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A Kind of Online Game Addictive Treatment Model about Young Person

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Xiaokang Liu*, Jiangtao Li, Yanyan Zhao, Yiyue Sun, Haibo Zhang

Foundation Department, Engineering University of PAP, Xi'an, 710086, China

***Corresponding Author:** Xiaokang Liu, Foundation Department, Engineering University of PAP, Xi'an, 710086, China.

Abstract

This paper constructs a kind of communication model with forced treatment of online game addicts. First, the regeneration matrix method is used to determine the basic regeneration number of the model, and then the local stability of online game model and online game addiction transmission conditions is judged according to the basic regeneration number. Further, the effect of treatment delay on online game addicts is analyzed. And last, with the help of numerical simulation to verify the stability of the equilibrium point, the author of this paper puts forward effective treatment cycle for online game addicts.

Keywords: online game addictive equilibrium; online game non-addictive equilibrium; time delay; stability

Introduction

Internet addiction refers to an individual can not control, excessive and compulsive to play online games resulting in physical, psychological and social function damage [1]. Teenagers addiction to online games will seriously affect their families and healthy growth, in recent years, many scholars have studied the causes and effects of online game addiction from the perspective of Psychology: online game addiction can bring the sense of spiritual pleasure, improve the subjective well-being [2]; However, there are many violent incidents caused by online game addiction [1]. Long-term online game addiction has a serious impact on social stability and family harmony [3]; Some scholars collect questionnaire data by using ACE model, Davis (2001) online cognitive behavior model, online Satisfaction Compensation Model [4] to Quantitative analysis the influence of various factors, but this kind of method has a high request to the questionnaire design, and it is easy to neglect some unexpected factors, which leads to the validity of the results of the model analysis. Therefore, this paper analyzes the existence and stability of the balance point of online game addiction and non-addiction in the transmission mechanism of online game addiction by means of infectious disease dynamics model, finally, the author puts forward some suggestions and measures for the treatment of online game addiction.

Epidemic Model

SEIR model is a kind of Infectious disease model, which generally divides the population in the epidemic area of Infectious disease into the following categories: Susceptible, Exposed, Infectious and Recovered, it takes a latent period for the infected person to become an addict, so SEIR model is more suitable for the study of the problem of online game addiction. Using SEIR model for reference, the adolescents were divided into 4 groups: Susceptible (S), Exposed (E), Infectious (I), Recovered (R). The total number of teenagers is N(t), $N(t) = S + E + I + R$.

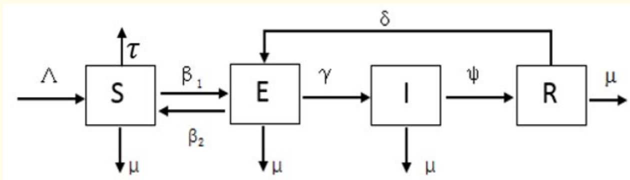

Figure 1: The diagram of the population flow in each compartment.

SEIR epidemic model:

$$\begin{cases} \dot{S} = \Lambda - \mu S - \beta_1 SE + \beta_2 E - \tau S \\ \dot{E} = \beta_1 SE - \beta_2 E - \mu E + \delta R - \gamma E \\ \dot{I} = \gamma E - \mu I - \psi I \\ \dot{R} = \psi I - \mu R - \delta R \end{cases} \quad (1)$$

Represents the growth rate of the adolescent population (children aged over 12 growing up to be adolescents), the natural mortality rate of adolescents, the migration rate of adolescents (adolescents aged over 29), the addiction rate of susceptible groups to online games, the rate of self-recovery, the rate of re-addiction, the rate of conversion from mild to severe addiction, and the rate of professional treatment in severe addiction groups. In system (1), there are four parameter variables S, E, I and R, they are all functions of time, N(t) is the total number of adolescents, and the four equations are the transmission mechanism of adolescents' online game addiction, therefore, all parameters are positive at t = 0, and the feasible solution domain of mathematical model (1) is:

$$\Omega = \{(S, E, I, R) \in R_+^4 \,|\, 0 \le S(t) + E(t) + I(t) + R(t) \le \frac{\Lambda}{\mu}\}$$

So $$\dot{N}(t) = \dot{S} + \dot{E} + \dot{I} + \dot{R} \le \Lambda - \mu N$$

Then $$0 \le N(t) \le \frac{\Lambda}{\mu} - N(0)e^{-\mu t}, \lim_{t \to \infty} N(t) = \frac{\Lambda}{\mu}$$

Therefore, all feasible solutions of the model (1) are included and are positive invariant sets of the system (1) [5-7].

Model Property Analysis

Online game addiction-free balance point and basic reproduction number

If the right of System (1) is zero, the balance point of online game non-addictive state can be obtained $E_0 = (\frac{\Lambda}{\mu + \tau}, 0, 0, 0)$. The basic regeneration number of system (1) is calculated by the method given by Van and Watmough (2002): if $x = (E, I, R, S)$ then.

$$\frac{dx}{dt}=F(x)-V(x)=\begin{pmatrix}\beta_1 SE\\0\\0\\0\end{pmatrix}-\begin{pmatrix}\beta_2 E+(\mu+\gamma)E+\delta R\\(\mu+\psi)I-\gamma E\\(\mu+\delta)R-\psi I\\(\mu+\tau)S+\beta_1 SE-\beta_2 E-\Lambda\end{pmatrix}$$

So $F(x)$ and $V(x)$ were:

$$F(x)=\begin{pmatrix}\beta_1 SE\\0\\0\\0\end{pmatrix}\qquad V(x)=\begin{pmatrix}\beta_2 E+(\mu+\gamma)E+\delta R\\(\mu+\psi)I-\gamma E\\(\mu+\delta)R-\psi I\\(\mu+\tau)S+\beta_1 SE-\beta_2 E-\Lambda\end{pmatrix}$$

The Jacobian matrices about the addiction-free equilibrium of online games are:

$$D(F(E_0))=\begin{pmatrix}F_{2\times 2} & B_1\\C_1 & D_1\end{pmatrix}$$

$$D(V(E_0))=\begin{pmatrix}\beta_2+\mu+\gamma & 0 & \delta & 0\\-\gamma & \mu+\psi & 0 & 0\\0 & -\psi & \mu+\delta & 0\\\beta_2 & 0 & 0 & \mu+\tau+\beta_1\dfrac{\Lambda}{\tau+\mu}\end{pmatrix}$$

$$B_1=C_1=D_1=\begin{pmatrix}0&0\\0&0\end{pmatrix}$$

So

$$F_{2\times 2}=\begin{pmatrix}\beta_1\dfrac{\Lambda}{u+\tau} & 0\\0 & 0\end{pmatrix}\qquad V_{2\times 2}=\begin{pmatrix}\beta_2+u+\gamma & 0\\-\gamma & u+\psi\end{pmatrix}$$

$$R_0=\rho(F_{2x2}V_{2x2}^{-1})=\frac{\Lambda\beta_1}{(\mu+\tau)(\gamma+\beta_2+\mu)}$$

Balance point of online game addiction

Theorem 1 $R_0>1$, There is a unique addiction equilibrium in the system P^* (E^*, I^*, R^*, S^*).

$$E^*=\frac{(\Lambda-S^*(\mu+\tau))\beta_1(\mu+\psi)(\mu+\delta)}{\beta_1(\mu+\gamma)(\mu+\delta)(\mu+\psi)-\delta\psi\gamma}$$

$$I^*=\frac{\gamma}{\mu+\psi}\times\frac{(\Lambda-S^*(\mu+\tau))\beta_1(\mu+\psi)(\mu+\delta)}{\beta_1(\mu+\gamma)(\mu+\delta)(\mu+\psi)-\delta\psi\gamma}$$

$$R^*=\frac{\psi\gamma}{(\mu+\psi)(\mu+\delta)}\times\frac{(\Lambda-S^*(\mu+\tau))\beta_1(\mu+\psi)(\mu+\delta)}{\beta_1(\mu+\gamma)(\mu+\delta)(\mu+\psi)-\delta\psi\gamma}$$

$$S^*=\frac{\beta_2}{\beta_1}+\frac{\mu}{\beta_1}-\frac{\delta\psi\gamma}{(\mu+\psi)(\mu+\delta)\beta_1}+\frac{\gamma}{\beta_1}$$

Proof: we can obtain from system (1)

$$\begin{cases} \Lambda-(\mu+\tau)S-\beta_1 SE+\beta_2\mathrm{E}=0 \\ \beta_1 SE-\beta_2 E-\mu E+\delta R-\gamma E=0 \\ \gamma E-\mu I-\psi I=0 \\ \psi I-\mu R-\delta R=0 \end{cases} \tag{2}$$

And then:

$$\begin{cases} I^*=\dfrac{\gamma E^*}{\mu+\psi} \\ R^*=\dfrac{\psi I^*}{\mu+\delta}=\dfrac{\psi\gamma E^*}{(\mu+\psi)(\mu+\delta)} \\ \beta_1 S^* E^*=\beta_2 E^*+\mu E^*-\dfrac{\delta\psi\gamma E^*}{(\mu+\psi)(\mu+\delta)}+\gamma E^* \end{cases} \tag{3}$$

So

$$S^*=\frac{\beta_2}{\beta_1}+\frac{\mu}{\beta_1}-\frac{\delta\psi\gamma}{(\mu+\psi)(\mu+\delta)\beta_1}+\frac{\gamma}{\beta_1}=W_*$$

$$S^*=\frac{(\Lambda-\mu E^*+\dfrac{\delta\psi\gamma E^*}{(\mu+\psi)(\mu+\delta)\beta_1}+\gamma E^*)}{(\mu+\tau)}$$

$$E^*=\frac{(\Lambda-W_*(\mu+\tau))\beta_1(\mu+\psi)(\mu+\delta)}{\beta_1(\mu+\gamma)(\mu+\delta)(\mu+\psi)-\delta\psi\gamma}$$

Finally, the conclusion is valid.

Balance point of online game non-addiction

Theorem 2 If

$$R_0<1,\, E_0=(\frac{\Lambda}{\mu+\tau},0,0,0)$$

Is locally asymptotically stable.

Proof: Jacobi Matrix of model (1)

$$J=\begin{pmatrix} -u-\tau-\beta_1 E & -\beta_1 S+\beta_2 & 0 & 0 \\ \beta_1 E & \beta_1 S-\beta_2-u-\gamma & 0 & 0 \\ 0 & \gamma & -u-\psi & 0 \\ 0 & 0 & \psi & -u-\delta \end{pmatrix}$$

Jacobi Matrix of E_0

$$J(E_0)=\begin{pmatrix} -u-\tau & -\beta_1\dfrac{\Lambda}{u}+\beta_2 & 0 & 0 \\ 0 & \beta_1\dfrac{\Lambda}{u}-\beta_2-u-\gamma & 0 & 0 \\ 0 & \gamma & -u-\psi & 0 \\ 0 & 0 & \psi & -u-\delta \end{pmatrix}$$

$R_0 < 1$, the eigen value of

$$J(E_0): -u-\tau<0,\ \ \beta_1\frac{\Lambda}{u}-\beta_2-u-\gamma<0, -u-\psi<0, -u-\delta<0$$

The real part of all eigenvalues is less than zero, so E_0 is Locally asymptotically stable.

Theorem 3

If $R_0 < 1$

Online game addiction-free balance point

$$E_0=(\frac{\Lambda}{\mu+\tau},0,0,0)$$

Is globally asymptotically stable.

Proof: Construct Lyapunov function

$$V=S-S_0-S_0\ln(\frac{S}{S_0})+E+I$$

$$\begin{aligned}\dot{V}&=\dot{S}-\frac{S_0}{S}\dot{S}+\dot{E}+\dot{I}\\&=(1-\frac{S_0}{S})(\Lambda-\mu S-\tau S-\beta_1 SE+\beta_2 E)+\beta_1 SE-\beta_2 E-\mu E+\delta R-\gamma E+\gamma E-\mu I-\psi I\\&=(1-\frac{S_0}{S})\Lambda-\mu S+\mu S_0+\tau S_0+\beta_1 S_0 E-\frac{S_0}{S}\beta_2 E-\mu I-\psi I-\mu E+\delta R\\&\le(1-\frac{S_0}{S})\Lambda-\mu S+\mu S_0+\tau S_0+\Lambda-\mu S_0-\tau S_0-\frac{S_0}{S}\beta_2 E-\mu I-\psi I-\mu E+\delta R\\&\le\Lambda(2-\frac{S_0}{S}-\frac{S}{S_0})-\frac{S_0}{S}\beta_2 E-\mu I-\psi I-\mu E+\delta R\end{aligned}$$

$$2-\frac{S_0}{S}-\frac{S}{S_0}\le 0, \psi I+\delta R<0$$

$$\text{if } R_0<1 \text{ then } \dot{V}\le 0\ ;\ \dot{V}=0 \text{ then } A=A_0, E=I=0;\ when\ t\to\infty, R\to 0$$

The Model (1) obtained by LaSalle invariant set principle is globally asymptotically stable when the addiction-free equilibrium of the online game is present [8, 9].

Time delay model analysis

The time-delay model is studied, a new model is obtained:

$$\begin{cases}\dot{S}=\Lambda-\mu S-\beta_1 SE+\beta_2 E-\tau S\\ \dot{E}=\beta_1 SE-\beta_2 E-\mu E+\delta R-\gamma E\\ \dot{I}=\gamma E-\mu I-\psi I(t-\tau_0)\\ \dot{R}=\psi I(t-\tau_0)-\mu R-\delta R\end{cases}\tag{4}$$

So, the balance point of online game addiction is $P^*(S^*, E^*, I^*, R^*)$.

Theorem 4

$$\text{If } R_0 > 1\ ,\quad E^* > \frac{\Lambda}{u+\gamma-\beta_2}$$

then the balance point of online game addiction is locally asymptotically stable.

Proof: Jacobi Matrix of P^* (S^*, E^*, I^*, R^*)

$$J(P_1^*) = \begin{pmatrix} -u-\tau-\beta_1 E^* & -\beta_1 S^* + \beta_2 & 0 & 0 \\ \beta_1 E^* & \beta_1 S^* - \beta_2 - u - \gamma & 0 & \delta \\ 0 & \gamma & -\psi & 0 \\ 0 & 0 & \psi & -u-\delta \end{pmatrix}$$

$$M = -J(P_1^*) = \begin{pmatrix} u+\tau+\beta_1 E^* & \beta_1 S^* - \beta_2 & 0 & 0 \\ -\beta_1 E^* & -\beta_1 S^* + \beta_2 + u + \gamma & 0 & -\delta \\ 0 & -\gamma & \psi & 0 \\ 0 & 0 & -\psi & u+\delta \end{pmatrix}$$

Δ_i is order principal minor determinant of *M*, so

$$\Delta_1 = \left| u+\tau+\beta_1 E^* \right| = u+\tau+\beta_1 E^* > 0\ ,\quad \Delta_3 = \Delta_2 \psi\ ,\quad \Delta_4 = (u+\delta)\Delta_3$$

$$\Delta_2 = (u+\gamma)\beta_1 E^* - (u+\tau)\beta_1 \frac{\Lambda + \beta_2 E^*}{u+\beta_1 E^* + \tau} > (u+\gamma)\beta_1 E^* - \beta_1(\Lambda + \beta_2 E^*)$$

$$\text{If} \quad R_0 > 1 \quad \text{then} \quad \Delta_2 > (u+\gamma)\beta_1 E^* - \beta_1(\Lambda + \beta_2 E^*) > 0\ , \Delta_3 > 0\ \ \Delta_4 > 0$$

So, *M* is positive definite matrix' eigen value of *M* are more than zero. the balance point (P_1^*) of online game addiction is locally asymptotically stable by Routh-hurwitz criterion.

Numerical Simulation

The system model is simulated numerically. We fix the parameters.

$$u = 0.014,\quad \tau = 0.0109,\quad \beta_2 = 0.009, \gamma = 0.52, \delta = 0.04, \Lambda = 0.13944$$

Fig 2 is obtained. S(t-30) and I(t-30) show the population size with time-delay. And same time R_0 = 0.5156 < 1, fig 2 show that If treated in a timely manner, the number of addicts will gradually decrease and tend to level off; if the treatment of online game addicts will be shelved from the beginning of a sudden surge, with the intervention of treatment of internet addicts fluctuating around a stble level, addicts can not be eliminated in the short term.

We fix the parameters.

$$u = 0.014, \tau = 0.0109, \beta_2 = 0.009, \gamma = 0.02, \delta = 0.04, \Lambda = 0.16, \psi = 0.0169$$

then R_0 = 7.4717 ≥ 1

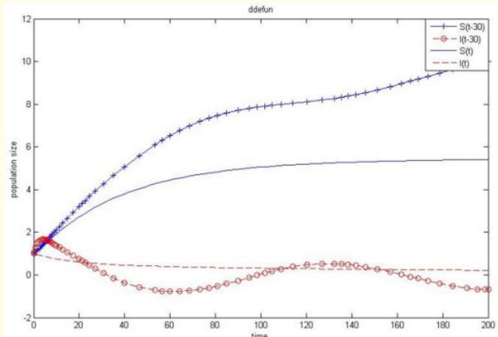

Figure 2: $R_0 < 1$ Relationship between time delay and online game addiction.

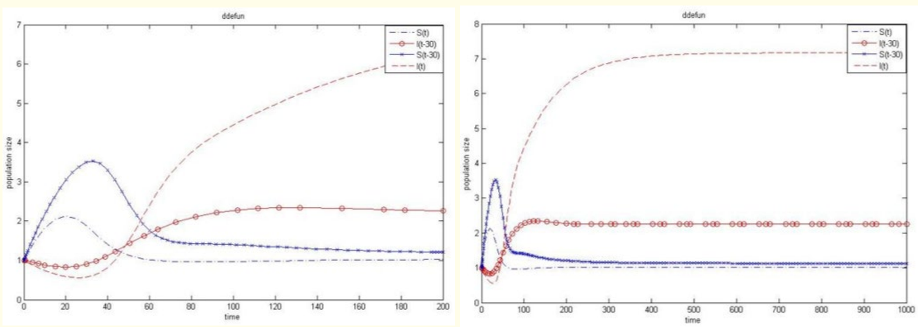

Figure 3: $R_0 > 1$Relationship between time delay and online game addiction.

Observing fig 3' we can know the number of online game addicts (I) increased sharply from the beginning, but remained in a large scale group with the decrease of the number of online game addicts treated, and the number of online game addicts did not decrease in a short period; In this case, delayed intervention time, addicts will gradually become more stable state, the size of the number of treatment is smaller than the case directly. The whole ecological environment failed to restrain the growth of online game addiction, and the online game addiction became a endemic disease to be maintained.

If the parameters can be affected artificially, then the value of the basic reproductive number will be less than 1. Now let's study the effect of different parameters on basic reproduction number.

γ fix different values

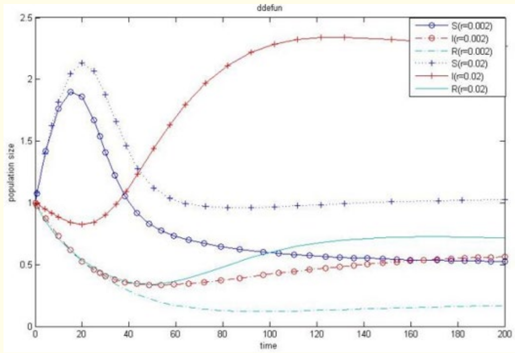

Figure 4: γ between and online game addiction.

Observe the above, γ respectively takes different values of the number of latecomers and infected, when the increase, the number of addicts I, the more likely the system tends to stabilize, if measures are taken to make the parameters, the smaller γ, it can inhibit the transformation speed and quantity of the latent person to the infected person, thus playing a certain inhibitory role to the online game addiction.

β_1 fix different values

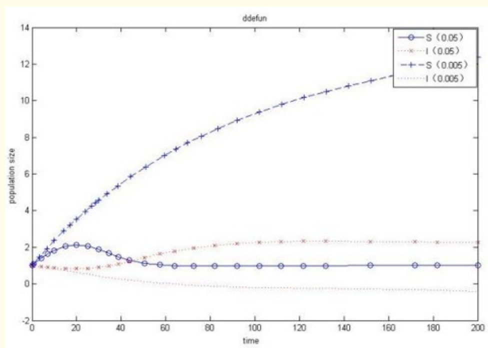

Figure 5: Between β_1 and online game addiction.

Observe the above, β_1 takes different values of the number of addicts, the more β_1 the bigger number of addicts, when the value of the basic number of regeneration is greater than 1, the group of addicts to maintain a stable size, become endemic disease to be maintained.

Conclusion

In this paper, we analyze the SEIR model of compulsory treatment of online game addicts with stage structure, obtain the threshold condition of online game addiction, and further compare and analyze the effect of treatment delay on the group of addiction. According to the definition of the basic reproduction number of the online game addicts, if $R_0 < 1$ the equilibrium point of the online game addiction-free is globally asymptotically stable through analysis, then the online game addiction can be controlled by compulsory treatment, the number of new students infected by online games has been reduced to a very low state, and the spread of online games has been curbed. At that time, R_0 ≥1, the balance point P^* (E^*, I^*, R^*, S^*) was reached. At that time, through the transmission mechanism, online game addiction continued to increase the number of new online game addicts, far outnumbering those who were cured and reaching a stable state, online game addiction will develop into an endemic disease that persists. When the treatment delay is considered, the group of online game addicts fluctuates greatly and can not reach a stable state at the first time. Moreover, R_0 ≥1, the scale of internet addicts is actually smaller than the situation of timely compulsory treatment.

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