Muhammad, Afiq W.; Patria, Bhina
Self-Regulation Effects on Smoking Addiction: A Bayesian Approach*

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Efectos de la autorregulación sobre la adicción al tabaco: un enfoque bayesiano

Afiq W. Muhammad
Universitas Gadjah Mada, Indonesia
ORCID: https://orcid.org/0000-0001-7170-0547
Bhina Patria[a]
Universitas Gadjah Mada, Indonesia
ORCID: https://orcid.org/0000-0003-1419-4240

[a] Correspondence author. Email: patria@ugm.ac.id

Abstract

This study aimed to determine the impacts of self-regulation on smoking addiction. Self-regulation is the capacity to overcome ineffective behavior to achieve goals. Previous research studies found that self-regulation is an effective mental defense against deviant behaviors such as smoking. This study hypothesized that self-regulation correlates negatively with smoking addiction. The subjects in this study were 155 students aged 13-18 years ($M = 13.37$, $SD = 1.07$) from three high schools in Sleman district, Yogyakarta, Indonesia. The data were analysed with Bayesian regression and simple linear regression as a comparison. The Bayesian regression showed that 95% posterior distribution HDI falls outside ROPE (-0.5-0). The results indicated that self-regulation has

significant effects on reducing smoking addiction. Additionally, the simple linear regression also showed similar results ($F_{(1.153)} = 82.12$, $p < 0.01$). The generalizability of the results is only limited to the sample being used in this study.

Keywords: smoking addiction; self-regulation; Bayesian regression; smoking; Bayesian inference

Resumen

Este estudio tiene como objetivo determinar el impacto de la autorregulación en la adicción al tabaco. La autorregulación es la capacidad de superar el comportamiento ineficaz para alcanzar los objetivos. Investigaciones previas encontraron que la autorregulación es una defensa mental efectiva contra conductas desviadas como fumar. La hipótesis de este estudio fue que la autorregulación se correlaciona negativamente con la adicción al tabaco. Los sujetos de estudio fueron 155 de entre 13 y 18 años ($M = 13.37$, $SD = 1.07$) estudiantes de tres escuelas secundarias en el distrito de Sleman, Yogyakarta, Indonesia. Los datos se analizaron mediante una regresión bayesiana y una regresión lineal simple como comparación. La regresión bayesiana mostró que el 95% de la distribución a posteriori HDI cae fuera de la ROPE (-0.5-0). Los resultados indicaron que la autorregulación tiene efectos significativos en la reducción de la adicción al tabaco. Además, la regresión lineal simple también mostró resultados similares ($F_{(1.153)} = 82.12$, $p < 0.01$).

Palabras clave: adicción al cigarrillo; autorregulación; regresión bayesiana; fumar; inferencia bayesiana

Among Indonesian adolescence, the smoking prevention program failed to attain its purposes. The 2014 survey showed that Indonesia was one of the largest adolescent smokers in Asia, with 20% of its adolescent (age 13-19) smokers. By gender, the rate is 36% in males and 4% in females (WHO, 2015). Furthermore, the data depicted that 32.1% of students smoked any tobacco product at least once in their lifetime. The number is increasing compared to five years earlier which was 30.4% (WHO, 2015).

Ogden (2005) defines an addict as a person who cannot resist temptation. The temptation causes many compulsive behaviors, such as repeatedly consuming a substance (e.g., alcohol, nicotine, and heroin) or continuously engaging in a specific activity (e.g., gaming, gambling, and eating). This addictive behavior is caused by specific stimulants that flooded the brain with dopamine and constructed a pleasurable memory associated with rewarding sensation (Schmidt et al., 2018). Smoking addicts have difficulties when trying to stop because they have associated smoking with pleasure. There are two types of Adolescence smoking addictions, behavioral addiction and physiological addiction (Deolia et al., 2018). Physiological addiction, also called biological addiction, was caused merely by the substances in cigarettes (i.e., nicotine) (Carey & Wilkinson, 2016). The main attributes of this addiction type are the presence of tolerance and withdrawal. On the other hand, behavioral addiction is caused by anything but substance effects (e.g., A teenager smoke because he values the smoking process as an enjoyable moment). Besides substance effects, smoking addiction is also influenced by social life, such as peer-group, neighborhood (Liu et al., 2017; Robalino & Macy, 2018), and personality (Abe et al., 2019; Choi et al., 2017).

Smoking causes many adverse effects on adolescents. Robert et al. (2019) stated a negative correlation between smoking behaviors and students' achievement in school since smoking might affect daily activities. Other research conducted by Ribeiro et al. (2013) also found smoking caused the delay in school activity and further addiction problem such as alcohol use. For example, when smokers crave a cigarette, they might experience concentration difficulties, anxiety, insomnia, and increasing appetite (Ranjit et al., 2019). Another research found that smoking is one of the risk factors for coronary disease (Farmawati et al., 2017). A teenager who smokes also has an increased risk factor of later mortality, such as cardiovascular disease (Khan et al., 2015). Although smoking had proved to cause harm, the smoking rate in Indonesian adolescence has not yet decreased. This means that there is an urgent need to tackle the smoking problem. Hence, the current study assessed whether self-regulation has an impact on adolescent smoking behavior.

Self-regulation has an important role in managing one's behaviors (Berkman, 2016). Self-regulation is categorized as basic social skills because it is associated with emotional control, cognitive and social development (Eisenberg et al., 2016). Developing self-regulation skills is important for adolescents since it becomes a mental defense and prevents deviant behavior (Billen et al., 2020). In addition, there is also self-regulation failure, which is divided into failures of under regulation and misregulation (Sayette & Creswell, 2016). Many juvenile delinquencies (Baumeister et al., 1994), and addictive behavior such as smoking (Evans et al., 2018), are caused by self-regulation failures. Self-regulation also plays a role in smoking cessation; its absence makes cessation more difficult for a smoker to cease (Daly et al., 2015). The research found that in the cessation process, a smoker whom a therapist helps to regain self-regulation tends to resist smoking relapse (Hatzigeorgiadis et al., 2016).

Method

Participant

One hundred and fifty-five male high school students were recruited for this study. Only 13-18 years old students *(M= 13.37, SD= 1.07)* were included in the study. The participant was selected from three different high schools in Sleman district, Yogyakarta, Indonesia. The selection used a purposive sampling method (Barreiro & Albandoz, 2001). The participation was voluntary, and all participants filled the informed consent form before filling the questionnaire.

Material

A survey study approach was chosen to gather data from subjects. The data were collected using two instruments. First, the self-regulation scale developed upon five aspects: selection, monitoring, evaluation, motivation, and inhibition. (1) Selection is an individual ability to identify his strength, set a goal, plan, and direct his strength to achieve his goal (Baltes, 1997; Barkley, 2012; Baumeister & Vohs, 2007; Zimmerman, 2000). (2) Monitoring is defined as the capacity to self-supervise his action or behavior, whether still on track or there is a deviation from the goal he set (Baltes, 1997; Barkley, 2012; Baumeister & Vohs, 2007; Zimmerman, 2000). (3) Evaluation; Self-adjustment ability to adapt his behavior, when someone finds any discrepancy in current activities, responds by reducing the gap between current action and his goals (Baltes, 1997; Barkley, 2012; Baumeister & Vohs, 2007; Zimmerman, 2000). (4) Motivation; Individual diligence and continuity to complete his work and achieve goals (Baumeister & Vohs, 2007). (5) Inhibition; Individual resistance from impulsive temptations and make an action even when it is undesirable (Barkley, 1997, 2001).

The second instrument was the smoking addiction scale developed based on four aspects of behavioral addiction and two aspects of substance addiction. The two aspects of substance

addiction were adapted from the Fagerstrom Test for Nicotine Dependence (FTND) (Heatherton et al., 1991). The two aspects are (1) time to first cigarette (i.e., the duration between wake-up time and the first cigarette); and (2) the average of daily cigarette consumption. The other four aspects of behavioral dependence were: smoking in certain social situations, cope with situations of varying degrees of stress, salience, and conflict. (1) Smoking with certain social situations; this aspect measure how far the social environment influence the emergence of smoking. According to Schane et al. (2009), a social situation can encourage smoking behavior without any sign of substance addiction. (2) Cope with varying degrees of stress; Smoking behavior is used as a coping strategy when experiencing emotional stress and negative mood (Griffiths, 2005; Rosenberg & Feder, 2014). (3) Salience; occurs when someone appraises high on smoking activity; smoking becomes important for him and dominates most of his thoughts, feelings, and activities (Griffiths, 2005; Rosenberg & Feder, 2014). (4) Conflict; the harmful effects caused by the continuity of smoking behavior. These effects resulted from smoking discrepancy to another activity, other people surroundings, and smokers themselves as personal (Griffiths, 2005; Rosenberg & Feder, 2014).

Both scales were designed using a five-point Likert scale. The results of internal reliability test were $\alpha = 0.893$ ($n = 86$) for self-regulation scale, and $\alpha = 0.935$ ($n = 86$) for smoking addiction. This result shows that both scales have a good reliability coefficient. According to Wells & Wollack (2003), the proper reliability coefficient for a non-high-risk measure instrument is >0.85.

Analysis method

The data were analyzed using Bayesian regression and linear regression. Although its simplicity and robustness, Wagenmakers (2007) argued that the regression formula could not guarantee statistical evidence because the sample size easily influences its p-value. Meanwhile,

the Bayesian formula does not require a large sample size. Previous studies showed that the Bayesian approach could process small data set with higher accuracy (van de Schoot & Depaoli, 2014; Zhang et al., 2007). One of the advantages of Bayesian is that it produces posterior distribution from the simulation chain of the prior distribution and considers probability from both null hypotheses and alternative hypotheses (Jarosz & Wiley, 2014). This method's result cam also also can be interpreted as a probability, while frequentist regression's interpretation is limited to the prediction of replication result. For example, the Bayesian approach may conclude that the probability of regression coefficient lie within some point is 95%. Despite the advantages, a few psychological research studies used Bayesian (van de Schoot & Depaoli, 2014).

Results

Bayesian regression

The data were estimated using BEST or Bayesian estimation constructed by Kruschke (2015), namely Jags-Ymet-Xmet-Mrobust. There is some advantage of using Stan; first, it uses efficient sampling algorithms (Kruschke, 2015). Second, it is open-source hence can be run into various programs such as R, Python, Matlab, and Stata (Baldwin & Larson, 2016). The Bayesian analysis regression model is presented below:

$$y \sim \beta_0 + \beta_1 * x, \sum$$

Normal distribution was chosen for prior distribution. After Markov Chain Monte Carlo (MCMC) simulation using Stan feature, posterior distribution was acquired. The MCMC simulation burned 5000 iterations in four chains and showed convergence. The convergence of the chain showing that the tested sample was actually drawn from the posterior distribution (Kruschke,

2015). Convergence achievement is shown by Figure 1, the upper left and lower right panel, the three lines overlap each other also lower left panel's line have stable movement, and its value was close to one.

Figure 1. Iteration process

INSERT FIGURE 1

The results of the MCMC simulation presented in the diagram consisted of the highest density interval (HDI). HDI determines where are the densest range in the posterior probability distribution (Kruschke, 2015). Ninety-five percent of HDI used to conclude the presented result. Kruschke & Liddell (2018) said the use of 95% HDI simply because of its familiarity with a 95% confidence interval in the frequentist method.

To assess null hypotheses, Kruschke (2015) suggested using a region of practical equivalence or ROPE. ROPE is a range of values that demonstrate null value equivalence (Kruschke, 2015). In this study, ROPE was set between -0.5 to 0, considering information from the theoretical review stating a negative correlation between independent variables and addiction (Sayette & Creswell, 2016). Therefore, the probability of posterior distribution density falls to zero or more is small.

Figure 2. Bayesian regression

INSERT FIGURE 2

According to Kruschke (2015), we can assess whether the null value is rejected or otherwise by observe 95% HDI. If it falls entirely outside the ROPE, then the null hypothesis is rejected. Figure 1 illustrates posterior distribution due to the MCMC simulation chain and ROPE

range value and HDI. The middle panel on Figure 2 portrays that the null value rejected as the result of 95% of HDI fall completely outside ROPE (-0.5- 0) (see Figure 2). To put it briefly, the result describes that self-regulation influences smoking addiction (see scatterplots in Figure 4). In Figure 5, the superimposed line illustrates the posterior predictive regression line, while the vertical line shows smoking addiction probability when self-regulation equals "x." For instance, if the self-regulation score is 70, then 95 % predicted posterior distribution of smoking addiction falls within the 25-71.5 range (see Figure 3).

Figure 3. Bayesian scatterplot between smoking addiction and self-regulation

INSERT FIGURE 3

Figure 4. Smoking addiction prediction score for self-regulation = 70

INSERT FIGURE 4

Linear regression

Linear regression analysis was conducted to determine if their self-regulation can predict subjects' smoking addiction. The null hypothesis tested was that the regression coefficient is equivalent to 0 (zero). Violation of assumption test was conducted. There was not any missing data. The linearity test result also did not find any violation, as both variable data had a significance value below 0.05 and an insignificant deviation from linearity value ($p > 0.05$). The next assumption test was Shapiro-Wilk to assess the data's normality. Result shows dependent variable data is normal ($SW = 0.987$, $df = 155$, $p = 0.162$) with skewness (0.121) and kurtosis (-0.524).

The result showed that the variability of smoking addiction score was predicted by self-regulation ($F(1.153) = 82.122$, $p < 0$, with adjusted r square (R^2) of 0.345. In other words, the self-regulation score is a good predictor of smoking addiction score.

Discussion

This study aimed to determine the relation between self-regulation and smoking addiction in adolescents, especially high school students. Results from both analysis methods showed a significant negative correlation between self-regulation and smoking addiction. This result is consistent with Sayette and Griffin (2016), who stated that addictive behavior is caused by self-regulation failure. In the addictive state, an adolescent unlikely to regulate nor control his emotion, behavior, and mind (Faulkner et al., 2020).

Sayette and Griffin (2016) argue that there are two models of self-regulation failure, misregulation and under-regulation. Misregulation refers to a wrong belief or method when regulating one behavior. For example, a teenager is convinced that smoking led to mood improvement and emotional serenity. Based on this conviction, they use smoking to regulate negative moods. They believe that their mood and emotion can be modified by smoking a cigarette. Nevertheless, a study found that when one considers that their negative mood is unchangeable, then the temptation to do impulse behavior (e.g., smoking) will be reduced (Tice et al., 2001).

The second model of regulation failure is under-regulation. Many self-regulation failures are conceived as under-regulation because it refers to the inability to show self-regulation aspects, either part or all of it. These incapacities led to blunder in regulating his behaviors. This leads to the inability to regulate the impulse (Baumeister et al., 1994).

Commonly, when adolescents develop smoking behavior, they suffer under-regulation, specifically to set a goal. They tend to have trouble selecting behavioral standards. The effect is that when the situation changes, their behavior is easily influenced by external variables. This case will lead to self-regulation failure because it is difficult, even impossible, to regulate anything when one has no standard or goal for their behavior (Baumeister et al., 1994). Inability to set a standard also impacts another self-regulation aspect, that is, monitoring an individual competence to supervise his behaviors.

Adolescent smokers who lack monitoring skill is likely to bring a conflict to themselves and their surroundings. Conflict is one of smoking addiction's aspects: the discrepancy between a smoker's behaviors and another activity, environment, or himself as a personal (Griffiths, 2005; Rosenberg & Feder, 2014). Even though this conflict causes many drawbacks for them and they have been recognized and aware of it, they continue to smoke because they cannot regulate themselves to cease smoking. For instance, even a lack of money will not stop them from finding cigarettes (e.g., asking their friend for cigarettes or cash; or even stealing to buy cigarettes). It can be understood since addictive teenagers also lack inhibition ability.

Ogden (2005) stated that a person who is addicted fails to resist an urge or temptation. Meanwhile, to be well regulated, someone must possess inhibition skills (Coulacoglou & Saklofske, 2017). Barkley (1997, 2001) argued that the main requirement in the self-regulation process is behavioral inhibition. Behavioral inhibition hampers behavior impulse and brings out productive behaviors even when it is undesirable. Without inhibition skills, someone will be prone to impulsive behaviors (Nigg, 2017) such as smoking addiction. The lack of inhibition also explains why adolescent smokers have difficulties when they want to stop (Hatzigeorgiadis et al., 2016).

Besides self-regulation, other variables influence smoking addiction. Regression analysis showed that 34% of the variance in smoking addiction score is explained by self-regulation while other variables influence the rest. The most studied variable correlated to smoking addiction is nicotine as the main substance in the cigarette. It is because nicotine affected smokers' brain and promote dependency (Faulkner et al., 2020). Another variable related to smoking addiction is the social factor. Smoking had been proven correlated to social awareness, social skills (Albert-Lőrincz et al., 2020), social desirability (Messeri et al., 2019), gender (Cui et al., 2018; Kodriati et al., 2018), and peer-group choice (Liu et al., 2017). Abe et al. (2019), Choi et al. (2017) also stated that personality factors influence the smoking dependence process. Even, Erzurumluoglu et al. (2020) found that genetic variation has a role in smoking behavior development. They argued that some individuals are more sensitive to cigarette dependence than others. Nevertheless, the environment remains a dominant influence on smokers. A study found teens more at risk of smoking if their parents and siblings are smokers (Andrade et al., 2017).

Students need to develop self-regulation ability because it is needed to prevent them from smoking. Besides, increasing self-regulation ability will help the smoking cessation process (Hatzigeorgiadis et al., 2016). Despite physical treatment, improving psychological skills, such as self-regulation and motivation, is an essential stage in the smoking cessation process (Biber & Ellis, 2017).

The generalisability of the results of this study is subject to certain limitations. The sample used in this study was three schools in the Sleman district; therefore, the generalisability of the results is limited to these schools only. Further studies should include more schools and more districts to understand the effects of self-regulation on smoking addiction among adolescents.

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Notes

*Research article.