

Learning Characteristics of Digital Natives: The Web The Influence of Games on the Cognitive Ability of New Generation Learners

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ABSTRACT

Using the data of China Education Tracking Survey (CEPS) 2014-2015, we analyse the impact of online games on the cognitive ability of new generation learners after controlling individual factors by using Pearson product-moment correlation coefficient and OLS linear regression method. The study found that: the longer the time of playing games, the lower the cognitive ability scores of learners; their cognitive ability is affected by significant and robust negative effects of online games; at the same time, the negative effect of playing games on weekdays is greater than that on weekends; online games do not affect the cognitive ability of learners in isolation, and personal bad behaviours, personal health, family cultural capital, network capital and so on together have a significant negative impact on students. How to correctly understand this effect and develop appropriate solutions will be the way to guarantee the cognitive ability of learners in the new era.

KEYWORDS

Digital natives; Learning characteristics; Online games; Cognitive ability

1 Introduction

In January 2025, the People's Republic of China issued the Outline of the Plan for the Construction of a Stronger Education Nation (2024-2035), which started a new journey for the high-quality development of education. In April 2025, the Ministry of Education and nine other departments jointly issued the Opinions on Accelerating the Advancement of Digitalisation in Education to comprehensively support the construction of a stronger education nation ^[1]. It shows that in the context of today's rapid development of digital technology, the integration of digitalisation into the field of education has become a general trend. In the process of realising the digitalisation of education, it is unavoidable that the new generation of learners will be exposed to the network earlier than before, and then the prolonged use of the network will have a certain impact on the cognitive ability of the learners, which should be correctly understood and treated.

Marc Prensky proposed in 2001 that "digital natives" refers to the generation that grows up with the birth and development of the Internet, whose living environment is highly digitalised, and who frequently use electronic devices such as computers, mobile phones and game consoles for communication and social interaction. This group has a natural advantage in the acceptance and application of digital technology, and the habits of technology use are deeply integrated into their lifestyles ^[2]. Sang Xinmin pointed out that the interconnected nature of the network can converge massive information resources, in this context, students do not need to spend a lot of time on repetitive learning tasks, but can devote more energy to challenging, personalised learning exploration in line with their own interests, thus stimulating the ability to explore and unleash creativity ^[3]. At the beginning, we only predicted the potential of the Internet to change the education model and focused on the positive effects of the Internet, but did not take into account the complexity and disorder of the Internet information may bring negative impacts, such as some ineffective information, making it difficult for learners to find what they really need, but also affecting the cognitive ability of the students to rely on the Internet, and for a long time will only be communicating with the Internet, and so on. At the same time, in the process of using the network is also easy to be attracted by online games, which has been shown that the mental health of adolescents and young people do have a significant and robust negative effect of online games ^[4]. So will online games have a significant and robust negative effect on the cognitive ability of the new generation of learners, that is, digital natives?

2 Literature review and hypotheses

Cognitive ability refers to an individual's ability to receive, process, store and apply information, which is the basic psychological condition for human beings to complete various cognitive activities (e. g. thinking, learning, problem solving, etc.). It involves multiple dimensions, covers a series of mental processes from simple information perception to complex logical reasoning, and is the core indicator of individual intelligence level and thinking effectiveness.

And assessing the impact of online games on the cognitive ability of the new generation of learners also needs to take into account the influence of complex and integrated factors. Common control variables in such studies are factors such as individual and family.

In terms of individual factors, an OECD study found that students who typically spent no more than 30 minutes online at school and 1-4 hours outside of school on weekends were found to perform better in science than those who never accessed the Internet or accessed the Internet more frequently^[5]. Adolescents were found to be more susceptible to cognitive biases and distractions when confronted with online information. Things like rich and fast moving images in online games can make it difficult for students to focus on the same thing. Activities such as online gaming may strongly activate neural reward pathways, producing effects similar to those of alcohol, opiates, and other psychoactive substances, and online gaming has been regarded as an "electronic opiate"^[6]. Fu Gangshan et al. also proposed the characteristics of strong network dependence of learners in the information age^[7]. Some learners with higher cognitive ability can easily stand out in online games and sift out effective information to feed their cognitive ability, while on the contrary, they may be addicted to the Internet, resulting in a decrease in cognitive ability. The increased maturation of the limbic system during adolescence makes adolescents more likely than adults to engage in addictive behaviours and more likely to develop psychological problems that lead to cognitive decline^[8].

In family factors, on the one hand, students who lack family supervision are easily addicted to the Internet, and according to statistics, 90% of Internet-addicted children are caused by the lack of family love and care^[9]. However, too strict supervision will also be counterproductive, more obsessed with the Internet, affecting their cognitive ability; at the same time, family disharmony will easily make the children have a stronger sense of belonging to the "shelter" provided by the virtual world, and thus easy to be addicted to online games and can not be extricated^[10]. On the other hand, the cultural capital brought by parents' education level and the amount of books in the family can easily make children orientated to a strong knowledge atmosphere, which in turn reduces the time they spend playing games online.

Although the above literature explains the negative impact of online games on learners' cognitive abilities to a certain extent, it still leaves room for expansion and innovation. Firstly, this study uses the China Education Tracking Survey (CETS) collected by the China Research and Data Centre (CRDC) of Renmin University of China (RUC) to investigate the impact of online gaming on the cognitive abilities of the new generation of Chinese learners. Secondly, in this age of digital natives, Internet regulation is lagging behind, and low cognitive ability induced by online games has become a common phenomenon at the national level, which provides a background for this study. Finally, when considering the effects of online games on learners' cognitive abilities, the use of time analysis of online game playing, especially taking into account individual characteristics and family characteristics control variables can help to draw more reliable conclusions.

Therefore, the research hypothesis is proposed here:

Whether online games will have a significant and robust negative effect on the cognitive ability of new generation learners.

3 Research design

3.1 Data sample

The data in this paper comes from the China Education Panel Survey (CEPS), a large-scale nationally representative tracking survey designed and implemented by the China Survey and Data Centre of Renmin University of China. Using the average education level of the population and the proportion of mobile population as stratification variables, 28 county-level units (counties, districts, and cities) were randomly selected from the whole country as survey sites. In this paper, we use CEPS 2014-2015 follow-up data, and the follow-up respondents are all students in the first year of junior high school (grade 7) at the time of the baseline survey. After data processing, the final 9,920 students who succeeded in the successful follow-up were left.

3.2 Variable design

3.2.1 Explained variables

The explanatory variable in this study is the standardised score of the cognitive ability test (using the 3PL model), which assumes that subjects' responses to items (e.g., answering correctly or incorrectly) are a function of subjects' latent traits (e.g., cognitive ability, intelligence, etc., usually denoted by θ) and items' characteristics (e.g., difficulty, differentiation, etc.), and is able to more accurately estimate the subjects' abilities and the attributes of the items. Its mathematical expression is:

$$P(\theta) = c + (1 - c) \frac{1}{1 + e^{-1.7a(\theta - b)}}$$

$P(\theta)$: indicates the probability that a subject with an ability level of θ answers an item correctly; θ : the subject's latent trait level, i.e., the cognitive ability level; a : the item differentiation parameter, reflecting the extent to which the item distinguishes between subjects with different ability levels. The item difficulty parameter represents the ability level of the subject when the probability of answering the item correctly is 0.5; b : the item difficulty parameter represents the ability level of the subject when the probability of answering the item correctly is 0.5; c : the guessing parameter represents the

probability of answering the item correctly by the low ability subject only by guessing.³ The PL model can reflect the true ability level of the subject more accurately, independent of the influence of the sample of the test questions and the test environment, and it can be converted into the equivalent value of the different tests, so that scores of the different tests can be comparable. The higher the score, the stronger the students' cognitive ability.

3.2.2 Core Independent Variables

The core independent variable of this study is the time of playing games online, and the data come from the CEPS (2014-2015) corresponding to the questions of surfing the Internet and playing games: (1) "Monday to Friday, the time you usually play games online every day" (2) "On weekends, the time you usually play games online every day". Count the amount of time the respondents fill in to play games. (1) "No"=1, "Less than 1 hour"=2, "About 1-2 hours"=3, "About 2-3 hours"=3, "About 2-3 hours"=4, "About 2-3 hours"=5 "about 2-3 hours" = 4, "about 3-4 hours" = 5, "about 4 hours or more" = 6, obtaining continuous integer variables with values from 1 to 6. (2) "None"=1, "less than 2 hours"=2, "about 2-4 hours"=3, "about 4-6 hours" = 4, "about 6-8 hours" = 5, "about 8 hours or more" = 6, to get the value of 1-6 continuous integer variables.

3.2.3 Control variables

There are two groups of control variables. One group is students' individual characteristic variables, and the other group is family characteristic variables. Individual characteristic variables include physical exercise, health self-assessment, personal communication, personal bad behaviour, personal ability, personal interests and so on. For physical exercise, "average daily exercise hours"; for health self-assessment, "very bad" = 1, "not so good" = 2, "average" "very bad" = 1, "not very good" = 2, "average" = 3, "good" = 4, "very good" = 5; personal bad behaviour and personal competence were determined by "cursing, swearing", "quarrelling", etc., respectively. Personal bad behaviour and personal competence were measured by a scale of 10 questions such as "swearing, swearing" and 6 questions such as "I am confident in completing the task", and the values were summed up to obtain a continuous variable and the larger the value, the more bad behaviour; the larger the value, the stronger the personal competence; personal hobbies, "specific amount", "better" = 4, "very good" = 5; personal interests. "specific number"; economic self-assessment, "very difficult" = 1, "more difficult" = 2, "moderate" = 3, "relatively wealthy" = 4, "very wealthy" = 5.

Family Characteristics Variables Cultural Capital, Network Capital, Confidence Capital, Parental Education, and Parental Supervision. Cultural capital, "amount of books in the home"; cyber capital, "whether or not there is a computer and internet at home, "neither" = 0, "computer, no internet" = 1, "With computer and internet" = 2"; Confidence capital, "Whether confident about child's future: "Not confident at all" = 1, "Not confident at all" = 1, and "Not too confident" = 2, "More confident" = 3, "Very confident" = 4"; parental supervision by Parental supervision was measured by a scale of six questions, such as "How strict is the control of children's Internet time", and a continuous variable was obtained by summing up the assigned values; the larger the value, the stricter the supervision.

4 Data analysis

4.1 Descriptive statistics

In terms of the explanatory variables, the mean value of the cognitive ability test scores is close to 0, indicating that the overall cognitive ability is low and there is still a lot of room for improvement in students' cognitive ability; at the same

Table 1 Descriptive statistics results

变量名	定义	均值	标准差	方差
认知能力测试标准化得分	因变量	0.2940045	0.8296213	0.6882715
周一到周五使用网络游戏时间	“没有”=1, “不到1小时”=2, “约1-2小时”=3, “约2-3小时”=4, “约3-4小时”=5, “约4小时以上”=6, 得到取值为1-6的连续性整数变量。	2.246325	1.440754	2.075773
周末使用网络游戏时间	“没有”=1, “不到2小时”=2, “约2-4小时”=3, “约4-6小时”=4, “约6-8小时”=5, “约8小时以上”=6, 得到取值为1-6的连续性整数变量。	2.61347	1.356733	1.840725
体育锻炼	每天多少分钟	46.10446	46.33322	2146.767
健康自评	“很不好”=1, “不太好”=2, “一般”=3, “比较好”=4, “很好”=5	3.852896	0.9389009	0.8815348
个人不良行为	赋值多变量合一	15.57022	4.883308	23.8467
个人能力	赋值多变量合一	17.69369	3.62654	13.15179
个人兴趣爱好	具体数量	1.732043	0.9823289	0.9649701
经济自评	“非常困难”=1, “比较困难”=2, “中等”=3, “比较富裕”=4, “非常富裕”=5	2.934767	0.6132876	0.3761217
文化资本	家庭图书量	3.059955	1.160847	1.347565
网络资本	家里是否有网络和电脑	1.378005	0.881789	0.7775519
自信资本	对孩子未来是否有自信: “根本没有自信”=1, “不太有自信”=2, “比较有自信”=3, “很有自信”=4	3.171553	0.6972172	0.4861118
父亲受教育程度	学历教育层级变量	4.236446	1.99243	3.969777
母亲受教育程度	学历教育层级变量	3.952487	1.986029	3.94431
家庭关系	父母经常吵架, 经常=1, 不经常=2	1.902434	0.296742	0.0880558
家庭规模	非独生子女=0; 独生子女=1	1.559615	0.4964587	0.2464713
家长监督	赋值多变量合一	13.82328	2.401258	5.766042

time, the degree of data dispersion is moderate and the individual differences are small.

In terms of students' individual characteristics, in the statistical sample, the average time of students playing games online from Monday to Friday is more than 1 hour, with a large standard deviation, indicating that there are obvious differences in the time of playing games among individuals, with some people hardly playing and some playing for more than 4 hours; the average time of playing games online on weekends is more than 2 hours, with more obvious individual differences, and the time of playing games on weekends is more obvious compared with that on weekdays. The average time students spent exercising was roughly 46 minutes per day, but the standard deviation $\approx$ mean, suggesting that the data are extremely scattered, with some hardly exercising at all (close to 0) and some exercising well above the mean (e.g., 90 minutes or more), and that subsequent studies need to be aware of the impact of their extreme values on the results. The effect of its extreme values on the results should be noted; the composite score of personal bad behaviour is medium, indicating that the frequency of personal bad behaviour is moderate, the bad behaviour is low, and the students are able to consciously abide by some discipline; in terms of personal ability, the composite score is high, and the average personal ability of the students is high and the distribution is concentrated; the number of personal hobbies is low, and the students may tend to play games on the Internet in their spare time; and the overall economic capital is medium, and the overall difference is not big.

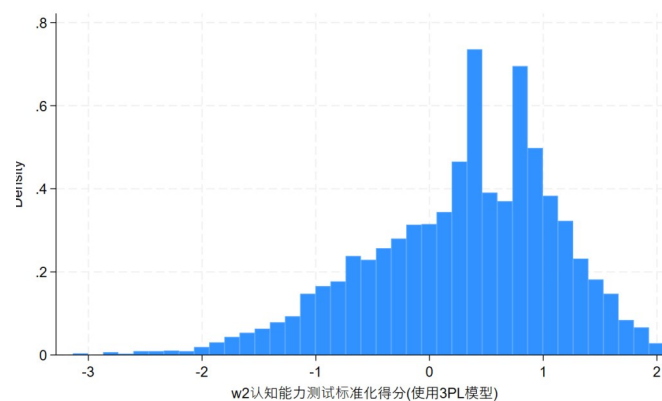


Figure 1 Cognitive ability standardised score

In terms of family characteristics, in the statistical sample, the amount of books in the family is medium, and the cultural capital is moderate; while the mean value in the Internet capital is close to 1, indicating that most families have Internet and computers, which provides conditions for students to play games online; overall, parents are generally confident in their children, and there is not a big difference in the degree of self-confidence; the education level of the parents is medium, in the high school tier, but the difference is obvious; the overall parents do not quarrel often, which indicating harmonious family relationships; family size is close to the maximum standard deviation of the dichotomous variable (0.5), indicating that the proportions of the two groups are close to each other; and the composite score of family supervision is medium, with moderate family supervision and little difference.

4.2 Pearson product moment correlation coefficient analysis

The correlation coefficient between "Monday to Friday, the amount of time you usually spend playing games on the Internet every day" and "Weekend, the amount of time you usually spend playing games on the Internet every day" is 0.5793, $P < 0.05$, and the two are significantly positively correlated, i.e., those who play a lot of games on weekdays also play a lot of games on weekends, which may reflect that the two groups are close to each other. The correlation coefficients were -0.1771^* and -0.0263^* respectively, which proved that cognitive ability had a stronger effect on weekdays, and the absolute value of the correlation coefficients was significantly higher than that of weekends. The absolute value of the correlation coefficient significantly exceeds that of weekends, probably because there is less free time on weekdays, and the time spent on playing games on the Internet will crowd out study time or sleep time, which will have a more direct negative effect on cognitive development. The negative effect of weekends on cognitive ability, although significant, is very weak, probably because weekend gaming time is more flexible and more likely to be accompanied by social activities, hobbies, reading and studying, etc., and the negative effect will be partially offset.

However, there may be an endogeneity problem, which could be "gaming $\rightarrow$ cognitive decline"; or "low cognitive ability $\rightarrow$ more addicted to gaming". An instrumental variable approach was used to demonstrate whether "low cognitive ability $\rightarrow$ more addicted to gaming", with "current overall health" as the instrumental variable. Firstly, the correlation test (health condition to cognition) was conducted, $F = 11.76 > 10$, the coefficient is significant and the F-statistic is large, $P = 0.001 < 0.05$, and then the exclusion test (adding control variables) was conducted, $P = 0.459 > 0.05$, it is not significant, which proves that this instrumental variable does not directly affect cognitive ability, so the instrumental variable was

regressed by two-stage least squares (2SLS). Therefore, the instrumental variable regression using two-stage least squares (2SLS) was conducted, and it was found that the standardised score coefficient of the cognitive ability test was -0.6766 (standard error 0.5472), $P=0.216$ (greater than 0.05), which proves that under the instrumental variable regression, it is not possible to prove that "low cognitive ability $\rightarrow$ more addicted to games".

4.3 Linear regression analysis and test

In order to further study the influence of online game playing time on cognitive ability, a linear regression model was constructed to further investigate the validity of the conclusion:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_k x_k + \varepsilon$$

Where y is the standardised score of cognitive ability test, β_0 is a constant term, $\beta_1, \dots, \beta_k$ is the regression coefficient (indicating the degree of influence of the independent variable on the dependent variable), x_1, x_2 are the core independent variables, and x_k is a control variable (e.g., whether there is internet and computer at home, etc.) ε is the error term.

Separately, the two core independent variables were made to undergo linear regression with the dependent variable and the results are shown in the table:

Table 2 Core regression

变量名	系数
周一到周五（工作日）使用网络玩游戏时间	-0.102***
周末使用网络玩游戏时间	-0.016***

Both have a significant negative effect on cognitive ability, while the cognitive ability and workday effects are stronger, with correlation coefficients exceeding weekends in absolute value. To ensure that the model is robust and valid, control variables (e.g., physical activity, health self-assessment, etc.) began to be added sequentially to observe the changes in the coefficients of the two core independent variables, as shown in the table:

Table 3 Control regression

	周一到周五（工作日）使用网络玩游戏时间	周末使用网络玩游戏时间
体育锻炼	-0.098***	-0.015***
健康自评	-0.101***	-0.014***
个人不良行为	-0.08***	0.014**
个人能力	-0.077***	0.019**
个人兴趣爱好	-0.073***	0.023**
文化资本	-0.077***	0.005
网络资本	-0.103***	-0.028***
自信资本	-0.098***	-0.025***
父亲受教育程度	-0.095***	-0.021***
母亲受教育程度	-0.095***	-0.021***
家庭关系	-0.095***	-0.021***
家庭规模	-0.095***	-0.022***
家长监管	-0.096***	-0.024***

Overall, for the core independent variable (i) after adding control variables sequentially, the coefficients are more stable and significantly negatively correlated, and the model is not overfitted by adding too many variables, indicating that the core effects can be captured without a complex model. The coefficients of the control effects on individual characteristics fluctuate more than those of the household variables, which shows that the relevant characteristics of individuals are the main force influencing the time spent online.

For the core independent variable (II), after adding control variables in turn, the significance of the independent variable on cognitive ability disappears after adding cultural capital, and there may be the role of cultural capital in regulating the direction of the effect of Internet time, so we carry out group regression verification for "high cultural capital" and "low cultural capital". Therefore, the regression of "high cultural capital" and "low cultural capital" was carried out, and the coefficient of time spent on the Internet was positive in the high cultural capital group ($\beta = 0.15$, $p = 0.06$) and negative in the low cultural capital group ($\beta = -0.04$ ***, $p = 0.00$). This indicates that the shift in the disappearance of significance stems from the moderating effect of cultural capital, where time spent on the Internet is positively associated with cognitive ability in high book volume families, while it remains negative in low book volume families. The effect of time spent online on cognitive ability is not fixed and attention needs to be paid to the key shaping role of family cultural capital.

And after adding personal bad behaviour, personal hobbies and personal ability, the significance has not disappeared but played a positive role, guessing that it may be due to its mediating effect or masking effect influence, so the test was carried out, and it was found that the coefficient of the bad behaviour on cognitive ability was significantly negative ($\beta = -0.03$ ***), and the effect of the core independent variable (ii) on personal bad behaviour ($\beta = 0.92$ ***) was significantly

positive. That is, the positive effect of online game playing time on personal bad behaviour masks the negative effect of bad behaviour on cognitive ability; core independent variable (ii) has a significant negative effect on personal hobbies ($\beta = -0.057^{***}$), and at the same time after controlling for this variable, the significance of core independent variable (ii) on cognitive ability is extremely low ($\beta = 0.10^*$), but personal hobbies are positively significant on cognitive ability ($\beta = 0.11^*$). **) indicating that core independent variable (ii) can indirectly affect cognitive ability by influencing the number of personal hobbies, personal hobbies have a greater positive significant effect on cognitive ability, and the direct effect of game time on cognitive ability is substantially weaker and close to non-significant; the core independent variable (ii) has a significant negative effect on personal ability ($\beta = -0.32^{***}$), and after controlling for this variable the core independent variable (ii) is not significant ($P = 0.232$), indicating that personal ability is a fully mediating variable and core independent variable (II) has no direct effect on cognitive ability, which is paradoxical to the results of previous studies.

5 Conclusion and shortcomings

After analysing the data, the study generally concludes that online games have a significant and robust negative effect on cognitive ability, and it is also found that family factors do not have as great an impact on online time and cognitive ability as the students themselves, and that a strong cultural atmosphere and so on only have a certain indirect impact, and that the learners themselves are still the backbone of cognitive ability improvement. The negative effect of playing online games on cognitive ability is greater on weekdays than on weekends, and the average time spent online on weekends is higher than that on weekdays, which means that there is more time on weekends to do other things to regulate the negative effect of playing online games on cognitive ability (exercising, highlighting one's personal ability, etc.), whereas there is a short period of time on weekdays to regulate the negative effect of playing online games effectively.

For learners to reasonably plan their daily time, learning and rest should be guaranteed on weekdays, and activities such as physical exercise and interest cultivation should be interspersed on weekends. Learners need to take the initiative to cultivate their time management ability, and they can set an upper limit on the length of the game, and replace some of the time spent on the game with their hobbies and interests, so as to avoid the formation of the vicious circle of "low cognition $\rightarrow$ addicted to the game $\rightarrow$ even lower cognition". The vicious circle. Families cannot forcefully control game time, but need to create a good family atmosphere, understand children's interests and accompany children to study, and the knowledge atmosphere of the family can buffer the negative effects of games.

The disadvantage is that personal ability, as the core foundation of cognitive ability, is likely to affect both online game time and cognitive ability, and the study only combines the values of questions such as "I remain calm even when the situation is bad" in the data, which is not a direct and perfect representation of personal ability. In addition, the study only counted the time spent playing games, not the types of games, ignoring the possibility that some strategic games, for example, may improve learners' cognitive abilities. Future research could further distinguish the differential effects of game types (e.g., competitive, puzzle) and game modes (single player vs. multi-player collaborative) on cognitive abilities, and avoid simply equating "time spent playing" with "negative effects".

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