
APM	0.898				
SelectByHotkeys	0.754				
AssignToHotkeys	0.766				
UniqueHotkeys	0.562				
MinimapAttacks					0.584
MinimapRightClicks			0.612		
NumberOfPACs	0.855				
GapBetweenPACs	-0.665				
ActionLatency	-0.831				
ActionsInPAC			0.853		
TotalMapExplored		0.602			
WorkersMade					
UniqueUnitsMade		0.702			
ComplexUnitsMade		0.781			
ComplexAbilitiesUsed		0.756			
component 1	**component 2**				
LeagueIndex	TotalMapExplored				
APM	UniqueUnitsMade				
SelectByHotkeys	ComplexUnitsMade				
AssignToHotkeys	ComplexAbilitiesUsed				
UniqueHotkeys					
NumberOfPACs	**component 4**				
GapBetweenPACs	HoursPerWeek				
ActionLatency	TotalHours				
	component 5				
component 3	Age				
MinimapRightClicks	MinimapAttacks				
ActionsInPAC					

Promax	Component				
	1	2	3	4	5
LeagueIndex	0.747				
Age					0.735
HoursPerWeek				0.942	
TotalHours				0.762	
APM	0.836				
SelectByHotkeys	0.867				
AssignToHotkeys	0.839				
UniqueHotkeys	0.678				
MinimapAttacks					0.619
MinimapRightClicks			0.697		
NumberOfPACs	0.876				
GapBetweenPACs	-0.595				
ActionLatency	-0.77				
ActionsInPAC			0.912		
TotalMapExplored		0.557			
WorkersMade					
UniqueUnitsMade		0.699			
ComplexUnitsMade		0.868			
ComplexAbilitiesUsed		0.846			
component 1	**component 2**				
LeagueIndex	TotalMapExplored				
APM	UniqueUnitsMade				
SelectByHotkeys	ComplexUnitsMade				
AssignToHotkeys	ComplexAbilitiesUsed				
UniqueHotkeys					
NumberOfPACs	**component 4**				
GapBetweenPACs	HoursPerWeek				
ActionLatency	TotalHours				
component 3	**component 5**				
MinimapRightClicks	Age				
ActionsInPAC	MinimapAttacks				

D.2 Interpretation Table (5 Factors, Varimax Rotation, No Outliers)

Subset_70%					
Rotated Component Matrix[a]					
	Component				
	1	2	3	4	5
LeagueIndex	0.776				
Age					0.716
HoursPerWeek				0.833	
TotalHours				0.713	
APM	0.849				
SelectByHotkeys	0.764				
AssignToHotkeys	0.730				
UniqueHotkeys	0.558				
MinimapAttacks					0.475
MinimapRightClicks			0.660		
NumberOfPACs	0.837				
GapBetweenPACs	-0.626				
ActionLatency	-0.784				
ActionsInPAC			0.875		
TotalMapExplored		0.664			
WorkersMade			0.500		
UniqueUnitsMade		0.736			
ComplexUnitsMade		0.760			
ComplexAbilitiesUsed		0.749			

component 1	LeagueIndex
	APM
	SelectByHotkeys
	AssignToHotkeys
	UniqueHotkeys
	NumberOfPACs
	GapBetweenPACs
	ActionLatency
component 2	TotalMapExplored
	UniqueUnitsMade
	ComplexUnitsMade
	ComplexAbilitiesUsed
component 3	MinimapRightClicks
	ActionsInPAC
	WorkersMade
component 4	HoursPerWeek
	TotalHours
component 5	Age
	MinimapAttacks

Appendix E – Results for Cluster Analysis

E.1 Results with outliers

E.1.1 Table Agglomeration Schedule

Agglomeration Schedule								
Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage	Diff. between Coef.	No. of cluster
	Cluster 1	Cluster 2		Cluster 1	Cluster 2			
686	2	390	37.440	683	682	691		10
687	5	486	40.206	675	680	693	2.766	9
688	300	576	42.949	681	656	692	2.743	8
689	505	663	44.420	0	0	695	1.472	7
690	20	129	48.740	678	661	693	4.320	6
691	1	2	53.693	685	686	692	4.953	5
692	1	300	66.751	691	688	694	13.059	4
693	5	20	78.719	687	690	694	11.967	3
694	1	5	86.992	692	693	695	8.273	2
695	1	505	186.487	694	689	0	99.495	1

E.1.2 Table of Initial Cluster Centres

Initial Cluster Centers				
	Cluster			
	1	2	3	4
REGR factor score 1 for analysis 1	0.03754	-0.06084	-1.03193	-0.8315
REGR factor score 2 for analysis 1	-0.2194	1.89091	-0.53367	0.56454
REGR factor score 3 for analysis 1	-0.13211	0.81152	0.87912	2.83732
REGR factor score 4 for analysis 1	-0.02772	-0.47574	2.38225	6.91486
REGR factor score 5 for analysis 1	0.05086	-0.44291	-0.66235	6.3266
Input from FILE Subcommand				

E.1.3 Table of Final Cluster Centres

Final Cluster Centers				
	Cluster			
	1	2	3	4
REGR factor score 1 for analysis 1	-0.43439	0.19184	0.74551	-0.83151
REGR factor score 2 for analysis 1	-0.24781	1.74878	-0.50422	0.56454
REGR factor score 3 for analysis 1	-0.34405	0.42551	0.40178	2.83731
REGR factor score 4 for analysis 1	-0.27998	-0.25717	0.61873	6.91486
REGR factor score 5 for analysis 1	0.19318	-0.28997	-0.27697	6.3266

E.1.4 Table of ANOVA

ANOVA						
	Cluster		Error		F	Sig.
	Mean Square	df	Mean Square	df		
REGR factor score 1 for analysis 1	62.72	3	0.732	692	85.634	0
REGR factor score 2 for analysis 1	138.028	3	0.406	692	340.016	0
REGR factor score 3 for analysis 1	37.911	3	0.84	692	45.134	0
REGR factor score 4 for analysis 1	69.651	3	0.702	692	99.164	0
REGR factor score 5 for analysis 1	39.647	3	0.832	692	47.627	0
The F tests should be used only for descriptive purposes because the clusters have been chosen to maximize the differences among cases in different clusters. The observed significance levels are not corrected for this and thus cannot be interpreted as tests of the hypothesis that the cluster means are equal.						

E.1.5 Distances between Final Cluster Centres

Distances between Final Cluster Centers				
Cluster	1	2	3	4
1		2.281	1.744	10.016
2	2.281		2.48	10.173
3	1.744	2.48		9.634
4	10.016	10.173	9.634	

E.1.6 Number of Cases in Each Cluster

Number of Cases in each Cluster		
Cluster	1	385
	2	111
	3	198
	4	2
Valid		696
Missing		1

E.2 Initial Cluster Centres after Removing Outliers

Initial Cluster Centers						
	Cluster					
	1	2	3	4	5	6
REGR factor score 1 for analysis 1	1.75778	0.50125	0.74342	-0.29801	0.11101	-0.13962
REGR factor score 2 for analysis 1	-0.40543	-0.04857	0.95243	-0.16799	2.42484	0.03719
REGR factor score 3 for analysis 1	-0.21366	1.40214	-0.76986	-0.13864	0.54553	0.65983
REGR factor score 4 for analysis 1	-0.24125	0.24354	2.73877	-0.07943	-0.67953	4.17556
REGR factor score 5 for analysis 1	-0.41125	1.41928	-0.22667	-0.05212	-0.79475	2.92354
Input from FILE Subcommand						

E.3 Number of Cases in Each Cluster after Removing Outliers

Number of Cases in each Cluster		
Cluster	1	141
	2	125
	3	59
	4	260
	5	83
	6	17
Valid		685
Missing		1

E.4 - Final Cluster Centres

Final Cluster Centers						
	Cluster					
	1	2	3	4	5	6
REGR factor score 1 for analysis 1	1.11213	-0.36839	0.22704	-0.61929	0.28664	0.76871
REGR factor score 2 for analysis 1	-0.55192	-0.36226	0.26901	-0.16511	1.81651	-0.03584
REGR factor score 3 for analysis 1	-0.10555	1.17422	-0.17092	-0.65223	0.4295	0.71285
REGR factor score 4 for analysis 1	-0.33892	-0.23854	2.23064	-0.15597	-0.47669	1.53611
REGR factor score 5 for analysis 1	-0.36854	0.44566	-0.31982	0.05518	-0.55542	2.75761

E.5 Cluster Members after Removing Outliers

Cluster Membership														
GameID	*Cluster*	*Distance*	*GameID*	*Cluster*	*Distance*	*GameID*	*Cluster*	*Distance*	*GameID*	*Cluster*	*Distance*	*Cluster*	*Distance*	*Distance*
1988	1	2.022	316	1	1.49	1108	4	2.506	568	1	1.701	910	5	1.167
7415	1	2.275	1575	2	2.784	497	2	1.543	790	5	1.079	1676	4	1.199
872	2	4.04	2970	6	2.309	4276	4	1.212	970	1	1.407	2533	4	1.127
144	3	3.9	398	6	2.109	1156	3	1.954	301	1	0.545	401	4	0.609
1719	2	2.23	1256	4	1.314	235	3	1.576	1013	4	0.817	1413	4	0.884
1825	4	2.061	383	3	1.872	1174	3	2.23	2677	4	1.252	987	1	1.092
1402	5	3.617	531	5	1.356	649	1	1.262	655	5	2.11	685	1	1.108
55	6	2.28	529	3	2.329	264	1	2.049	2237	4	1.629	1055	1	1.018
314	2	2.631	1105	3	1.692	754	4	0.901	672	2	0.733	712	1	1.511
5640	6	3.142	513	3	1.711	158	1	1.246	656	1	1.051	1302	2	1.075
1009	3	4.348	981	6	2.165	877	5	1.12	3587	4	1.526	818	3	1.373
711	3	3.134	1232	4	1.099	736	2	1.619	1369	4	2.098	958	1	1.002
8672	1	3.616	4177	4	1.466	213	2	1.809	3146	4	0.874	281	5	1.676
251	6	2.479	705	5	1.709	766	4	1.534	196	4	1.691	581	1	0.981
7848	5	2.651	2729	2	1.349	2442	2	1.374	267	1	1.052	1289	1	0.848
8048	6	2.426	160	4	0.982	3152	1	1.618	3752	4	1.44	1062	4	1.379
796	1	2.372	1275	1	1.412	338	2	1.938	921	4	1.16	3339	4	1.061
834	2	1.34	557	5	1.496	898	2	1.392	438	4	1.367	776	4	0.654
1338	4	2.316	1582	1	2.12	1348	1	1.417	1634	4	1.423	93	4	1.326
631	1	2.092	351	5	2.471	2314	2	1.878	3061	4	0.904	1310	5	1.31
3927	4	0.96	585	2	1.415	4943	4	1.183	713	5	1.114	442	4	1.636
2423	2	2.056	680	1	1.782	138	5	1.036	997	1	1.725	1023	1	0.992
1545	5	2.399	674	5	1.433	297	1	0.968	3389	4	1.264	1312	4	1.231
1298	3	3.179	842	1	1.894	1150	4	0.787	5004	4	1.093	998	5	1.041
750	6	2.186	250	4	0.577	3237	4	1.608	851	5	0.651	765	4	1.664
1433	5	2.815	381	1	2.124	342	4	1.499	1333	1	1.362	822	4	1.002
1361	5	3.896	3210	4	1.575	230	2	1.591	3580	4	1.732	2657	4	1.087
837	3	1.597	260	4	2.157	1179	5	2.01	2988	4	1.622	209	5	1.523
212	3	1.772	288	2	1.477	3012	4	1.717	388	1	1.865	724	4	1.108
730	1	2.082	1414	5	1.932	833	1	1.221	784	1	1.739	2077	4	0.758
4607	3	2.819	1525	3	1.6	1335	4	1.542	747	4	1.92	1235	4	1.333
1454	1	2.072	2153	2	1.51	1106	5	1.568	1603	4	1.271	905	4	1.306
1624	6	1.17	389	2	1.613	3428	4	0.892	792	5	1.512	793	4	1.052
3287	2	1.861	1493	1	1.265	630	5	1.274	1495	2	1.374	1025	4	1.074
1352	5	2.865	874	2	1.601	434	5	1.68	961	2	1.17	378	4	1.168
1463	3	2.672	194	1	2.13	1604	4	1.039	1325	2	1.252	774	2	0.91
967	6	1.702	1389	4	1.407	651	4	1.685	1541	2	1.123	1064	.	.
3027	3	2.314	1379	5	0.787	1211	5	1.741	3344	4	1.351	1713	4	1.474
2029	1	2.496	636	2	2.168	3787	4	1.287	193	4	1.533	1265	4	1.42
1392	4	2.583	225	3	1.929	511	4	1.705	1030	1	1.033	1077	2	1.569
458	5	2.258	2997	4	1.302	1137	4	0.301	426	4	1.182	1210	4	1.62
2791	2	3.197	1814	4	3.009	2284	4	1.425	336	4	1.179	97	4	1.316
455	2	2.359	140	4	2.113	1611	1	0.984	780	4	2.246	535	5	1.461
182	5	2.204	1753	4	1.759	203	3	1.639	915	5	1.216	1237	4	1.549
1408	5	2.114	532	4	1.008	1207	2	1.986	1913	4	1.469	3773	4	0.874
9202	6	2.241	3621	4	1.823	201	2	1.118	1478	2	1.423	1182	4	1.524
611	3	1.729	105	4	1.195	600	4	1.265	1982	4	1.1	60	4	1.168
2575	4	1.954	588	5	1.659	244	1	1.578	1249	1	1.012	1091	4	1.233
357	1	2.276	350	5	1.062	546	4	1.944	527	5	1.504	1291	1	1.197
1344	2	1.194	572	1	1.426	228	2	1.754	1341	1	0.26	1921	1	1.366
223	5	2.084	1390	1	2.285	4510	4	1.569	514	4	1.182	1339	4	1.269
403	1	1.915	7889	1	1.269	1167	1	0.888	633	1	1.314	632	5	1.486
454	1	1.779	816	1	1.255	2449	4	2.423	901	2	1.185	210	1	1.385
2076	3	2.458	1285	3	1.362	626	1	1.861	762	4	1.664	1648	4	1.263
2662	2	2.886	5604	5	1.874	2068	2	1.569	3114	4	1.688	175	4	1.88
704	3	1.445	1358	5	2.211	1336	1	1.251	645	2	0.699	1399	1	1.409
902	2	2.547	536	1	1.308	526	2	1.31	1469	4	1.341	623	3	1.384
418	5	2.692	604	1	1.326	1714	4	0.965	204	4	0.92	1053	4	0.82
77	3	1.642	339	1	1.445	1488	2	1.324	519	2	1.53	220	4	0.746
517	2	1.974	180	2	1.474	384	3	1.405	779	2	1.239	614	4	1.244
3782	4	2.139	1133	2	1.355	154	1	0.892	628	4	0.562	1154	4	1.531
371	1	2.372	3044	4	0.514	1299	4	1.322	57	4	1.408	257	5	1.306
2212	3	2.236	664	2	1.415	720	1	1.815	396	5	1.284	1876	2	1.59
8760	1	3.07	141	1	1.477	61	4	0.942	1193	4	1.704	865	4	0.839
187	2	1.385	841	2	1.483	1259	1	0.457	184	1	0.776	1277	5	1.96
171	2	1.873	1337	4	1.243	246	1	1.906	3857	4	0.76	1816	4	0.949
547	3	3.752	569	2	1.26	302	5	2.286	995	4	0.757	2978	4	1.295
1380	2	2.019	1000	1	1.069	2661	3	1.421	1076	5	1.362	699	4	0.63

(continue with next page)

Cluster Membership														
GameID	*Cluster*	*Distance*	*GameID*	*Cluster*	*Distance*	*GameID*	*Cluster*	*Distance*	*GameID*	*Cluster*	*Distance*	*Cluster*	*Distance*	*Distance*
219	1	1.615	601	1	1.576	1293	4	1.861	1107	4	1.608	1417	4	1.371
3037	4	2.12	2012	5	2.386	2228	4	1.2	2138	4	1.104	168	1	1.175
1286	1	1.578	265	2	0.844	966	4	1.656	609	1	1.016	2221	4	0.665
280	5	1.119	363	4	1.533	883	2	1.171	875	2	1.364	1292	4	1.497
449	4	1.024	1774	1	1.396	1416	3	1.807	1595	4	1.772	578	1	1.454
6469	6	2.856	692	1	1.448	490	2	1.945	2974	3	1.537	1071	4	0.979
523	3	2.732	256	1	1.033	542	5	1.366	1890	2	1.226	181	2	0.774
4517	4	2.396	3734	4	1.228	1047	1	0.66	3031	4	0.765	691	4	1.518
476	3	1.935	1169	2	1.317	1238	4	1.804	423	2	1.411	1397	5	1.555
1247	3	2.731	118	5	1.308	1141	4	1.393	891	1	1.367	1127	4	1.023
843	2	1.273	2995	4	1.651	6177	1	1.647	703	2	1.011	1382	4	0.893
6393	3	2.245	1230	4	1.78	1767	1	1.397	4269	4	1.447	1132	4	0.98
2095	2	1.909	912	4	1.262	4191	4	0.867	787	1	1.533	226	1	1.126
1096	3	1.907	1070	2	1.695	1902	4	1.145	1905	1	1.024	439	4	1.055
1810	6	2.539	4263	4	1.709	1281	3	1.641	584	4	1.187	1953	4	1.556
953	6	2.202	701	5	1.106	1175	2	1.117	941	4	1.299	758	4	0.999
892	3	1.998	2915	3	2.605	234	1	1.443	2639	2	1.198	1351	2	1.375
480	1	1.547	1033	2	1.679	545	2	1.903	1966	4	0.989	2727	2	0.864
3710	4	2.223	1262	5	2.159	1008	3	1.329	1110	4	1.174	1364	4	1.094
408	5	1.594	739	1	1.442	1430	2	1.09	993	1	1.248	1477	4	0.651
1029	5	2.562	1886	3	2.013	591	1	1.489	215	4	1.169	3539	5	1.397
142	5	2.795	169	1	1.904	81	1	0.747	1537	5	1.332	1620	1	1.442
52	6	1.859	3092	4	1.785	887	4	1.332	1839	4	1.278	789	1	1.302
9098	2	2.486	229	5	1.245	607	4	1.465	422	4	1.152	1111	4	1.561
1212	2	2.361	299	1	0.971	1063	2	2.051	975	4	1.303	1314	4	1.182
1580	2	2.279	1274	1	1.959	681	4	1.339	127	2	1.709	2231	4	1.375
366	2	1.582	771	4	1.325	1124	4	1.367	797	1	0.934	638	3	1.909
58	2	2.487	722	1	1.767	1010	1	1.472	1852	4	1.387	5289	3	1.48
1034	2	2.764	457	5	1.072	1043	4	0.967	525	1	1.563	694	4	1.35
1255	3	2.341	149	4	1.446	760	1	1.322	1796	4	1.177	1125	3	1.924
1431	1	0.973	2984	3	2.048	637	1	1.792	132	5	1.808	2178	4	1.414
1346	2	1.265	3494	4	2.071	1221	1	1.253	4565	4	0.785	290	4	1.902
1168	5	1.846	1241	1	2.408	1164	5	1.092	2625	5	1.465	2229	4	1.104
361	2	2.199	4777	4	1.667	2740	4	1.464	1118	4	0.966	1319	4	2.345
1178	4	1.706	3104	4	1.044	866	4	1.001	2722	2	1.848	2865	2	1.458
4555	6	2.931	1862	2	1.158	509	1	1.216	849	1	0.965	1930	1	1.691
7459	1	1.763	320	2	1.563	1366	2	1.632	473	1	1.193	1273	3	1.246
1004	3	2.817	1830	4	1.002	928	4	0.979	4157	4	0.982	1021	1	2.041
3801	4	1.522	321	4	2.127	1233	4	1.146	2557	4	0.901	1253	4	1.242
98	2	1.643	1439	3	1.477	683	3	1.445	1264	1	1.584	643	3	1.678
3091	1	2.626	178	2	1.009	650	2	1.543	836	5	1.266	3265	2	1.278
888	2	1.359	1061	5	1.516	435	5	0.758	560	1	0.863	1820	4	1.39
1521	5	2.365	979	4	1.934	576	5	0.895	799	4	0.777	1279	4	1.434
1403	2	2.951	798	2	1.179	512	4	1.588	444	4	1.477	666	2	1.507
4699	6	1.913	400	5	1.443	3449	4	1.259	1926	4	1.544	312	3	1.523
652	2	2.775	392	1	1.079	1848	5	1.261	2989	4	1.797	893	1	0.899
1208	2	2.394	1607	4	2.057	2191	4	0.977	3139	4	1.047	1959	2	1.438
2618	2	1.653	4889	4	2.184	942	5	1.565	464	1	1.186	1340	5	1.745
1514	3	1.354	1447	4	1.707	1301	4	1.827	654	4	1.075	1770	4	1.596
1143	5	2.739	1375	4	1.707	824	2	1.36	974	4	1.137	1093	4	0.747
3426	2	2.188	1128	4	1.27	1074	4	1.273	56	2	1.992	2051	4	1.756
590	5	2.647	1809	2	1.544	819	4	1.855	284	1	1.788	240	2	1.714
411	2	1.126	393	1	1.638	813	4	2.142	746	2	1.306	1216	1	2.297
2188	3	1.211	751	5	1.973	1172	2	1.621	621	5	1.496	394	1	0.447
263	5	1.921	1196	1	2.122	3423	4	0.899	2475	4	1.271	272	4	1.026
1356	1	2.005	2013	4	1.205	1309	1	1.143	1159	4	1.54	1479	1	0.731
424	4	1.91	1969	4	0.808	407	1	0.49	475	4	1.478	1491	1	1.273
1016	4	1.38	4960	2	1.869	1347	2	1.699	3302	4	0.848	3125	1	1.758
443	2	1.497	3880	2	2.21	3764	4	1.009	1248	2	1.585	689	4	1.75
608	3	1.701	1318	4	1.224	570	1	1.28	732	4	0.783	723	5	0.981
731	4	1.97	139	2	1.527	1822	4	1.052	3843	4	1.298	2253	4	1.412
1032	4	1.165	759	3	1.56	266	4	1.611	1476	1	0.932	1692	4	0.973
710	2	2.072	1173	4	1.95	716	4	1.191	735	2	1.02	329	2	1.536
163	5	1.947	4684	2	2.393	1826	4	1.096	1383	1	1.03	1094	4	1.167
1464	4	2.64	506	2	1.46	268	2	0.977	1031	4	1.146	1365	4	1.504
1688	1	2.132	333	4	2.394	436	4	1.488	1626	2	2.19	1588	4	1.237
305	1	2.229	162	3	1.35	3135	4	0.965	1679	4	0.837	4283	4	2.129
1411	1	1.37	788	1	1.532	1083	4	0.973	1240	1	1.308	540	1	1.135
781	5	2.58	508	1	1.068	756	3	1.988	931	2	1.517	1228	2	1.475
161	4	0.863												

E.6 ANOVA Table after Removing Outliers

ANOVA						
	Cluster		Error		F	Sig.
	Mean Square	df	Mean Square	df		
REGR factor score 1 for analysis 1	62.196	5	0.549	679	113.213	0
REGR factor score 2 for analysis 1	68.922	5	0.5	679	137.889	0
REGR factor score 3 for analysis 1	62.04	5	0.551	679	112.693	0
REGR factor score 4 for analysis 1	76.435	5	0.445	679	171.954	0
REGR factor score 5 for analysis 1	41.137	5	0.704	679	58.396	0
The F tests should be used only for descriptive purposes because the clusters have been chosen to maximize the differences among cases in different clusters. The observed significance levels are not corrected for this and thus cannot be interpreted as tests of the hypothesis that the cluster means are equal.						

E.7 Distances between Final Cluster Centres after Removing Outliers

Distances between Final Cluster Centers						
Cluster	1	2	3	4	5	6
1		2.13	2.84	1.913	2.575	3.787
2	2.13		3.041	1.897	2.606	3.179
3	2.84	3.041		2.641	3.185	3.335
4	1.913	1.897	2.641		2.529	3.738
5	2.575	2.606	3.185	2.529		4.333
6	3.787	3.179	3.335	3.738	4.333	

E.8 Results of Validation

E.8.1 Table of Initial Cluster Centres

Initial Cluster Centers						
	Cluster					
	1	2	3	4	5	6
REGR factor score 1 for analysis 1	1.8178	0.46884	0.65562	-0.3027	0.1364	-0.60244
REGR factor score 2 for analysis 1	-0.47837	0.0641	0.95382	-0.1898	2.45784	-0.05798
REGR factor score 3 for analysis 1	-0.08309	1.51845	-0.77195	-0.13012	0.57902	0.91155
REGR factor score 4 for analysis 1	-0.1443	0.23766	2.81328	-0.06617	-0.62074	4.45423
REGR factor score 5 for analysis 1	-0.37099	1.31195	-0.1674	-0.0978	-0.75821	2.31476
Input from FILE Subcommand						

Final Cluster Centers						
	Cluster					
	1	2	3	4	5	6
REGR factor score 1 for analysis 1	1.33039	-0.40124	0.24429	-0.54665	0.31986	-0.86564
REGR factor score 2 for analysis 1	-0.55166	-0.17868	0.37776	-0.27671	1.77064	-0.11165
REGR factor score 3 for analysis 1	-0.00257	1.39582	-0.25541	-0.48895	0.40973	1.3819
REGR factor score 4 for analysis 1	-0.18798	-0.07865	2.42082	-0.19249	-0.48635	4.15265
REGR factor score 5 for analysis 1	-0.19002	0.79421	-0.35825	-0.07255	-0.53491	1.58079

E.8.2 Distances between Final Cluster Centres

Distances between Final Cluster Centers						
Cluster	1	2	3	4	5	6
1		2.465	2.99	1.962	2.606	5.377
2	2.465		3.321	2.085	2.688	4.329
3	2.99	3.321		2.832	3.297	3.303
4	1.962	2.085	2.832		2.46	5.024
5	2.606	2.688	3.297	2.46		5.647
6	5.377	4.329	3.303	5.024	5.647	

E.8.3 ANOVA Table

ANOVA						
	Cluster		Error		F	Sig.
	Mean Square	df	Mean Square	df		
REGR factor score 1 for analysis 1	48.739	5	0.498	470	97.895	0
REGR factor score 2 for analysis 1	47.882	5	0.541	470	88.427	0
REGR factor score 3 for analysis 1	42.087	5	0.632	470	66.58	0
REGR factor score 4 for analysis 1	65.609	5	0.453	470	144.845	0
REGR factor score 5 for analysis 1	16.311	5	0.745	470	21.882	0
The F tests should be used only for descriptive purposes because the clusters have been chosen to maximize the differences among cases in different clusters. The observed significance levels are not corrected for this and thus cannot be interpreted as tests of the hypothesis that the cluster means are equal.						

E.8.4 Table of Number of Cases in each Cluster

Number of Cases in each Cluster		
Cluster	1	89
	2	72
	3	40
	4	211
	5	60
	6	4
Valid		476
Missing		1

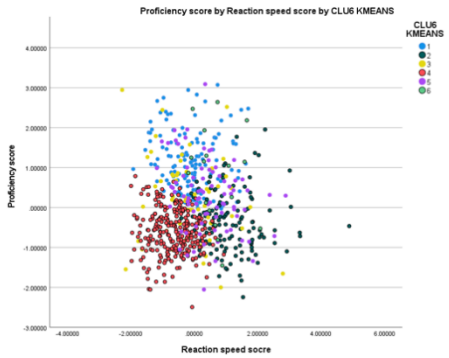
E.9 Comparison between Total Set and Subset

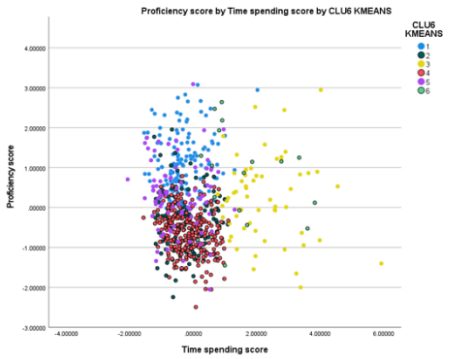
Validation Part			
GameID	Cluster (total set)	Cluster (subset)	Comparison
1988	1	1	1
7415	1	1	1
872	2	2	1
144	3	3	1
1719	2	2	1
1825	4	4	1
1402	5	5	1
55	6	6	1
314	2	2	1
...			
226	1	1	1
439	4	4	1
1953	4	4	1
2657	4	4	1
209	5	5	1
905	4	4	1
1025	4	4	1
378	4	4	1
774	2	4	0
1064		0	1

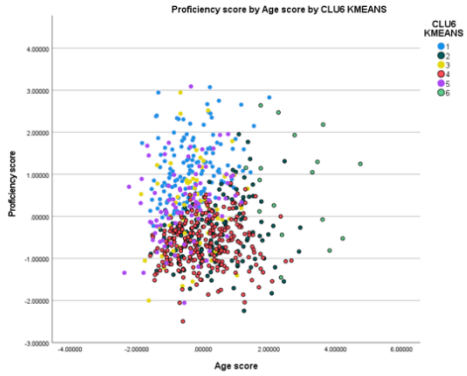
Correct Rate
0.871848739

If the cluster of subset is the same as the total set, we set the value of variable ‘Comparison’ as 1.

E.10 Scatter Plots for Different Factors with 6 Clusters

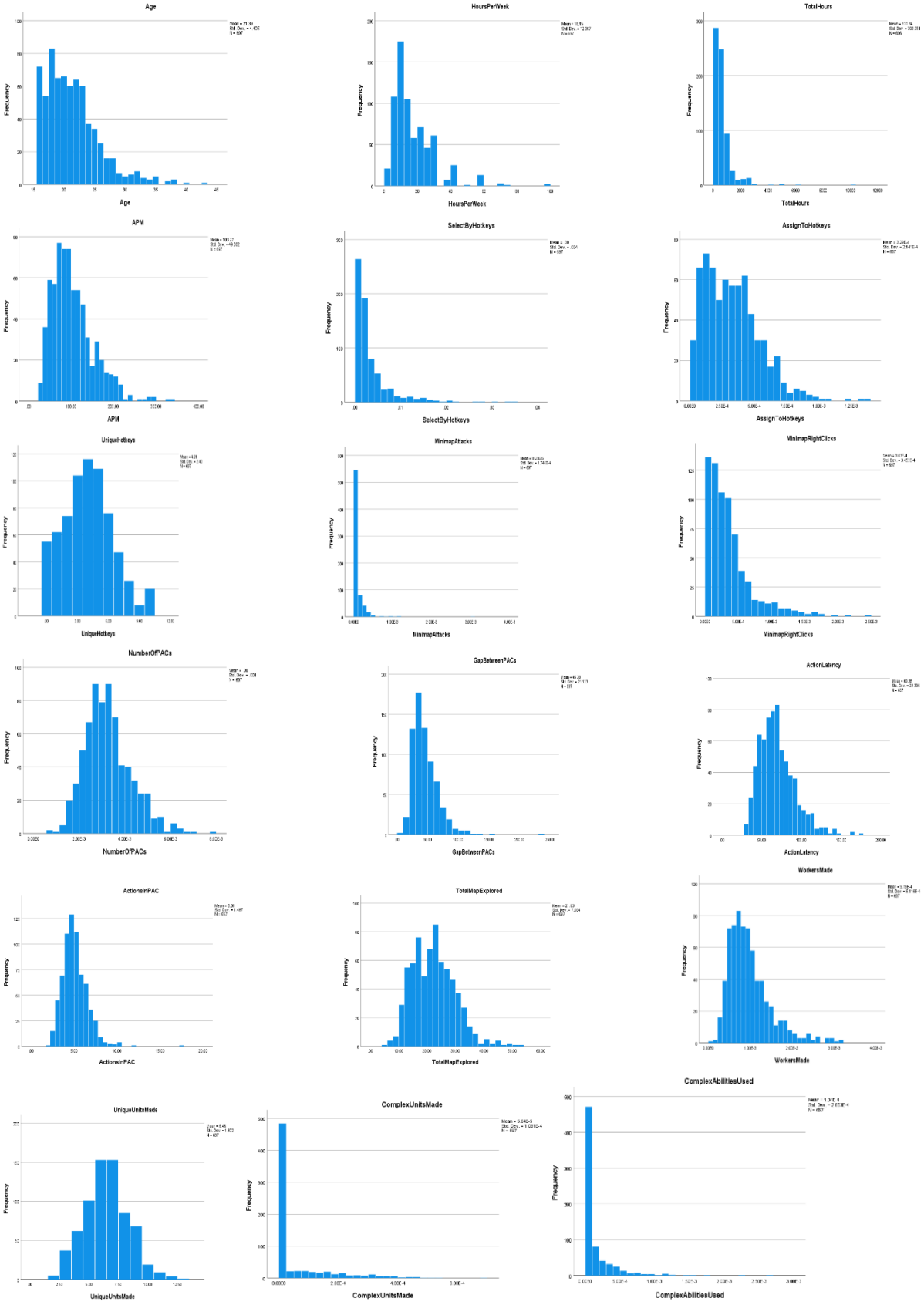





Proficiency score by Age score by CLU6 KMEANS
CLU6 KMEANS
1
2
3
4
5
6
Proficiency score
4.00000
3.00000
2.00000
1.00000
.00000
-1.00000
-2.00000
-3.00000
-4.00000
-2.00000
.00000
2.00000
4.00000
6.00000
Age score

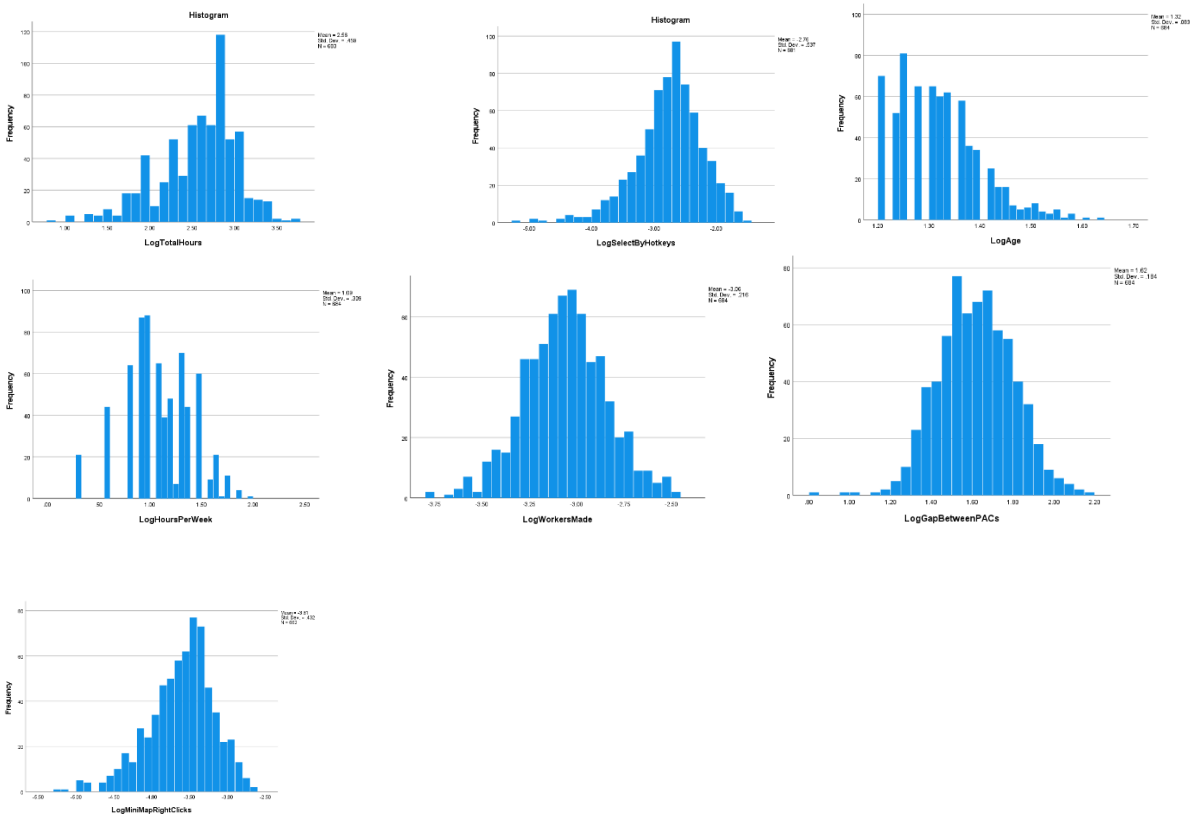
Appendix F – Assumption of Multiple Linear Regression

F.1 Histograms of all 18 independent variables, without transformation

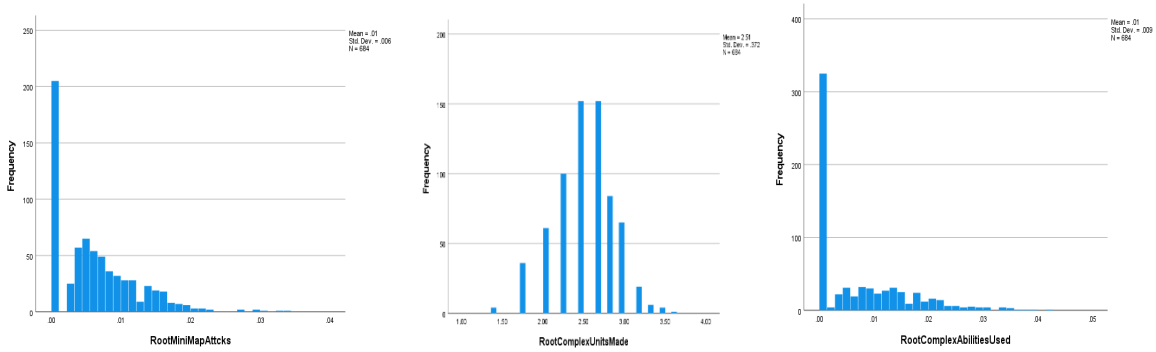


Appendix F.2 – Histograms of transformed variables

log transformations on **Age, HoursPerWeek, TotalHours, SelectByHotkeys, GapbetweenPACs, Workersmade, Minimaprightclicks**



Square root transformation on **MinimapAttacks, ComplexUnitsMade, ComplexAbilitiesUsed**.



Appendix G – Collinearity Matrices

G.1 All independent variables, without transformation

Correlation Matrix

		Age	Hours Per Week	Total Hours	APM	Select By Hotkeys	Assign To Hotkeys	Unique Hotkeys	Minimap Attacks	Minimap Right Clicks	Number Of PACs	Gap Between PACs	Action Latency	Actions In PAC	Total Map Explored	Workers Made	Unique Units Made	Complex Units Made	Complex Abilities Used
Correlation	Age	1.000	-0.205	-0.034	-0.203	-0.115	-0.123	0.007	0.061	-0.046	-0.178	0.127	0.242	-0.087	-0.013	-0.108	0.012	-0.100	-0.074
	HoursPerWeek	-0.205	1.000	0.462	0.294	0.257	0.211	0.124	0.089	0.070	0.253	-0.171	-0.236	0.071	0.105	0.112	0.100	0.079	0.031
	TotalHours	-0.034	0.462	1.000	0.408	0.312	0.310	0.199	0.255	0.112	0.425	-0.285	-0.390	0.052	0.229	0.219	0.158	0.144	0.106
	APM	-0.203	0.294	0.408	1.000	0.810	0.604	0.384	0.305	0.365	0.751	-0.613	-0.774	0.408	0.298	0.517	0.185	0.261	0.204
	SelectByHotkeys	-0.115	0.257	0.312	0.810	1.000	0.533	0.364	0.191	0.121	0.525	-0.327	-0.464	0.119	0.178	0.281	0.110	0.140	0.102
	AssignToHotkeys	-0.123	0.211	0.310	0.604	0.533	1.000	0.464	0.267	0.188	0.578	-0.436	-0.531	0.093	0.257	0.321	0.183	0.259	0.232
	UniqueHotkeys	0.007	0.124	0.199	0.384	0.364	0.464	1.000	0.186	0.109	0.430	-0.197	-0.339	-0.055	0.325	0.191	0.303	0.181	0.145
	MinimapAttacks	0.061	0.089	0.255	0.305	0.191	0.267	0.186	1.000	0.218	0.262	-0.254	-0.259	0.119	0.244	0.129	0.145	0.076	0.061
	MinimapRightClicks	-0.046	0.070	0.112	0.365	0.121	0.188	0.109	0.218	1.000	0.235	-0.290	-0.304	0.360	0.158	0.269	0.132	0.121	0.121
	NumberOfPACs	-0.178	0.253	0.425	0.751	0.525	0.578	0.430	0.262	0.235	1.000	-0.539	-0.836	-0.139	0.481	0.363	0.330	0.291	0.265
	GapBetweenPACs	0.127	-0.171	-0.285	-0.613	-0.327	-0.436	-0.197	-0.254	-0.290	-0.539	1.000	0.686	-0.364	-0.095	-0.352	-0.072	-0.120	-0.153
	ActionLatency	0.242	-0.236	-0.390	-0.774	-0.464	-0.531	-0.339	-0.259	-0.304	-0.836	0.686	1.000	-0.180	-0.384	-0.409	-0.256	-0.280	-0.261
	ActionsInPAC	-0.087	0.071	0.052	0.408	0.119	0.093	-0.055	0.119	0.360	-0.139	-0.364	-0.180	1.000	-0.113	0.361	-0.095	0.080	0.056
	TotalMapExplored	-0.013	0.105	0.229	0.298	0.178	0.257	0.325	0.244	0.158	0.481	-0.095	-0.384	-0.113	1.000	0.102	0.585	0.336	0.285
	WorkersMade	-0.108	0.112	0.219	0.517	0.281	0.321	0.191	0.129	0.269	0.363	-0.352	-0.409	0.361	0.102	1.000	0.084	0.184	0.099
	UniqueUnitsMade	0.012	0.100	0.158	0.185	0.110	0.183	0.303	0.145	0.132	0.330	-0.072	-0.256	-0.095	0.585	0.084	1.000	0.381	0.332
	ComplexUnitsMade	-0.100	0.079	0.144	0.261	0.140	0.259	0.181	0.076	0.121	0.291	-0.120	-0.280	0.080	0.336	0.184	0.381	1.000	0.615
	ComplexAbilitiesUsed	-0.074	0.031	0.106	0.204	0.102	0.232	0.145	0.061	0.121	0.265	-0.153	-0.261	0.056	0.285	0.099	0.332	0.615	1.000

G.2 APM removed

Correlation Matrix

		Age	Hours Per Week	Total Hours	Select By Hotkeys	Assign To Hotkeys	Unique Hotkeys	Minimap Attacks	Minimap Right Clicks	Number Of PACs	Gap Between PACs	Action Latency	Actions In PAC	Total Map Explored	Workers Made	Unique Units Made	Complex Units Made	Complex Abilities Used
Correlation	Age	1.000	-0.205	-0.034	-0.115	-0.123	0.007	0.061	-0.046	-0.178	0.127	0.242	-0.087	-0.013	-0.108	0.012	-0.100	-0.074
	HoursPerWeek	-0.205	1.000	0.462	0.257	0.211	0.124	0.089	0.070	0.253	-0.171	-0.236	0.071	0.105	0.112	0.100	0.079	0.031
	TotalHours	-0.034	0.462	1.000	0.312	0.310	0.199	0.255	0.112	0.425	-0.285	-0.390	0.052	0.229	0.219	0.158	0.144	0.106
	SelectByHotkeys	-0.115	0.257	0.312	1.000	0.533	0.364	0.191	0.121	0.525	-0.327	-0.464	0.119	0.178	0.281	0.110	0.140	0.102
	AssignToHotkeys	-0.123	0.211	0.310	0.533	1.000	0.464	0.267	0.188	0.578	-0.436	-0.531	0.093	0.257	0.321	0.183	0.259	0.232
	UniqueHotkeys	0.007	0.124	0.199	0.364	0.464	1.000	0.186	0.109	0.430	-0.197	-0.339	-0.055	0.325	0.191	0.303	0.181	0.145
	MinimapAttacks	0.061	0.089	0.255	0.191	0.267	0.186	1.000	0.218	0.262	-0.254	-0.259	0.119	0.244	0.129	0.145	0.076	0.061
	MinimapRightClicks	-0.046	0.070	0.112	0.121	0.188	0.109	0.218	1.000	0.235	-0.290	-0.304	0.360	0.158	0.269	0.132	0.121	0.121
	NumberOfPACs	-0.178	0.253	0.425	0.525	0.578	0.430	0.262	0.235	1.000	-0.539	-0.836	-0.139	0.481	0.363	0.330	0.291	0.265
	GapBetweenPACs	0.127	-0.171	-0.285	-0.327	-0.436	-0.197	-0.254	-0.290	-0.539	1.000	0.686	-0.364	-0.095	-0.352	-0.072	-0.120	-0.153
	ActionLatency	0.242	-0.236	-0.390	-0.464	-0.531	-0.339	-0.259	-0.304	-0.836	0.686	1.000	-0.180	-0.384	-0.409	-0.256	-0.280	-0.261
	ActionsInPAC	-0.087	0.071	0.052	0.119	0.093	-0.055	0.119	0.360	-0.139	-0.364	-0.180	1.000	-0.113	0.361	-0.095	0.080	0.056
	TotalMapExplored	-0.013	0.105	0.229	0.178	0.257	0.325	0.244	0.158	0.481	-0.095	-0.384	-0.113	1.000	0.102	0.585	0.336	0.285
	WorkersMade	-0.108	0.112	0.219	0.281	0.321	0.191	0.129	0.269	0.363	-0.352	-0.409	0.361	0.102	1.000	0.084	0.184	0.099
	UniqueUnitsMade	0.012	0.100	0.158	0.110	0.183	0.303	0.145	0.132	0.330	-0.072	-0.256	-0.095	0.585	0.084	1.000	0.381	0.332
	ComplexUnitsMade	-0.100	0.079	0.144	0.140	0.259	0.181	0.076	0.121	0.291	-0.120	-0.280	0.080	0.336	0.184	0.381	1.000	0.615
	ComplexAbilitiesUsed	-0.074	0.031	0.106	0.102	0.232	0.145	0.061	0.121	0.265	-0.153	-0.261	0.056	0.285	0.099	0.332	0.615	1.000

G.3 Final model – only important variables

Correlation Matrix

		Action Latency	Assign To Hotkeys	Total Hours	Select By Hotkeys	Minimap Attacks	Workers Made	Number Of PACs	Gap Between PACs
Correlation	ActionLatency	1.000	-0.531	-0.390	-0.464	-0.259	-0.409	-0.836	0.686
	AssignToHotkeys	-0.531	1.000	0.310	0.533	0.267	0.321	0.578	-0.436
	TotalHours	-0.390	0.310	1.000	0.312	0.255	0.219	0.425	-0.285
	SelectByHotkeys	-0.464	0.533	0.312	1.000	0.191	0.281	0.525	-0.327
	MinimapAttacks	-0.259	0.267	0.255	0.191	1.000	0.129	0.262	-0.254
	WorkersMade	-0.409	0.321	0.219	0.281	0.129	1.000	0.363	-0.352
	NumberOfPACs	-0.836	0.578	0.425	0.525	0.262	0.363	1.000	-0.539
	GapBetweenPACs	0.686	-0.436	-0.285	-0.327	-0.254	-0.352	-0.539	1.000

G.4 transformed variables

Correlation Matrix

		APM	Assign To Hotkeys	Unique Hotkeys	Number Of PACs	Action Latency	Actions In PAC	Total Map Explored	Unique Units Made	Root MiniMap Attcks	Root Complex AbilitiesUsed	Root Complex UnitsMade	Log Age	Log Hours PerWeek	Log Total Hours	Log MiniMap RightClicks	Log GapBetween PACs	Log Workers Made	Log SelectBy Hotkeys
Correlation	APM	1.000	0.603	0.378	0.754	-0.773	0.392	0.300	0.185	0.342	0.193	0.190	-0.184	0.286	0.451	0.342	-0.634	0.533	0.743
	AssignToHotkeys	0.603	1.000	0.461	0.578	-0.525	0.080	0.252	0.177	0.285	0.267	0.178	-0.105	0.192	0.339	0.173	-0.444	0.341	0.655
	UniqueHotkeys	0.378	0.461	1.000	0.427	-0.332	-0.067	0.322	0.298	0.199	0.128	0.294	0.036	0.106	0.236	0.094	-0.194	0.189	0.413
	NumberOfPACs	0.754	0.578	0.427	1.000	-0.836	-0.149	0.479	0.324	0.295	0.293	0.329	-0.154	0.232	0.435	0.215	-0.532	0.397	0.583
	ActionLatency	-0.773	-0.525	-0.332	-0.836	1.000	-0.167	-0.382	-0.253	-0.292	-0.295	-0.256	0.212	-0.234	-0.454	-0.318	0.661	-0.453	-0.558
	ActionsInPAC	0.392	0.080	-0.067	-0.149	-0.167	1.000	-0.117	-0.096	0.128	0.000	-0.097	-0.084	0.085	0.127	0.369	-0.386	0.351	0.125
	TotalMapExplored	0.300	0.252	0.322	0.479	-0.382	-0.117	1.000	0.581	0.287	0.319	0.581	-0.006	0.091	0.239	0.129	-0.087	0.102	0.246
	UniqueUnitsMade	0.185	0.177	0.298	0.324	-0.253	-0.096	0.581	1.000	0.174	0.425	0.995	0.016	0.068	0.204	0.118	-0.036	0.106	0.178
	RootMiniMapAttcks	0.342	0.285	0.199	0.295	-0.292	0.128	0.287	0.174	1.000	0.093	0.177	0.064	0.074	0.268	0.294	-0.307	0.184	0.266
	RootComplexAbilitiesUsed	0.193	0.267	0.128	0.293	-0.295	0.000	0.319	0.425	0.093	1.000	0.420	-0.055	0.034	0.151	0.095	-0.136	0.137	0.191
	RootComplexUnitsMade	0.190	0.178	0.294	0.329	-0.256	-0.097	0.581	0.995	0.177	0.420	1.000	0.014	0.069	0.203	0.122	-0.035	0.120	0.184
	LogAge	-0.184	-0.105	0.036	-0.154	0.212	-0.084	-0.006	0.016	0.064	-0.055	0.014	1.000	-0.219	-0.031	-0.077	0.104	-0.099	-0.096
	LogHoursPerWeek	0.286	0.192	0.106	0.232	-0.234	0.085	0.091	0.068	0.074	0.034	0.069	-0.219	1.000	0.441	0.050	-0.191	0.122	0.196
	LogTotalHours	0.451	0.339	0.236	0.435	-0.454	0.127	0.239	0.204	0.268	0.151	0.203	-0.031	0.441	1.000	0.132	-0.377	0.286	0.329
	LogMiniMapRightClicks	0.342	0.173	0.094	0.215	-0.318	0.369	0.129	0.118	0.294	0.095	0.122	-0.077	0.050	0.132	1.000	-0.328	0.294	0.164
	LogGapBetweenPACs	-0.634	-0.444	-0.194	-0.532	0.661	-0.386	-0.087	-0.036	-0.307	-0.136	-0.035	0.104	-0.191	-0.377	-0.328	1.000	-0.393	-0.374
	LogWorkersMade	0.533	0.341	0.189	0.397	-0.453	0.351	0.102	0.106	0.184	0.137	0.120	-0.099	0.122	0.286	0.294	-0.393	1.000	0.443
	LogSelectByHotkeys	0.743	0.655	0.413	0.583	-0.558	0.125	0.246	0.178	0.266	0.191	0.184	-0.096	0.196	0.329	0.164	-0.374	0.443	1.000

Appendix H – Simple regression to find the significant variables

Predictor Variable	R2	Durbin-Watson	Significance from ANOVA	Standardized coeff beta
APM	0.517	1.164	0	0.719
NumberOfPACs	0.501	1.263	0	0.708
AssignToHotkeys	0.389	0.988	0	0.623
SelectByHotkeys	0.274	0.844	0	0.523
TotalHours	0.178	0.507	0	0.422
WorkersMade	0.177	0.735	0	0.421
UniqueHotkeys	0.143	0.658	0	0.378
TotalMapExplored	0.124	0.653	0	0.352
MinimapAttacks	0.099	0.544	0	0.315
MinimapRightClicks	0.087	0.529	0	0.295
HoursPerWeek	0.075	0.588	0	0.275
ComplexUnitsMade	0.058	0.531	0	0.241
ComplexAbilitiesUsed	0.058	0.517	0	0.241
UniqueUnitsMade	0.055	0.546	0	0.234
ActionsInPAC	0.017	0.429	0.01	0.129
Age	0.017	0.45	0.01	-0.131
GapBetweenPACs	0.31	0.77	0	-0.556
ActionLatency	0.5	1.212	0	-0.707

Appendix I – Final model results (5)

Model Summary[i]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.701[a]	0.491	0.49	1.26	
2	.755[b]	0.57	0.569	1.159	
3	.778[c]	0.605	0.603	1.112	
4	.789[d]	0.623	0.621	1.086	
5	.799[e]	0.639	0.636	1.064	
6	.805[f]	0.649	0.646	1.05	
7	.809[g]	0.655	0.652	1.041	
8	.813[h]	0.661	0.657	1.033	2.046

a. Predictors: (Constant), ActionLatency
b. Predictors: (Constant), ActionLatency, AssignToHotkeys
c. Predictors: (Constant), ActionLatency, AssignToHotkeys, TotalHours
d. Predictors: (Constant), ActionLatency, AssignToHotkeys, TotalHours, SelectByHotkeys
e. Predictors: (Constant), ActionLatency, AssignToHotkeys, TotalHours, SelectByHotkeys, MinimapAttacks
f. Predictors: (Constant), ActionLatency, AssignToHotkeys, TotalHours, SelectByHotkeys, MinimapAttacks, WorkersMade
g. Predictors: (Constant), ActionLatency, AssignToHotkeys, TotalHours, SelectByHotkeys, MinimapAttacks, WorkersMade, NumberOfPACs
h. Predictors: (Constant), ActionLatency, AssignToHotkeys, TotalHours, SelectByHotkeys, MinimapAttacks, WorkersMade, NumberOfPACs,
i. Dependent Variable: LeagueIndex

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	7.54	0.16		47.124	0		
	ActionLatency	-0.056	0.002	-0.701	-25.632	0	1	1
2	(Constant)	5.646	0.224		25.153	0		
	ActionLatency	-0.042	0.002	-0.525	-17.692	0	0.719	1.392
	AssignToHotkeys	2826.6	252.828	0.332	11.18	0	0.719	1.392
3	(Constant)	5.004	0.231		21.668	0		
	ActionLatency	-0.037	0.002	-0.461	-15.54	0	0.662	1.51
	AssignToHotkeys	2577.276	244.78	0.302	10.529	0	0.706	1.416
	TotalHours	0.001	0	0.204	7.704	0	0.833	1.201
4	(Constant)	4.763	0.229		20.76	0		
	ActionLatency	-0.034	0.002	-0.424	-14.304	0	0.632	1.582
	AssignToHotkeys	2027.637	257.283	0.238	7.881	0	0.61	1.64
	TotalHours	0.001	0	0.186	7.138	0	0.821	1.218
	SelectByHotkeys	77.156	13.329	0.168	5.789	0	0.661	1.514
5	(Constant)	4.637	0.226		20.523	0		
	ActionLatency	-0.033	0.002	-0.409	-14.031	0	0.626	1.596
	AssignToHotkeys	1853.852	254.102	0.218	7.296	0	0.6	1.666
	TotalHours	0.001	0	0.164	6.369	0	0.802	1.247
	SelectByHotkeys	76.684	13.059	0.167	5.872	0	0.66	1.514
	MinimapAttacks	1840.187	339.698	0.133	5.417	0	0.888	1.126
6	(Constant)	4.134	0.251		16.452	0		
	ActionLatency	-0.03	0.002	-0.376	-12.633	0	0.586	1.708
	AssignToHotkeys	1749.604	251.946	0.205	6.944	0	0.595	1.682
	TotalHours	0	0	0.159	6.243	0	0.8	1.25
	SelectByHotkeys	73.224	12.914	0.159	5.67	0	0.658	1.52
	MinimapAttacks	1845.883	335.292	0.133	5.505	0	0.888	1.126
	WorkersMade	380.06	87.375	0.11	4.35	0	0.812	1.231
7	(Constant)	2.716	0.468		5.808	0		
	ActionLatency	-0.021	0.003	-0.268	-6.323	0	0.285	3.509
	AssignToHotkeys	1573.23	254.579	0.185	6.18	0	0.572	1.747
	TotalHours	0	0	0.146	5.724	0	0.784	1.276
	SelectByHotkeys	64.939	13.01	0.141	4.992	0	0.637	1.569
	MinimapAttacks	1825.806	332.444	0.132	5.492	0	0.887	1.127
	WorkersMade	385.244	86.632	0.112	4.447	0	0.812	1.232
	NumberOfPACs	281.728	78.659	0.159	3.582	0	0.26	3.852
8	(Constant)	2.669	0.464		5.751	0		
	ActionLatency	-0.015	0.004	-0.187	-3.911	0	0.219	4.566
	AssignToHotkeys	1465.582	254.38	0.172	5.761	0	0.564	1.773
	TotalHours	0	0	0.145	5.722	0	0.784	1.276
	SelectByHotkeys	65.76	12.905	0.143	5.095	0	0.637	1.57
	MinimapAttacks	1716.326	331.22	0.124	5.182	0	0.879	1.137
	WorkersMade	356.614	86.316	0.103	4.131	0	0.805	1.243
	NumberOfPACs	316.872	78.665	0.179	4.028	0	0.255	3.916
	GapBetweenPACs	-0.01	0.003	-0.11	-3.487	0.001	0.504	1.985

a. Dependent Variable: LeagueIndex

Appendix J – MLR validation results

Model Summary[b,c]

Model	R		R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson Statistic	
	selection = 1 (Selected)	selection ~= 1 (Unselected)				selection = 1 (Selected)	selection ~= 1 (Unselected)
1	.834[a]	0.786	0.696	0.689	1.001	2.048	2.035

a. Predictors: (Constant), NumberOfPACs, MinimapAttacks, WorkersMade, TotalHours, SelectByHotkeys, GapBetweenPACs,

b. Unless noted otherwise, statistics are based only on cases for which selection = 1.

c. Dependent Variable: LeagueIndex

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.186	0.653		4.882	0		
	TotalHours	0.001	0	0.176	5.171	0	0.752	1.33
	SelectByHotkeys	77.444	20.03	0.143	3.866	0	0.635	1.574
	AssignToHotkeys	1622.928	366.992	0.182	4.422	0	0.515	1.942
	ActionLatency	-0.02	0.005	-0.248	-3.803	0	0.205	4.871
	MinimapAttacks	1399.367	396.554	0.113	3.529	0	0.855	1.17
	WorkersMade	271.856	113.423	0.081	2.397	0.017	0.772	1.295
	GapBetweenPACs	-0.009	0.004	-0.099	-2.384	0.018	0.506	1.978
	NumberOfPACs	232.774	111.993	0.129	2.078	0.038	0.227	4.4

a. Dependent Variable: LeagueIndex

b. Selecting only cases for which selection = 1

Appendix K – R square result on simple regression among all variables

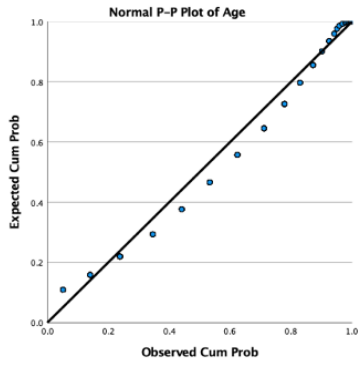
Dependent variable	R square
Age	0.139
HoursPerWeek	0.268
TotalHours	0.352
APM	0.979
SelectByHotkeys	0.917
AssignToHotkeys	0.493
UniqueHotkeys	0.311
MinimapAttacks	0.194
MinimapRightClicks	0.258
NumberOfPACs	0.951
GapBetweenPACs	0.585
ActionLatency	0.819
ActionsInPAC	0.899
TotalMapExplored	0.488
WorkersMade	0.352
UniqueUnitsMade	0.41
ComplexUnitsMade	0.447
ComplexAbilitiesUsed	0.413

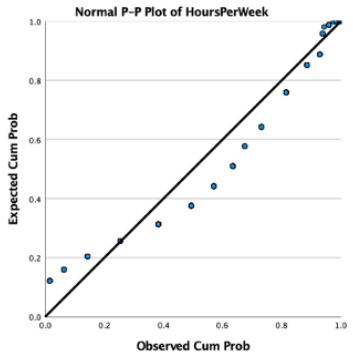
Dependent variable	R square
Age	0.134
HoursPerWeek	0.268
TotalHours	0.352
SelectByHotkeys	0.416
AssignToHotkeys	0.486
UniqueHotkeys	0.311
MinimapAttacks	0.178
MinimapRightClicks	0.258
NumberOfPACs	0.857
GapBetweenPACs	0.584
ActionLatency	0.816
ActionsInPAC	0.579
TotalMapExplored	0.487
WorkersMade	0.324
UniqueUnitsMade	0.407
ComplexUnitsMade	0.445
ComplexAbilitiesUsed	0.406

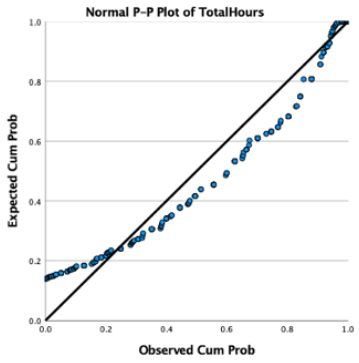
Figure on the left give the results of R square based on the simple regression, R square for APM is close to 1, which means, 'APM' can be explained by other variables. After dropping 'APM' and re-run the simple regression, we notice that R square for all variables is below 0.9.

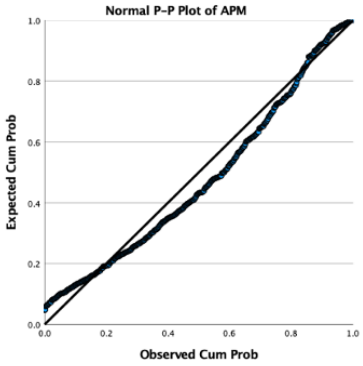
Appendix L - Assumption: Multiple Discriminant Analysis

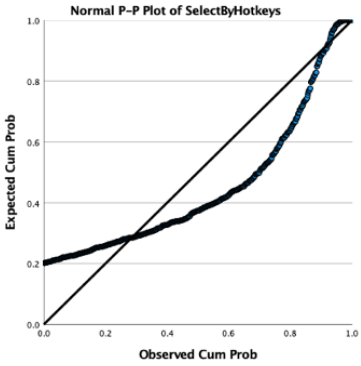
L.1 Normality

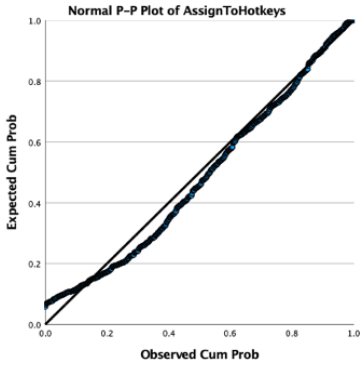


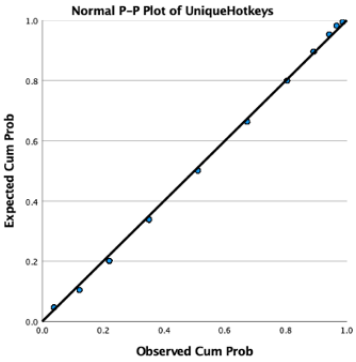


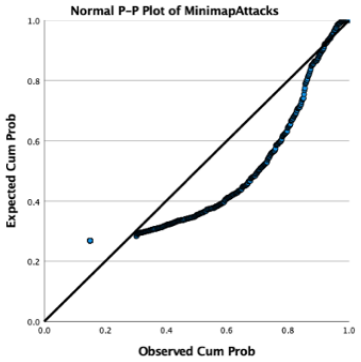


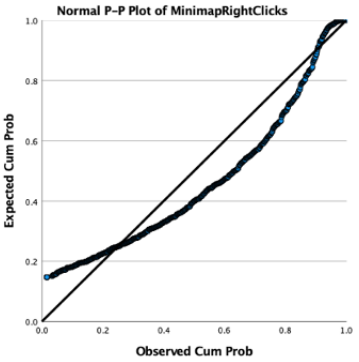


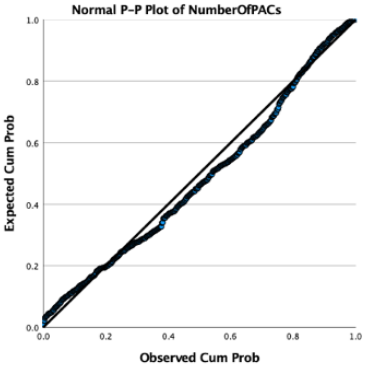


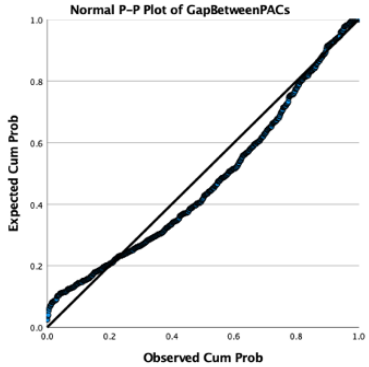


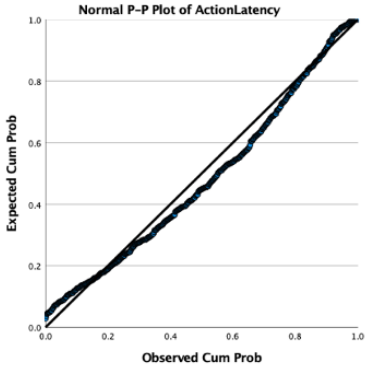


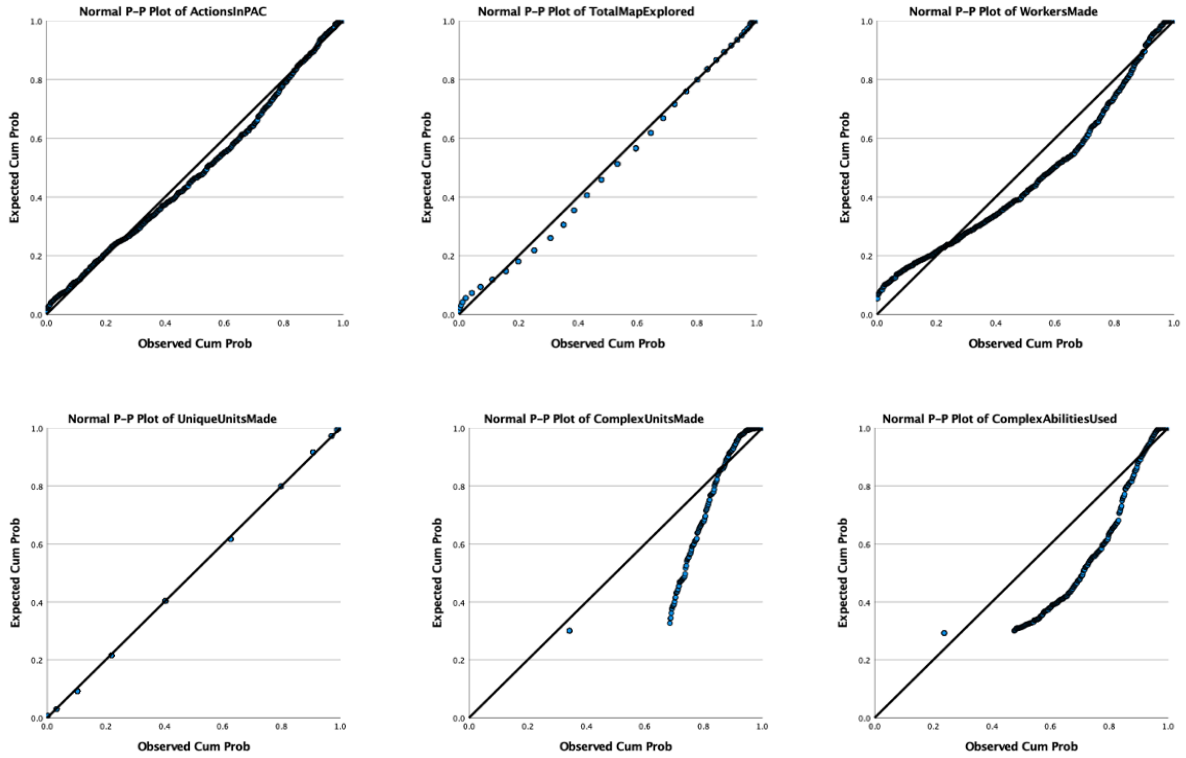












L.2 No multicollinearity

Pooled Within-Groups Matrices

Correlation

	Age	HoursPerWeek	TotalHours	SelectByHotkeys	AssignToHotkeys	UniqueHotkeys	MinimapAttacks	MinimapRightClicks	NumberOfPACs	GapBetweenPACs	ActionLatency	ActionsInPAC	TotalMapExplored	WorkersMade	UniqueUnitsMade	ComplexUnitsMade	ComplexAbilitiesUsed
Age	1	-0.167	0.031	-0.055	-0.078	0.042	0.089	0.024	-0.119	0.041	0.164	-0.011	0.045	-0.021	0.034	-0.068	-0.003
HoursPerWeek	-0.167	1	0.38	0.167	0.082	0.049	-0.109	-0.026	0.116	-0.016	-0.082	0.021	0.022	-0.04	0.071	0.015	-0.057
TotalHours	0.031	0.38	1	0.063	0.055	0.042	0.057	-0.032	0.138	-0.08	-0.135	-0.003	0.092	0.02	0.104	0.039	-0.083
SelectByHotkeys	-0.055	0.167	0.063	1	0.269	0.2	-0.04	-0.055	0.24	-0.077	-0.205	0.076	-0.026	0.118	0.041	0.039	0.03
AssignToHotkeys	-0.078	0.082	0.055	0.269	1	0.298	0.055	0.077	0.352	-0.232	-0.32	0.015	0.105	0.185	0.129	0.202	0.171
UniqueHotkeys	0.042	0.049	0.042	0.2	0.298	1	0.06	0.021	0.266	-0.034	-0.192	-0.078	0.248	0.031	0.27	0.119	0.125
MinimapAttacks	0.089	-0.109	0.057	-0.04	0.055	0.06	1	0.191	-0.008	-0.088	-0.046	0.118	0.159	0.085	0.108	0.06	0.048
MinimapRightClicks	0.024	-0.026	-0.032	-0.055	0.077	0.021	0.191	1	0.075	-0.206	-0.176	0.348	0.072	0.159	0.103	0.066	0.021
NumberOfPACs	-0.119	0.116	0.138	0.24	0.352	0.266	-0.008	0.075	1	-0.389	-0.749	-0.271	0.329	0.152	0.257	0.194	0.164
GapBetweenPACs	0.041	-0.016	-0.08	-0.077	-0.232	-0.034	-0.088	-0.206	-0.389	1	0.598	-0.312	0.096	-0.205	-0.003	-0.004	-0.043
ActionLatency	0.164	-0.082	-0.135	-0.205	-0.32	-0.192	-0.046	-0.176	-0.749	0.598	1	-0.133	-0.203	-0.223	-0.179	-0.172	-0.133
ActionsInPAC	-0.011	0.021	-0.003	0.076	0.015	-0.078	0.118	0.348	-0.271	-0.312	-0.133	1	-0.151	0.276	-0.09	0.053	0.051
TotalMapExplored	0.045	0.022	0.092	-0.026	0.105	0.248	0.159	0.072	0.329	0.096	-0.203	-0.151	1	-0.078	0.546	0.268	0.2
WorkersMade	-0.021	-0.04	0.02	0.118	0.185	0.031	0.085	0.159	0.152	-0.205	-0.223	0.276	-0.078	1	-0.035	0.05	0.007
UniqueUnitsMade	0.034	0.071	0.104	0.041	0.129	0.27	0.108	0.103	0.257	-0.003	-0.179	-0.09	0.546	-0.035	1	0.313	0.196
ComplexUnitsMade	-0.068	0.015	0.039	0.039	0.202	0.119	0.06	0.066	0.194	-0.004	-0.172	0.053	0.268	0.05	0.313	1	0.41
ComplexAbilitiesUsed	-0.003	-0.057	-0.083	0.03	0.171	0.125	0.048	0.021	0.164	-0.043	-0.133	0.051	0.2	0.007	0.196	0.41	1

Each pairwise correlation is lower than 0.8, the assumption of "no multicollinearity" is not violated.

L.3 Homoscedasticity

Group Statistics

LeagueIndex				Valid N (listwise)	
		Mean	Std. Deviation	Unweighted	Weighted
1	Age	21.6358	4.72626	324	324
	HoursPerWeek	13.4753	9.74645	324	324
	TotalHours	365.5093	292.76999	324	324
	SelectByHotkeys	0.0018	0.00221	324	324
	AssignToHotkeys	0.0002	0.00015	324	324
	UniqueHotkeys	3.429	2.14733	324	324
	MinimapAttacks	0	0.00008	324	324
	MinimapRightClicks	0.0003	0.00029	324	324
	NumberOfPACs	0.0028	0.00068	324	324
	GapBetweenPACs	51.9047	19.53998	324	324
	ActionLatency	78.3845	20.01293	324	324
	ActionsInPAC	4.9021	1.39085	324	324
	TotalMapExplored	20.1883	6.56511	324	324
	WorkersMade	0.0009	0.00052	324	324
	UniqueUnitsMade	6.1698	1.72907	324	324
	ComplexUnitsMade	0	0.0001	324	324
	ComplexAbilitiesUsed	0	0.00019	324	324
2	Age	20.64	3.18191	150	150
	HoursPerWeek	19.32	14.30414	150	150
	TotalHours	885.1333	734.225	150	150
	SelectByHotkeys	0.0054	0.0044	150	150
	AssignToHotkeys	0.0004	0.00018	150	150
	UniqueHotkeys	5.0533	2.38785	150	150
	MinimapAttacks	0.0001	0.0001	150	150
	MinimapRightClicks	0.0005	0.00044	150	150
	NumberOfPACs	0.004	0.00081	150	150
	GapBetweenPACs	32.8224	9.68783	150	150
	ActionLatency	52.8359	10.35843	150	150
	ActionsInPAC	5.3441	1.27209	150	150
	TotalMapExplored	24.7733	7.70526	150	150
	WorkersMade	0.0013	0.00058	150	150
	UniqueUnitsMade	6.96	1.91034	150	150
	ComplexUnitsMade	0.0001	0.00013	150	150
	ComplexAbilitiesUsed	0.0001	0.00033	150	150
3	Age	21.9444	2.64513	18	18
	HoursPerWeek	27	18.11402	18	18
	TotalHours	1392.7778	755.31688	18	18
	SelectByHotkeys	0.0097	0.00571	18	18
	AssignToHotkeys	0.0008	0.00033	18	18
	UniqueHotkeys	6.7778	1.83289	18	18
	MinimapAttacks	0.0003	0.00023	18	18
	MinimapRightClicks	0.0005	0.00034	18	18
	NumberOfPACs	0.0052	0.00071	18	18
	GapBetweenPACs	23.1922	5.9436	18	18
	ActionLatency	40.0316	6.10335	18	18
	ActionsInPAC	4.865	0.94622	18	18
	TotalMapExplored	27.6667	6.18347	18	18
	WorkersMade	0.0012	0.00073	18	18
	UniqueUnitsMade	6.9444	1.95455	18	18
	ComplexUnitsMade	0.0001	0.00014	18	18
	ComplexAbilitiesUsed	0.0002	0.00038	18	18

L.4 Homogeneity: Box's M test results

Log Determinants

LeagueIndex	Rank	Log Determinant
1	9	-61.571
2	9	-58.3
3	9	-58.723
Pooled within-groups	9	-58.777

The ranks and natural logarithms of determinants printed are those of the group covariance matrices.

Test Results

Box's M		830.812
F	Approx.	8.134
	df1	90
	df2	6190.051
	Sig.	0

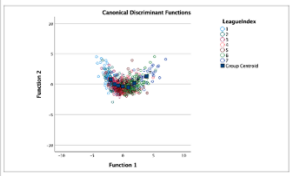
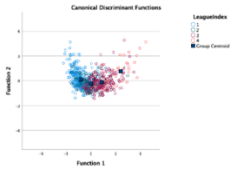
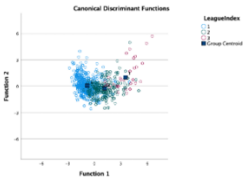
Tests null hypothesis of equal population covariance matrices.

Appendix M - Comparation between different grouping results

M.1 summary of classification results (with variable 'APM')

Summary of results

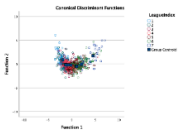
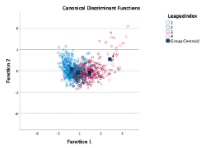
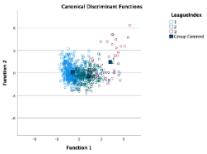
With APM

		7 expert levels	4 expert levels	3 expert levels
	Variables used in Analysis	**8 variables used**: 'APM', 'ActionLatency', 'AssignToHotkeys', 'ActionInPAC', 'TotalHours', 'HoursPerWeek', 'WorkersMade', 'MinimapAttacks'	**10 variables used:** 'NumberOfPACs' and'WorkersMade' were added compare to 7 expert levels	**8 variables used**: 'APM', 'TotalHours', 'AssignToHotkeys', 'NumberOfPACs', 'MinimapAttacks', 'MinimapAttacks','WorkersMade', 'ComplexUnitsMade', 'ActionLatency'
Canonical Discriminant Function	**Canonical Discriminant Functions**	$f_1(x) = -1.146 - 0.002x_1 + 0.001x_2 + 0.019x_3 + 1886.932x_4 + 3009.138x_5 - 0.019x_6 - 0.184x_7 + 287.043x_8$ $f_2(x) = -5.555 + 0.049x_1 + 0.024x_3 - 73.745x_4 + 3413.081x_5 - 0.063x_6 - 0.359x_7 - 371.718x_8$ $f_3(x) = 1.146 - 0.018x_1 - 0.019x_3 + 1920.568x_4 + 6052.259x_5 - 0.016x_6 + 0.354x_7 - 853.588x_8$ where where x_1 is 'HoursPerWeek', x_2 is 'TotalHours', x_3 is 'APM', x_4 is 'AssignToHotkeys', x_5 is 'MinimapAttacks', x_6 is 'ActionLatency', x_7 is 'ActionInPAC', x_8 is 'WorkersMade'.	$f_1(x) = -4.257 - 0.002x_1 + 0.001x_2 + 0.013x_3 + 1680.851x_4 + 2874.823x_5 + 510.857x_6 - 0.001x_7 + 230.285x_8$ $f_2(x) = -6.926 - 0.045x_1 + 0.012x_3 - 84.95x_4 + 4578.395x_5 + 408.471x_6 + 0.06x_7 - 610.189x_8$ where where x_1 is 'HoursPerWeek', x_2 is 'TotalHours', x_3 is 'APM', x_4 is 'AssignToHotkeys', x_5 is 'MinimapAttacks', x_6 is 'NumberOfPACs', x_7 is 'ActionLatency', x_8 is 'WorkersMade'.	$f_1(x) = -5.038 + 0.015x_2 + 1371.076x_3 + 2973.214x_4 + 582.637x_5 + 0.008x_6 + 145.835x_7 - 998.605x_8$ $f_2(x) = -4.081 + 0.007x_3 + 1456.92x_3 + 5131.851x_4 + 64.286x_5 + 0.044x_6 - 699.795x_7 - 2914.426x_8$ where where x_1 is 'TotalHours', x_2 is 'APM', x_3 is 'AssignToHotkeys',x_4 is 'MinimapAttacks', x_5 is 'NumberOfPACs', x_6 is 'ActionLatency', x_7 is 'WorkersMade', x_8 is 'ComplexUnitsMade'
	Eigenvalues(Variances explained)	**First function** explain 88.8% of total variances, **second function** explain9.2% of total variances, **third function** explain 1.1% of total variance, less than 1% of total variances are explained by the rest three functions.	**First function** explain 93.9% of total variances, **second function** explain5.2% of total variances, **third function** explain 0.9% of total variance.	**First function** explain 95.4% of total variances, **second function** explain 4.6% of total variances.
	Wilk's Lambda test	First 2 functions are significantly distinguish difference between different expert level, p<0.1. Others are not significant.	First 2 functions are significantly distinguish difference between different expert level, p<0.1. Third function is not significant.	Both functions are significantly distinguish difference between different expert level, p<0.1.
	Variables importance ***(see details in Appendix E)***	**Importance** / **7 experts levels** / **Standardized Canonical Discriminant Function Coefficients** 1 APM 0.588 2 MinimapAttacks 0.339 3 AssignToHotkeys 0.299 4 ActionLatency -0.284 5 TotalHours 0.257 6 ActionsInPAC -0.252 7 Workersmade 0.139 8 HoursPerWeek -0.016	**Importance** / **4 experts levels** / **Standardized Canonical Discriminant** 1 APM 0.509 2 NumberOfPACs 0.446 3 MinimapAttacks 0.349 4 AssignToHotkeys 0.233 5 TotalHours 0.228 6 ActionLatency 0.139 7 ComplexUnitsMade -0.108 8 Workersmade 0.081	**Importance** / **3 experts levels** / **Standardized Canonical Discriminant** 1 APM 0.436 2 NumberOfPACs 0.375 3 MinimapAttacks 0.336 4 AssignToHotkeys 0.276 5 TotalHours 0.243 6 Workersmade 0.126 7 HoursPerWeek -0.017 8 ActionLatency -0.016
Classification Results	**selected original correctly classified**	43.50%	71.20%	81.40%
	unselected original correctly classified	37.80%	71.50%	80.80%
	cross-validated correctly classified	39.80%	69.60%	80.00%
	All-group scatter plot			

M.2 summary of classification results (without variable 'APM')

Summary of results

Without 'APM'

		7 expert levels	4 expert levels	3 expert levels
Canonical Discriminant Function	**Variables used in Analysis**	**10 vaiables used** : 'NumberOfPACs', 'TotalHours','HoursPerWeek', 'SelectByHotkeys', 'ActionInPAC', 'AssignToHotkeys','MinimapAttacks', 'WorkersMade','GapBetweenPACs', 'ActionLatency'	**10 vaiables used** : 'compare with 7 expert options, it choose 'UniqueUnitsMade' but not 'GapbetweenPACs'	**9 vaiables used** in the final steps,same as in 4 expert levels except 'HoursPerWeek '
	Canonical Discriminant Functions	$f_1(x) = -3.865 - 0.005x_1 + 0.001x_2 + 111.57x_3 + 2043.657x_4 + 3052.926x_5 + 717.405x_6 - 0.012x_7 - 0.001x_8 + 0.076x_9 + 182.711x_{10}$ $f_2(x) = -10.772 + 0.018x_1 + 53.416x_3 + 641.262x_4 + 5053.735x_5 + 1252.045x_6 + 0.012x_7 + 0.073x_8 + 0.191x_9 - 864.834x_{10}$ $f_3(x) = -6.083 + 0.029x_1 + 89.734x_3 - 1873.343x_4 - 5414.722x_5 + 586.892x_6 + 0.012x_7 + 0.029x_8 + 0.13x_9 + 935.442x_{10}$ where x_1 is 'HoursPerWeek',x_2 is 'TotalHours',x_3 is 'SelectByHotkeys', x_4 is 'AssignToHotkeys',x_5 is 'MinimapAttacks',x_6 is 'NumberOfPACs',x_7 is 'GapBetweenPACs',x_8 is 'ActionLatency',x_9 is 'ActionInPAC',x_10 is 'WorkersMade'	$f_1(x) = -5.778 - 0.006x_1 + 0.001x_2 + 86.92x_3 + 1806.16x_4 + 3089.95x_5 + 969.237x_6 + 0.006x_7 + 0.182x_8 + 88.413x_9 - 0.03x_{10}$ $f_2(x) = -4.208 + 0.022x_1 + 10.981x_3 + 1198.394x_4 + 6105.133x_5 + 734.837x_6 + 0.048x_7 - 0.043x_8 - 888.012x_9 - 0.216x_{10}$ where x_1 is 'HoursPerWeek',x_2 is 'TotalHours',x_3 is 'SelectByHotkeys',x_4 is 'AssignToHotkeys',x_5 is 'MinimapAttacks', x_6 is 'NumberOfPACs',x_7 is 'ActionLatency',x_8 is 'ActionInPAC',x_9 is 'WorkersMade',x_10 is 'UniqueUnitsMade'	$f_1(x) = -6.115 + 0.001x_1 + 85.989x_2 + 1645.543x_3 + 3319.394x_4 + 1030.493x_5 + 0.012x_6 + 0.173x_7 + 25.386x_8 - 0.057x_9$ $f_2(x) = -4.364 + 0.02x_2 - 152.306x_3 + 4773.693x_4 + 0.005x_5 + 0.047x_6 - 0.122x_7 - 759.339x_8 - 4327.571x_9$ where x_1 is 'TotalHours',x_2 is 'SelectByHotkeys',x_3 is 'AssignToHotKeys', x_4 is 'MinimapAttacks',x_5 is 'NumberOfPACs',x_6 is 'ActionLatency', x_7 is 'ActionInPAC', x_8 is 'WorkersMade',x_9 is 'UniqueUnitsMade'
	Eigenvalues(Variances explained)	**First function** explain 86.4% of total variances, **second function** explain9.9% of total variances, **third function** exxplain 2% of total variance, less than 2% of total variances are explained by the rest three functions.	**First function** explain 90.6% of total variances, **second function** explain 8.3% of total variances, **third function** explain 1.1% of total variance.	**First function** explain 92% of total variances, **second function** explain 8% of total variances.
	Wilk's Lambda test	First three functions are significant in distinguishing the difference between different expert levels ,p<0.1.	First two functions are significant in distinguishing the difference between different expert levels ,p<0.1.	Both functions are significantly distinguish difference between different expert level, p<0.1
	Variables importance ***(see details in Appendix E)***	**Importance** / **7 experts levels** / **Standardized Canonical Discriminant** 1 NumberOfPACs 0.483 2 TotalHours 0.352 3 SelectByHotkeys 0.341 4 AssignToHotkeys 0.326 5 MinimapAttacks 0.282 6 GapBetweenPACs -0.192 7 ActionsInPAC 0.102 8 WorkersMade 0.085 9 HoursPerWeek -0.063	**Importance** / **4 experts levels** / **Standardized Canonical Discriminant** 1 NumberOfPACs 0.679 2 TotalHours 0.372 3 AssignToHotkeys 0.3 4 MinimapAttacks 0.298 5 SelectByHotkeys 0.276 6 ActionsInPAC 0.244 7 ActionLatency 0.097 8 HoursPerWeek -0.071 9 UniqueUnitsMade -0.054 10 WorkersMade 0.048	**Importance** / **3 experts levels** / **Standardized Canonical Discriminant** 1 NumberOfPACs 0.743 2 TotalHours 0.349 3 MinimapAttacks 0.321 4 AssignToHotkeys 0.28 5 SelectByHotkeys 0.275 6 ActionsInPAC 0.232 7 ActionLatency 0.2 8 UniqueUnitsMade -0.102 9 WorkersMade 0.014 10 / /
Classification Results	**selected original correctly classified**	45.50%	73.00%	85.00%
	unselected original correctly classified	34.20%	68.40%	77.70%
	cross-validated correctly classified	40.20%	72.00%	83.70%
	All-group scatter plot			

Appendix N - Outputs from original expert grouping

N.1 Variances explanation by 6 Discriminant functions from original 'LeagueIndex' outputs

Eigenvalues				
Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	2.440[a]	86.4	86.4	0.842
2	.280[a]	9.9	96.2	0.467
3	.057[a]	2	98.3	0.233
4	.031[a]	1.1	99.4	0.172
5	.015[a]	0.5	99.9	0.122
6	.003[a]	0.1	100	0.056
a. First 6 canonical discriminant functions were used in the analysis.				

N.2 Unstandardized Canonical Discriminant functions at group centroid

Functions at Group Centroids						
	Function					
LeagueIndex	1	2	3	4	5	6
1	-1.904	0.876	0.223	0.153	-0.033	-0.004
2	-1.262	-0.156	0.001	-0.215	0.164	0.042
3	-0.651	-0.17	-0.186	-0.102	-0.072	-0.101
4	-0.143	-0.24	-0.269	0.095	-0.14	0.075
5	1.027	-0.491	0.07	0.271	0.138	-0.024
6	2.062	-0.086	0.368	-0.154	-0.11	0.01
7	4.508	1.72	-0.539	-0.079	0.162	-0.001
Unstandardized canonical discriminant functions evaluated at group means						

Appendix O - Misclassification cases

Casewise Statistics

Case Number	Actual Group	Predicted Group	Highest Group				Second Highest Group			Discriminant Scores	
			P(D>d | G=g)		P(G=g | D=d)	Squared Mahalanobis Distance to Centroid	Group	P(G=g | D=d)	Squared Mahalanobis Distance to Centroid	Function 1	Function 2
			p	df							
358	1	2**	0.845	2	0.62	0.336	1	0.379	2.86	0.72	-0.584
362	1	2**	0.401	2	0.941	1.826	3	0.032	4.346	2.406	0.325
371	1	2**	0.901	2	0.786	0.208	1	0.214	4.346	1.049	-0.809
382	1	2**	0.566	2	0.583	1.138	1	0.417	3.349	0.942	0.601
383u	1	2**	0.593	2	0.912	1.046	1	0.08	7.448	1.892	0.402
393u	1	2**	0.428	2	0.938	1.7	1	0.035	9.792	2.295	0.399
395	1	2**	0.486	2	0.957	1.443	1	0.025	10.279	2.384	0.047
398	1	2**	0.747	2	0.533	0.582	1	0.467	2.384	0.54	-0.618
402	1	2**	0.478	2	0.706	1.476	1	0.294	4.769	0.682	-1.473
409	1	2**	0.962	2	0.758	0.076	1	0.242	3.897	1.132	-0.176
412	1	2**	0.869	2	0.676	0.282	1	0.324	3.297	0.814	-0.678
413	1	2**	0.783	2	0.544	0.489	1	0.456	2.379	0.718	0.011
419u	1	2**	0.439	2	0.723	1.644	1	0.277	5.106	0.701	-1.56
420	1	2**	0.972	2	0.755	0.057	1	0.245	3.844	1.047	-0.483
451u	2	2	0.87	2	0.604	0.28	1	0.396	2.661	0.762	-0.282
452	2	3**	0.309	2	0.938	2.351	2	0.062	12.041	4.718	0.016
497	2	1**	0.91	2	0.952	0.188	2	0.048	4.602	-0.661	0.513
500u	2	1**	0.921	2	0.97	0.165	2	0.03	5.552	-1.073	-0.208
501u	2	1**	0.6	2	0.729	1.022	2	0.271	1.459	0.067	-0.372
504	2	1**	0.596	2	0.739	1.035	2	0.261	1.58	0.018	-0.463
507u	2	1**	0.852	2	0.868	0.32	2	0.132	2.552	-0.287	-0.075
532	2	1**	0.151	2	0.574	3.781	2	0.426	2.835	0.088	-1.608
533	2	1**	0.352	2	0.58	2.09	2	0.42	1.195	0.587	0.437
534u	2	1**	0.848	2	0.904	0.331	2	0.096	3.268	-0.533	-0.387
535	2	2	0.89	2	0.92	0.233	1	0.079	6.682	1.735	-0.271
536u	2	1**	0.798	2	0.852	0.452	2	0.148	2.406	-0.154	0.192
537u	2	1**	0.398	2	0.567	1.842	2	0.433	0.842	0.536	0.132
552u	2	2	0.823	2	0.56	0.389	1	0.44	2.409	0.709	-0.15
553u	2	1**	0.366	2	0.888	2.013	2	0.112	4.604	-0.679	-1.301
555	2	1**	0.623	2	0.749	0.945	2	0.251	1.588	0.015	-0.386
556	2	1**	0.401	2	0.552	1.828	2	0.448	0.705	0.435	-0.389
557	2	2	0.664	2	0.509	0.82	1	0.491	2.432	0.726	0.308
559	2	2	0.103	2	0.76	4.537	3	0.237	2.627	3.355	0.041
560	2	3**	0.021	2	0.963	7.772	2	0.037	18.505	5.539	-0.979
561u	2	3**	0.001	2	1	13.695	2	0	41.539	4.573	5.124
562	2	2	0.068	2	0.876	5.391	3	0.123	5.08	3.574	-0.729
563	2	2	0.121	2	0.97	4.221	1	0.03	12.722	1.687	-2.426
564u	2	1**	0.395	2	0.584	1.86	2	0.416	0.998	0.306	-0.657
565u	2	3**	0.012	2	0.995	8.888	2	0.005	23.684	2.934	4.162
569u	2	3**	0.115	2	0.979	4.326	2	0.021	16.242	5.303	-0.294
573	2	3**	0.376	2	0.662	1.955	2	0.338	7.538	3.979	0.06
638	2	1**	0.603	2	0.721	1.01	2	0.279	1.367	0.176	-0.01
642u	2	1**	0.618	2	0.817	0.963	2	0.183	2.413	0.056	0.55
645	2	1**	0.364	2	0.589	2.021	2	0.411	1.201	0.256	-0.817
647	2	1**	0.386	2	0.619	1.902	2	0.381	1.334	0.194	-0.822
652	2	1**	0.48	2	0.629	1.466	2	0.371	0.981	0.387	0.026
654	2	1**	0.374	2	0.646	1.966	2	0.354	1.629	0.494	0.597
666u	3	2**	0.02	2	0.918	7.792	3	0.081	8.405	3.871	-1.438
667	3	2**	0.077	2	0.874	5.127	3	0.124	4.788	3.526	-0.647
673u	3	2**	0.462	2	0.85	1.544	1	0.143	6.654	1.674	0.764
674	3	2**	0.673	2	0.968	0.793	1	0.03	9.306	2.137	-0.634
675u	3	2**	0.052	2	0.557	5.902	3	0.442	2.12	3.652	0.083
676u	3	2**	0.828	2	0.867	0.379	1	0.131	5.693	1.565	0.13
677	3	2**	0.05	2	0.892	5.986	3	0.107	5.991	3.661	-0.949
680u	3	2**	0.972	2	0.849	0.058	1	0.15	5.059	1.405	-0.211
681	3	2**	0.487	2	0.971	1.44	1	0.017	11.05	2.472	-0.339
683u	3	2**	0.064	2	0.505	5.499	3	0.49	1.32	3.07	1.096
684	3	2**	0.615	2	0.913	0.971	1	0.079	7.398	1.887	0.359
685u	3	2**	0.562	2	0.96	1.152	1	0.029	9.69	2.287	-0.057
686	3	2**	0.106	2	0.788	4.49	1	0.157	9.253	1.81	1.637

For the original data, squared Mahalanobis distance is based on canonical functions.

u. Unselected case

**. Misclassified case

Here are some examples of misclassified cases, players will be placed to the wrong group with higher classification scores.

Appendix P - Meeting minutes

P.1 – Discussion 1

1. Time: 2021/2/16 16:30-17:20
2. Location: Online
3. Discussion Summary
   (1) Approaches decided for three questions
      - Q1: MDA or MR (not in rush)
      - Q2: PCA + Cluster (focused in the first week)
      - Q3: FA (focused in the second week)
   (2) Timeline and work allocation: Everyone should complete the tasks for question 2 before next meeting.
      - PCA (all)
      - Clustering
        - Single-linkage (nearest-neighbour) – Keming, Yoyo
        - Complete-linkage (farthest-neighbour) – Siying, Sreenidhi
        - Centroid – Jiayin
        - Ward – Yuhsuan
   (3) Interpretation will be discussed on Friday
   (4) Literature research and report writing should be finished before 2/23
   (5) Structure of the Report
      - Cover Page
      - Executive Summary
      - Table of Content
      - Question 1 for 3 pages
      - Question 2 for 3 pages
      - Question 3 for 3 pages
      - Appendix
      - Reference

P.2 – Discussion 2

1. Time: 2021/2/19 15:00-16:00
2. Location: Online
3. Discussion Summary
   (1) Keming, Siying, Yuhsuan, and Sreenidhi presented the result of question 2
   (2) Initial solution to question 2
      - Solution 1: Choose a few variables derived from question 1and use these variables to apply PCA and clustering.
      - Solution 2: Use all variables to apply PCA and select PCs with eigen value larger than 1 then cluster.
      - Need more exploration.
      - Problems: How to interpret the result? How to identify the “distinguish features”?
   (3) Timeline and work allocation
      - Question 2 – Sreenidhi, Siying and Keming
      - Question 3 – Jiayin, Yuhsuan and Yoyo

P.3 – Discussion 3

1. Time – 2021/2/26 14:00-15:30
2. Location: Online
3. Discussion summary
   (1) Question 3: Yuhsuan presented the result on the whole dataset, and Sreenidhi presented the output on full dataset without outliers.
   (2) Keming worked on question for the conclusion
   (3) Timeline and work allocation
      - Yuhsuan and Yoyo – report for Q3 will be finished before next meeting
      - Jiayin, Siying – use regression on Q1 and factor analysis on Q2
      - Sreenidhi and Keming – work further on Q1 and finalize Q2

P.4 – Discussion 4

1. Time – 2021/3/5 14:00-15:30
2. Location: Online
3. Discussion Summary
   (1) Siying, Sreenidhi, and Keming Cross checked answers for question 1. They will work on regression and MDA to verify with the initial solution presented today by Siying.
   (2) Yuhsuan compared the results of question 3 by choosing 5 and 6 factors.
   (3) Timeline and work allocation
      - Report for Q1 – Siying, Keming, Sreenidhi, Jiayin
      - Report for Q3 – Yoyo, Yuhsuan

P.5 – Discussion 5

1. Time – 2021/3/12 14:00-15:30
2. Location: Online
3. Discussion Summary
   (1) Siying, Sreenidhi, and Keming presented the result of question1
   (2) Yuhsuan showed the validation results for question 3
   (3) Timeline and work allocation: Everyone should complete the testing and report before next meeting
      - Report for Q1 – Siying, Sreenidhi
      - Report for Q2 - Keming, Jiayin
      - Report for Q3 – Yuhsuan
      - Combine report – Yoyo

P.6 – Discussion 6

1. Time – 2021/3/16 15:30-16:30
2. Location: PG hub
3. Discussion Summary
   (1) Siying, Sreenidhi, Keming, Jiayin, and Yuhsuan presented the final results for each question.
   (2) Timeline and work allocation: Everyone should finalize the reports
      - Report for Q1 – Siying, Sreenidhi
      - Report for Q2 - Keming, Jiayin
      - Report for Q3 – Yuhsuan

- Introduction – Yoyo

P.7 – Discussion 7

1. Time – 2021/3/19 14:00-16:30
2. Location: PG hub
3. Discussion Summary
   (1) Timeline and work allocation
   - Sreenidhi –finalise report for part of the question 1
   - Siying – combine report with cover, content, appendix, and review reports to revise grammar errors
   - Keming – finalise report and figures for question 2
   - Jiayin – finalise report and figures for question 2
   - Yuhsuan – reorganize figures and tables, finish summary and data preparation parts, and compile meeting minutes
   - Yoyo – finish introduction part

P.8 – Discussion 8

1. Time – 2021/3/21 15:00-
2. Location: Online
3. Discussion Summary