Iyer, S. et al. (Eds.) (2022). Proceedings of the 30th International Conference on Computers in Education.
Asia-Pacific Society for Computers in Education

Using Unsupervised Machine Learning to Model Taiwanese High-School Students' Digital Distraction Profiles Concerning Internet Gaming Disorder

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Abstract: Digital distraction is cognitive attention wandering or being directed to digital sources other than the main learning task. Adolescents with digital distractions may also be addicted to Internet gaming or even suffer Internet gaming disorder (IGD), severely harming their physical and mental development and learning performance. Digital distraction is related to low self-esteem, which is one of the antecedents of IGD. Therefore, this study investigates the association between digital distraction and IGD. We collected responses from 793 Taiwanese senior high students. Results showed that students utilize digital devices for entertainment when learning. Two-stage clustering classified students into four groups concerning their digital distraction constructs: perceived attention problems (PAP) and self-regulation strategies (SRS). The IGD-suspected participants were in the groups with strong PAP profile. We found that digital distraction would be associated with IGD. To mitigate IGD, we suggest early digital distraction screening and provide self-regulation strategies for high schoolers to mitigate their attention and IGD issues.

Keywords: Machine learning in Education, Internet Gaming Disorder, Digital Distraction, Self-Regulation Strategies, Learner and Student Modeling

1. Introduction

Internet Gaming Disorder (IGD) has already been included in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) since 2013. Paulus, Ohamann, Gontard, and Popow (2018) and Saunders et al. (2017) found that IGD occurs more frequently in teenagers, especially in Eastern countries. Research has indicated multiple upstream factors of IGD, such as genes, social requirements, harmful gaming motivations, and low self-esteem (Laconi, Pires, & Chabrol, 2017; Paulus et al., 2018). Despite the fruitful achievement, investigating IGD through educational perspectives has remained almost untreated.

As digital devices become part of our daily lives, some crucial issues and the impact of digital distraction gradually intensify. Specifically, in the online learning context, students are highly likely to be distracted by advertisements, social media, or online games (Wu, 2017). Wu and Cheng (2019) indicated that digital distraction induces low self-esteem, a crucial antecedent of IGD (Paulus et al., 2018).

However, much more research is needed to validate the link between digital distraction and IGD. This study attempts to extend previous digital distraction work by examining how IGD-suspected schoolers' would demonstrate their digital distraction profiles. The study results may provide insights into digital distraction and IGD, improving teaching and learning practices.

2. Literature Review

2.1 Internet Gaming Disorder

IGD was included in DSM-5 by American Psychiatric Association and was defined in terms of nine diagnostic criteria in 2013 as follows:

- Preoccupation with gaming
- Withdrawal symptoms when gaming is taken away or not possible (sadness, anxiety, irritability)
- Tolerance, the need to spend more time gaming to satisfy the urge
- Inability to reduce playing, unsuccessful attempts to quit gaming
- Giving up other activities, loss of interest in previously enjoyed activities due to gaming
- Continuing to the game despite problems
- Deceiving family members or others about the amount of time spent on gaming
- The use of gaming to relieve negative moods, such as guilt or hopelessness
- Risk, having jeopardized or lost a job or relationship due to gaming

Although the exact cause of IGD has not been found yet (Gentile et al., 2017), some research has found that the prevalence of IGD has significant differences in sex, age, culture, game genre, and gaming motivation. The prevalence among males is about 11.9% compared with females, which is 2.9% (Laconi, Pires, & Chabrol, 2017; Paulus et al., 2018). Besides, most IGD patients are teenagers (Hawi, Samaha, & Griffiths, 2018; Paulus et al., 2018). Saunders et al. (2017) found that the prevalence in Eastern countries is generally higher.

Many scholars also studied the influences of IGD. Saunders et al. (2017) unified the physical and psychological effects and burdens of IGD, including sleep deprivation, day-night reversal, dehydration, etc. Although these physical and psychological effects do not seem highly life-threatening, some sporadic deaths are caused by prolonged sitting in front of the computer (Lee, 2004).

2.2 Digital Distraction and Self-Regulation Strategies

In a personal learning environment (PLE), most learners would likely use digital devices as learning tools. Although digital learning positively affects learning performance and motivation (Lin et al., 2017), it also shows adverse effects, such as learning procrastination (Wu & Cheng, 2019). When required to use online resources for learning, learners may also visit irrelevant websites, such as social media and internet games, simultaneously (Wu & Xie, 2018) and would be interrupted and keep browsing behaviors unrelated to classes (Taneja, Fiore, & Fischer, 2015). This situation negatively impacts learning performance (Duncan, Hoekstra, & Wilcox, 2012).

However, if students have low learning performance or attention discontinuity, it is not entirely because of the use of digital devices or social media; it might result from their inadequate self-regulation strategies for coping with digital distraction instead (Ho, Liao, Weng, Cheng, & Wu, 2021). Hence, teachers and parents can guide students to establish appropriate self-regulation strategies to regulate distractions and improve their autonomous learning self-efficacy.

3. Method

3.1 Participants

This study utilized data from an extensive national survey. Seven hundred and ninety-three participants were Taiwanese high school or vocational students from grades 10 to 12.

3.2 Ten-Item Internet Gaming Disorder Test (IGDT-10)

This study uses the Ten-Item Internet Gaming Disorder Test (IGDT-10), adapted from Király et al. (2017), which based on the symptoms defined by DSM-5. It is scored on a three-point Likert scale, namely “frequently," “sometimes," and “never.” A participant who chooses “frequently” in five out of ten questions can be determined as an IGD patient. The diagnostic accuracy rate of this cut-off point is as high as 99%, which is also applicable to Taiwanese adolescents (Ko et al., 2014).

3.3 Online Learning Motivated Attention Regulation and Strategies Scale (OL-MARS)

This study uses the Online Learning Motivated Attention Regulation and Strategies Scale (OL-MARS) to assess digital distraction (Wu, 2015). The OL-MARS is scored on a five-point Likert scale.

Wu (2015) indicated that there are two constructs of digital distraction: Perceived Attention Problems (PAP) and Self-Regulation Strategies (SRS). On the one hand, PAP consists of Social Media Notification (SMN) and Lingering Thoughts (LT). SMN indicates how students perceive whether they are susceptible to social media or digital devices' prompt messages, sounds, or vibrations. LT indicates the anticipation and alertness to events unrelated to learning.

On the other hand, SRS consists of Behavioral Strategy (BS) and Outcome Appraisal (OA). BS indicates using external behavioral strategies to control Internet use. OA means how students appraise their online learning outcomes and relate to their emotions to direct their attention mentally.

3.4 Two-stage Clustering Analysis

Clustering analysis, including hierarchical and non-hierarchical clustering analysis, is a statistical method for grouping participants according to the commonality of attributes. Although non-hierarchical clustering analysis is more widely used, its disadvantage is that it is more sensitive to initial distance. However, the agglomeration process of hierarchical clustering analysis is usually less critical. It is currently inclined to use two-stage clustering analysis to address both shortcuts (Milligan & Sokol, 1908). The first stage uses hierarchical clustering analysis. Since the data are all continuous variables, this study selects Euclidean distance, which is the most suitable for continuous variables and the best way to express the distance between two points, and Ward's minimum variance method, to minimize the variance of each cluster. The second stage uses non-hierarchical clustering analysis/unsupervised machine learning. In this study, *k*-means clustering is selected, the number specified in the first stage is used as a *k* value, and the final clustering results are named by their characteristics. We took the sum of SMN and LT as the PAP score and the sum of BS and OA as the SRS score. The scores of PAP and SRS were used as the clustering variables to form heterogeneous groups of PAP and SRS.

4. Results

4.1 Descriptive Statistical Analysis

Among the data from 793 students, 48% were males (52% females), and 79% were senior high school students (21% avocational students). Twenty-seven students were suspected of having IGD, and only five were female. The prevalence was about 3.4%, a little higher than the reported world average, but was in line with the prevalence in Taiwan (Chiu, Pan, & Lin, 2018).

In this study, we found that the three most common reasons for high school students to use digital devices were surfing social media (89.3%), browsing video websites (86.8%), and playing online games (82.8%).

We used the *R* (version 4.0.4) to compute the descriptive statistics of the two scales (i.e., PAP and SRS). The results showed that the data is normally distributed with skewness and kurtosis distributed between ±3. In addition, both scales are reliable (Cronbach's $\alpha \geq .80$), and the data is suitable for cluster analysis, as shown in *Table 1*.

Table 1. *Item statistics of online learning motivated attention regulation and strategies scale (OL-MARS) and ten-item Internet gaming disorder test (IGDT-10)*

Scale/Item	*M*	*SD*	*α*	*Range*		*Skewness*	*Kurtosis*
				MIN	*MAX*		
OL-MARS							
Perceived Attention Problems (PAP)							
SMN1	2.89	1.16	.86	1	5	0.07	-0.73

SMN2	2.85	1.16		1	5	0.09	-0.74
SMN3	2.59	1.14		1	5	0.38	-0.57
LT1	2.61	1.05	.85	1	5	0.28	-0.20
LT2	3.01	1.15		1	5	-0.04	-0.64
LT3	3.09	1.01		1	5	-0.05	-0.13
LT4	2.86	1.02		1	5	0.22	-0.18
Self-Regulation Strategies (SRS)							
BS1	2.52	1.26	.86	1	5	0.44	-0.81
BS2	3.15	1.30		1	5	-0.11	-1.04
BS3	3.10	1.25		1	5	-0.12	-0.91
BS4	3.10	0.97		1	5	-0.02	-0.11
BS5	3.09	1.00		1	5	-0.03	-0.19
BS6	3.28	0.99		1	5	-0.18	-0.04
OA1	3.45	1.17	.85	1	5	-0.38	0.63
OA2	3.20	1.20		1	5	-0.19	-0.83
OA3	3.93	1.06		1	5	-0.68	-0.29
IGDT-10							
IGD1	1.66	0.62	.86	1	3	0.37	-0.67
IGD2	1.35	0.54		1	3	1.21	0.47
IGD3	1.35	0.57		1	3	1.39	0.94
IGD4	1.39	0.58		1	3	1.21	0.45
IGD5	1.20	0.46		1	3	2.27	4.48
IGD6	1.50	0.64		1	3	0.90	-0.27
IGD7	1.36	0.57		1	3	1.33	0.76
IGD8	1.91	0.68		1	3	0.11	-0.85
IGD9	1.13	0.38		1	3	3.03	9.03
IGD10	1.47	0.61		1	3	0.94	-0.14

4.2 Unsupervised Machine Learning: Two-stage Clustering Analysis

4.2.1 Ward's Minimum Variance Method

Regarding the PAP and SRS scores, this study utilized Ward's minimum variance method and Euclidean distance at the first stage of hierarchical clustering analysis. The results are shown in *Figure 1*, suggesting that four groups were the most suitable solution.

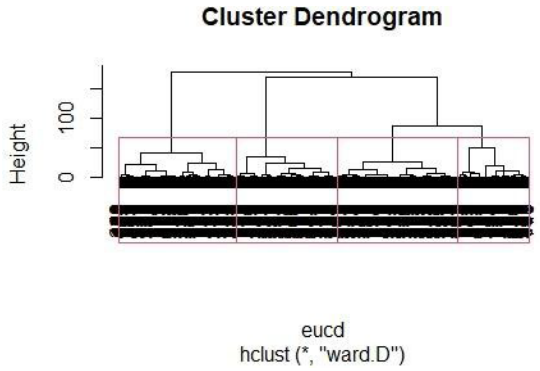

Figure 1. Hierarchical clustering analysis results in a dendrogram

4.2.2 k-means

Based on the results from the first stage, this study set the *k* value as 4 for *k*-means analysis. The clustering results are shown in *Figure 2*.

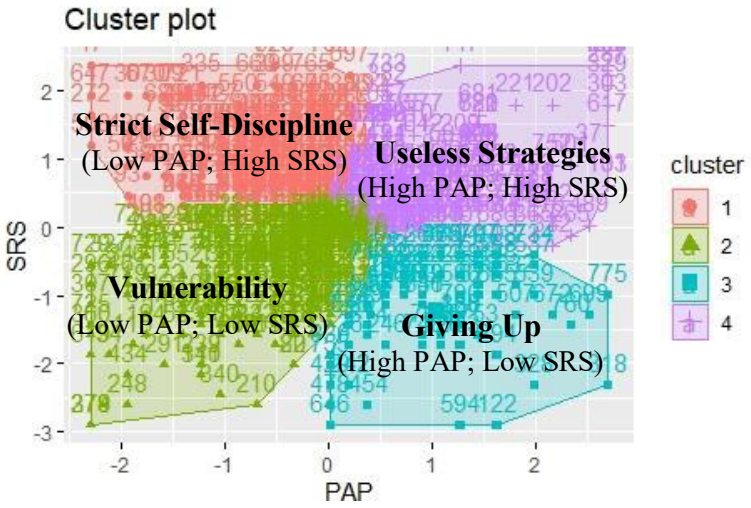

Figure 2. k-means cluster plot

Participants were distinctly divided into four groups: high PAP and high SRS, high PAP and low SRS, low PAP and high SRS, and low PAP and low SRS. Accordingly, these groups were named: Useless Strategies, Giving Up, Strict Self-Discipline, and Vulnerability. We performed further post-hoc with the *Scheffe test* for the results of clustering. The results showed that the SRS scores were significantly different among the groups, which can be expressed as follows:

- Strict Self-Discipline>Useless Strategies>Vulnerability>Giving Up

The PAP scores among the groups can be expressed as follows:

- Useless Strategies≒ Given Up>Vulnerability>Strict Self-Discipline

We further checked the grouping status of the twenty-seven participants who are suspected of having IGD. The results showed that 70.37% were in Useless Strategies (*N*=19), 22.22% were in Giving Up (*N*=6), and only 7.41% were in Strict Self-Discipline (*N*=2).

5. Discussion

This study analyzed the influence of digital distraction on IGD for Taiwanese high school students. We evidenced that Internet has become indispensable in teenagers' daily lives, and playing online games is a prevalent entertainment. We effectively classified participants into four groups by analyzing digital distraction (i.e., PAP and SRS) with a two-stage clustering analysis. Participants suspected of having IGD tend to have higher PAP. Therefore, future instructors should teach students more appropriate self-regulation strategies to alleviate IGD.

6. Conclusion

Easily distracted by digital devices and being unable to stop playing online games are signs of IGD. As digital devices are more prevalent in young learners' daily lives, they are more susceptible to IGD and digital distraction than ever before. This study demonstrates the relationship between digital distraction and IGD from an educational perspective. The results reveal that students with higher PAP are vulnerable to IGD, and appropriate self-regulation strategies may prevent students from having IGD. Hence, it is possible to prevent IGD if instructors can identify students with digital distraction issues early and intervene.

Although we obtain promising results on the early identification of IGD through analyzing digital distraction, this study is not without limitations. This study only used questionnaire scores for analysis. More rigorous experiments (i.e., neuroscience research) should be combined to explore the causal relationship between digital distraction and IGD.

Acknowledgements

This work was partially supported by the Higher Education Sprout Project from the Ministry of Education (MOE) and by the research grant from the Ministry of Science and Technology (MOST 110-2525-H-A49-001-MY4, MOST 108-2511-H-009-011-MY4), Taiwan.

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