# The Effects of Class Time and Air Quality on Ego Depletion: Self-control as a Moderator

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**Abstract**

Ego depletion is important to people's daily life. Previous researches on ego depletion mainly focused on the relationships between ego depletion and other individual's mental factors. To have a bigger picture of the influence factors on ego depletion, this study took university students' learning activities as context, combining natural environmental, social environmental and personal factors into a systematic model to study students' ego depletion. Effects of model's different levels on ego depletion: the influences of air pollution (as a natural environmental factor) and class time (as a social environmental factor) as well as self-control (as a personal factor) were examined by a diary study. 148 participants attended this research. We tested whether the length of class time, air quality and individuals' self-control capacity could affect participants' ego depletion state (ego depletion on morning and sleep quality were controlled). In addition, we examined the self-control's moderator effects on the influences of class time and air quality on ego depletion. Results showed that both air pollution and class time have significant influences on ego depletion. The heavier air pollution or the longer class time, the worse people's ego depletion state will be. Besides, self-control moderates both effects: the higher the self-control, the smaller the changes of ego depletion state will be. The mechanism of influences and implications for research on environment effects and for intervention programs were discussed.

**Key Words** ego depletion; air pollution; diary study; self-control; multilevel regression analysis

## Introduction

Ego depletion refers to a temporary reduction in the individual's capacity to engage in more volitional actions after one exerts self-control (including controlling the environment, making choices and controlling the self) based on a limited resource model (Baumeister, Bratslavsky, Muraven, & Tice, 1998). Up to date, great amounts of researchers have investigated the effects and causes of ego depletion.

Ego depletion has a lot of negative effects on people's daily life such as worsening one's cognitive performance, leading to negative emotions and weakening one's volition or bringing out problematic behavior in behavior controlling. Researchers have found that ego depletion can cause the reduction of one's cognitive resources (Baumeister, 1998) and influence the general reactions including attention (Inzlicht & Gutsell, 2007; Inzlicht & Kang, 2010), memory (Kemps, Tiggemann, & Grigg, 2008; Zwaan & Truitt, 1998; Wegner, 1994) and thinking (Baumeister et al., 1998; Schmeichel et al., 2006; Schmeichel et al., 2003). Ego depletion also has impacts on people's social cognitive process (Fischer et al., 2007; Price & Yates, 2010; Gordijin et al., 2004; Tangney et al., 2004). As for the effects of ego depletion on emotions, ego depletion can result in one's negative emotions and make people insensitive to guilt after they conducted immoral behavior (Fishbach, Eyal, & Finkelstein, 2010). For influences on behavior, ego depletion will make people more easily

give up and more passive when they face temptations or conquer obstacles (Muraven et al, 1998). And all the behavior needing self-control will be impacted by ego depletion like prohibiting unwise shopping behavior (Rawn & Vohs, 2011), resisting the temptation of food (Inzlicht & Kang, 2010), avoiding eating disorders and arranging all the issues related to money, work as well as health (Baumeister, Gailliot, DeWall, & Oaten, 2006). Besides, ego depletion can lead to cheating (Mead et al., 2009), unethical behavior (Gino, Schweitzer, Mead, & Ariely, 2011) and violent behavior (Stucke & Baumeister, 2006).

In view of so many negative effects caused by ego depletion, the mechanism of how ego depletion happens undoubtedly attracts researchers' attention. Self-regulation resources theory is one of the most dominant theories to explain the relationship of self-control and ego depletion (Baumeister, Gailliot, & Tice, 2009). This theory believes that 1) exerting self-control consumes self-regulation resources; 2) self-regulation resources are limited and they will be temporarily reduced after being consumed; 3) the self-regulation resources will get replenished after resting or by improving moods. It proposes the lack of self-regulation resources results in ego depletion due to the former exercise (Inzlicht, & Schmeichel, 2012). Ego depletion can easily happen because there are so many tasks in our lives needing self-regulation resources. For example, when individual needs to exert control over himself/herself or when he/she deals with the external world like making choices, taking responsibility and taking actions to complete plans, self-regulation resources will be depleted, which results in ego depletion (Baumeister, 1998). What's more, if individuals do not get enough rest to replenish the self-regulation resources, they will stay in a state of ego depletion. Lanaj, Johnson and Barnes (2014) have found that cell phone use the previous night and poor sleep quality can lead to participants' ego depletion.

In spite of the fact that researchers have contributed a lot to ego depletion study, some factors have still been omitted and need to be investigated if we want to learn about the entire perspective and study mechanism of ego depletion more deeply. Previous researches usually focused on personal factors like abilities, emotions and behaviors we have mentioned above. Few researches about ego depletion considered the environmental factors. It is undeniable that we are always embedded in a place. "We shape not only buildings but also the land, the waters, the air, and other life forms—and they shape us." (Gifford, R., 2014). So does ego depletion studies. The conditions of surroundings matter a lot to people and researches. Glass, Singer, and Friedman (1969) found that when participants were exposed to unpredictable noise stress, they showed reductions in frustration tolerance, which may be seen as the performance of ego depletion. Considering environmental factors in the study of ego depletion will help us to learn the mechanism better.

Another problem with previous research may be the research methods. Previous experiments usually adopted a dual-task paradigm in which participants are randomly assigned to receive an initial task that requires self-control (as experiment group) or a task that does not require self-control (as compare group) and then they complete another task requiring self-control to see how ego depletion affects the performance (Hagger, & Chatzisarantis, 2013). This kind of experiment can often be finished once for each participants. Although some researchers try to do several different tasks in dual-task paradigm frame to test the hypotheses and make sure the validity of the experiment conclusions, a study found that many researches on ego depletion cannot be replicated (Hagger, & Chatzisarantis, 2016). It makes us cannot help considering that the reason is probably that most of these researches were conducted in the laboratory, which may cause accidental errors and result in differences because of experimenter's diverse operations and other irrelevant variables. Besides,

these laboratory studies which participants' conduct tasks under experimenters' observation may lack external validity. Fortunately, the diary study method can compensate for this "once for all" method and may shed new lights on the study of ego depletion. Some researchers (Diestel, Rivkin, & Schmidt, 2015) used the diary study method to investigate the relationship of sleep quality, self-control and emotion labor, which showed some advantages over the previous laboratory studies in aspect of external validity and long research span.

In this following study, we chose the air quality as a natural environmental factor, the length of study time in class as a social environmental factor and we developed assumptions of their influences on ego depletion. What's more, we assumed that self-control moderates the interactions of air quality and class time on ego depletion. We applied a diary study to test these predictions.

**Poor Air Quality and Ego Depletion**

Poor air quality as a natural environmental factor may cause ego depletion. Recently, air pollution has become a severe pollution problem in China. Some school in many provinces even have holidays for the pollution of fog and haze.

Poor air quality has a great impact on humans' mind and body health.People exposed to air pollution have a high possibility of impairments of their cognitive functions, memory and executive functions (Tzivian, Winkler, Dlugaj, Schikowski, Vossoughi, Fuks, ... & Hoffmann, 2015). Air pollution can cause diseases like respiratory and lung diseases (Aubier and Lambrozo 2000; Leikauf 2002; Larrieu et al. 2007), cardiovascular disease (Pope et al. 2004) and certain types of cancer (Hill, Doyon, and Sancho-Garnier 1997). Besides, it has some bad effects on people's emotions and behavior. Researchers found that air pollution had great influences on individuals' mood and made people feel worried (Wolkoff, P., 2013).

In view of so many negative impacts caused by poor air quality, two possible mechanisms could lead to ego depletion according to self-regulation resources theory. One is that people need to consume their limited resources when they have to resist the influences of air pollution. They need to conquer the influences like discomfort caused by disease, mental distraction (Baron, 1990; Danuser et al., 2003; Michael et al., 2005; Millot et al., 2002; Sakamoto et al., 2005; Hey et al., 2009) and negative emotions. The other mechanism is that poor air quality may affect the resources replenishing process. Self- regulation resources need resting or improving mood to replenish (Baumeister, Gailliot, & Tice, 2009). Being in an ill state or bad moods caused by air pollution and the grey sky may keep individuals away from resting or sleeping well, which will bring out the shortage of self-regulation resources lasting for a long time.

Regardless of whether poor air quality influences the resources consuming process or resources replenishing process, poor air quality has a high possibility to be one of the causes of ego depletion. Thus, we expect to investigate it and assume that day-specific air quality has an impact in predicting ego depletion:

*Hypothesis 1(H1)*: Air quality has influences on ego depletion: the poorer the air quality, the worse the individual's ego depletion state.

**Long Class Time and Ego Depletion**

For students' daily life, class time arranged on curriculum schedule can be considered as an objective social environment factor. Educational institutions like universities often rely on a curriculum timetable to function smoothly (Chan, Gooi, & Lim, 2002). Students often arrange their study plan according to the curriculum timetable.

For curriculum formation, lectures are often consecutive, without any break in between

(Cacchiani, Caprara, Roberti, & Toth, 2013), which requires students to study consecutively. Studying is a complex process, which may consume lots of self-regulation resources. Studying requires people to maintain their attention and process information quickly. Baumeister (2002) believes that maintaining attention needs self-regulation resources and results in ego depletion. Researchers have proved that participants who exert mind controlling or emotion regulation will perform worse in the second task in the dual-task paradigm (Hagger, & Chatzisarantis, 2013). Other researchers explain that the reason why students and pilots have their attention distracted, after they maintain attention for a long time, is because their resources are depleted and ego depletion prevents them from continuing to control themselves (Thomson, D. R., Besner, D., & Smilek, D., 2015). So we propose that continuous study needs self-regulation resources.

Then we could get a conclusion that long class time means long self-controlling time and long self-regulation resources being consumed time.

*Hypothesis 2(H2)*: The state of ego depletion is related to class time and the longer the class time is, the heavier the individual's state of ego depletion will be.

**Self-Control as a Moderator**

What's more, personalities and traits will also influence the process of consuming self-regulation resources. Ego depletion is a state but self-control seems a stable feature of personality. Tangney, Baumeister and Boone (2004) measured people's self-control as stable with respect to individual differences. Research showed that people with high levels of self-control appear to be more popular and successful while people with low levels are more inclined to check Facebook habitually and have procrastination (Meier, Reinecke, & Meltzer, 2016). It has been proved that managing the threat of death consumes self-regulation and leads to self-depletion and self-control moderates the effects of death-related thought and anxiety (Gailliot, Schmeichel, & Baumeister, 2006).

*Hypothesis 3(H3)*: We assumed that the influence of class time on ego depletion will be moderated by individual's self-control and the higher the levels of self-control, the weaker the effects of class time on ego depletion.

*Hypothesis 4(H4)*: We assumed that the influence of air pollution on ego depletion will be moderated by individual's self-control and the higher the levels of self-control, the weaker the effects of air pollution on ego depletion.

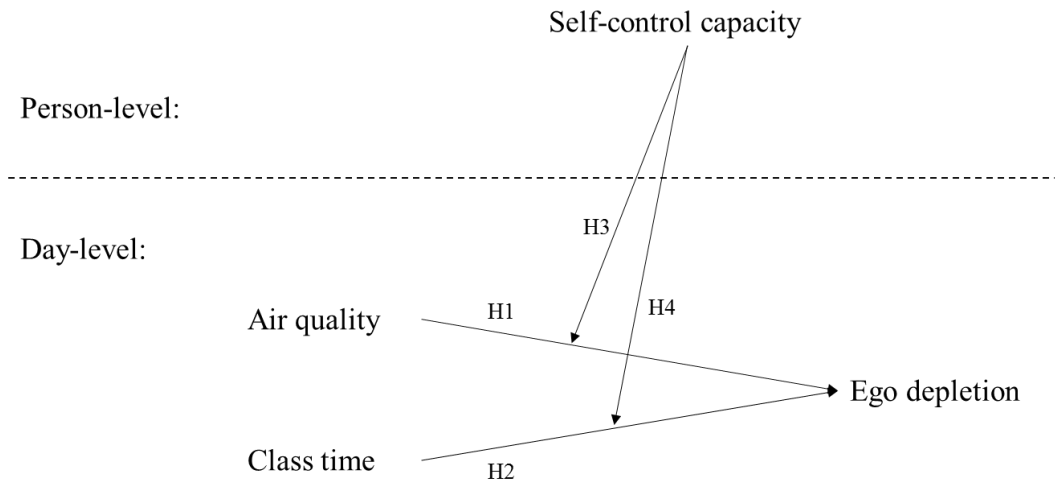

Figure 1

## Method

**Participants.** 148 undergraduates from Beijing Normal University attended this study. Eleven participants were excluded for answering ego depletion questions regularly; nineteen were excluded for missing self-control trait answer; thirteen were excluded for lying in answering the self-control trait as detected from question answers as they showed big difference in answering the same questions in different location in the questionnaire. Thus, a final sample of 105 participants could be employed, which came from different majors. Among these participants, 83 were female and the mean age when both genders were included was 20.36 (range from 17 to 22) years. Some of the participants received credit towards fulfilling a course requirement and the others got paid.

**Measures.** A diary study was conducted. All the participants were instructed to answer questions about their ego depletion state every morning (07:45-09:00, as a control variable) and noon (11:00-13:00, as the dependent variable). The data was collected every other day and this study lasted 27 days (the data was collected 14 times). At the end of the study, participants completed a general survey about their self-control trait. Their course information, age, gender and majors were all collected from the School Academic Affairs Office instead of from students to avoid possible bias.

*Ego depletion (noon).* The state of ego depletion was measured with four items selected from State Self-Control Capacity Scale (Twenge, Muraven & Tice, 2004). They are: 1) "Right now, it would take a lot of effort for me to concentrate on something." 2) "I feel ready to concentrate." 3) ". If I were given a difficult task right now, I would give up easily." 4) "If I were tempted by something right now, it would be very difficult to resist." All the 4 items were 11-point Likert scale (0= *very inconsistent*, 10= *very consistent*). The *Cronbach α* value was 0.822 and an explore factor analysis with principal axis factoring and direct oblimin was conducted. Results showed that *KMO*=0.799, *Bartlett sphere* examination was 0.000 and one factor was abstracted. Then the mean value of these four items was calculated as the measurement of ego depletion at noon.

*Class time.* We calculated the number of students' courses on that morning as their study time. We got every students' class schedule from the School Academic Affairs Office and recorded their study time when they completed the ego depletion scale.

*Air pollution.* We used Air Quality Index (AQI) of Beijing from the China Meteorological Administration as the measure of air pollution. The AQI ranged from 1(*Excellent*) to 6(*Severely Polluted*).

*Self-control.* The self-control trait was measured by Self-Control Scale (Tangney, Baumeister, & Boone, 2004). All the items were on the 5-point Likert scale (1=*not at all*, 5=*very much*). In addition, we repeated two questions as a test to see whether participants may have lied when answering the scale (if they answered the same questions with one answer less than 3 and the other more than 3, we would think they probably lied). After removing the two test questions, the *Cronbach α* value was 0.855. Finally, the mean value was calculated as the measurement of self-control trait.

**Control variables.** To test the effects of study time and air pollution as well as self-control trait on ego depletion more accurately, we set up control variables as described below.

*Sleep quality.* There are indications that people's self-regulation resources can be influenced by the sleep quality of the previous night (Lanaj, Johnson, & Barnes, 2014, Kühnel, Bledow, &

Feuerhahn, 2016). So we made participants rate their sleep quality the previous night from 0(*very bad*) to 10(*very good*) and treated it as a control variable.

*Ego depletion (morning).* We used the same four items as at noon to measure participants' state of ego depletion and treated it as the control variable. The *Cronbach α* value was 0.849 and an explore factor analysis with principal axis factoring and direct oblimin was conducted. Results showed that *KMO*=0.814, *Bartlett sphere* examin Trait self-control stracted. Then we calculated the mean value of these four items as the measurement of ego depletion in the morning.

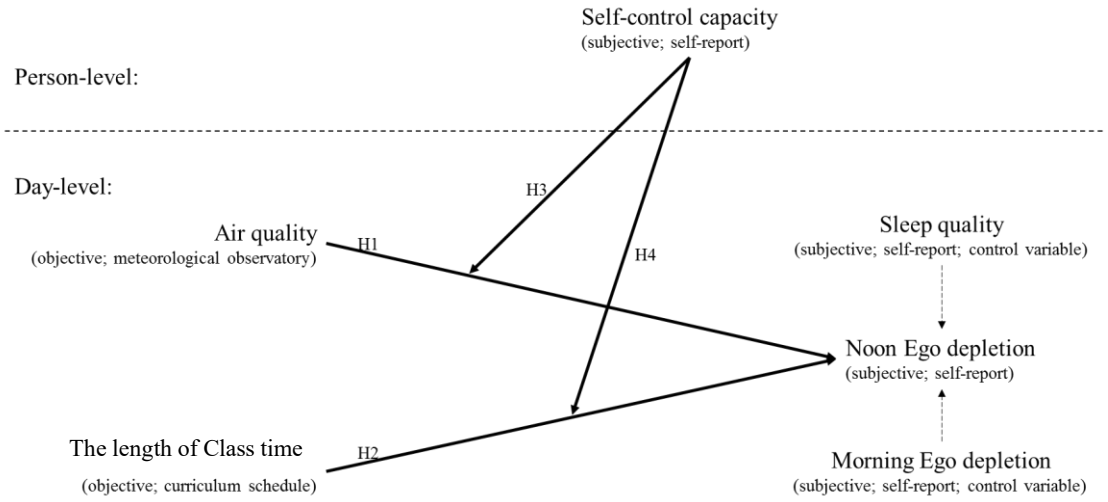


**Figure 2**

**Analytical procedure.** To test our hypotheses, we used a multilevel regression model with day-level data (level 1) nested within the person-level data (level 2) (Fraley & Hudson, 2014). We conducted analysis with Mplus 7.0. The null model only included the intercept. Model 1 included the self-control trait to see whether self-control as a personal trait has effects on individual's ego depletion state. In Model 2, we added control variables in level 1(sleep quality and ego depletion state in the morning) and tested their interactions with the self-control trait. In Model 3, we added independent variable in level 1(study time and air pollution) and tested the interactions between level 1 and level 2(self-control trait). All the level 1(except air pollution because it is ordinal variable) and Level 2 variables were centered around their grand mean to reduce the risk of confounding effects (Diestel et al., 2015).

## Results

Table 1 displays the descriptive statistics and reliabilities of the study variables. Morning ego-depletion has a high significant correlation with noon ego-depletion and has a medium significant correlation with sleep quality. Self-control trait has a medium correlation with noon ego-depletion and a medium correlation with sleep quality. These correlations re-emphasize to set sleep quality and morning ego-depletion as control variables. Before testing our hypotheses, we examined the within-person (Level 1) variance to see whether grouped data violate the assumption of independence of all observations. We calculated *Intraclass Correlation(ICC) and ICC* $=\tau^2 intercept/(\tau^2 intercept+\sigma^2)$=0.351 (see Null model in Table 2) (Maas, & Hox, 2005), which necessitates the application of multilevel modeling and setting self-control trait as the level 2

variable. Model 3 with independent variables showed an improved fit compared with Model 2 with control variables by the significant difference in the log likelihood ratios.

**Test of hypotheses.** Hypothesis 1 proposed that the class time aggravates the state of ego depletion. In line with this proposition, multilevel regression analysis revealed that class time influenced ego depletion significantly and β was 1.169, which means the longer class time participants take, the worse their ego depletion state will be (see Table 2, Model 3).

Hypothesis 2 proposed that air pollution has an influence on the state of ego depletion and the heavier air pollution is, the worse participants' ego depletion state will be. The results also supported this hypothesis: air pollution has a significant effect on ego depletion and β was 0.535 (see Table 2, model 3).

For Hypothesis 3, we can see significant interactions between self-control and the independent variables in level 1(class time and air pollution). We did simple slope effect test and the results (see Figure 1 & Figure 2) indicated that the higher self-control, the smaller changes of ego depletion state would be, which approved the Hypothesis 3.

## Discussion

This study found that class time as well as air pollution leaded ego depletion and self-control moderated their influences, which is consistent with previous research. Continuous studying and air pollution consumes individual's self-regulation resources. The longer class time participants take, the heavier air pollution participants endure, the worse their ego depletion state will be. In addition, their effects can be weakened if individuals have high self-control trait.

The class time's effect on ego depletion can be explained. Students should control themselves to maintain attention on what teacher says and to process and then understand the knowledge, resist temptations of entertainments and obey school rules. The longer they study, the more resources they deplete and they do not have time to replenish their resources because break of classes is short. So their state of ego depletion gets worse.

The reason why air pollution causes individual's ego depletion can be discussed in two aspects. First, air pollution has a lot of harms to people and this may bring threaten to people's lives, which causes their anxiety. People need to consume the resources to bear this uncomfortable anxiety and maintain their focus on their work or study. Second, air pollution can make people feel uncomfortable when they breathe and it will cause some diseases. People often need to deplete self-regulation resources to continue their work and normal life. They only go to hospital when they feel it's necessary. Self-control moderates the relationship not only between air pollution and ego depletion but also between study time and ego depletion. As the previous research, the higher levels of trait self-control, the less negative influence individuals will have. Self-control can be built by exercise. People can make themselves more successful by exercise their self-control.

However, there are some disadvantages in this study. First, we use self-report in our study dairy, which may result the lack of objective indicator. Second, participants are all students, which suggests that the results should be tested in other groups.

Our study investigated environment factors on ego depletion and can be applied in our lives. It inspires us to improve our environment and have a good rest to lighten the state of ego depletion and consider more about environmental impacts when we conduct experiments.

Future study may investigate the mechanism of how environment leads ego depletion.

**References (Omitted)**

Table 1

*Means, Standard Deviations, Internal Consistencies (Cronbach's Alpha) and Intercorrelations*

| Variable | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1. Noon ego depletion | (0.822) | .035 | .018 | -.017 | .183** | |
| 2. Class time | 0.028 | - | -.016 | -.007 | -.191** | |
| 3. Air pollution | 0.074 | -0.069 | - | -.014 | -.030 | |
| 4. Sleep quality | -0.007 | -0.007 | -0.015 | - | -.283** | |
| 5. Morning ego depletion | 0.424** | -0.115 | 0.057 | -0.342** | (0.849) | |
| 6. Self-control | -0.288** | -0.074 | -0.025 | 0.310** | -0.267** | (0.855) |
| M | 5.00 | 1.52 | 4.00 | 7.11 | 5.01 | 3.22 |
| SD | 1.96 | 1.49 | 1.83 | 2.22 | 2.10 | 0.43 |

*Note.* Cronbach's alpha for day-level variables are mean internal consistencies averaged over all measurement days. Correlations below the diagonal are person-level correlations (N = 105). Correlations above the diagonal are day-level correlations (N = 1247).

**.Correlation is significant at the 0.01 level (2-tailed).

Table 2

*Multilevel Estimates for Models Predicting Noon Ego Depletion*

| Parameter | Null model | | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|---|---|
| | β | (SE) | β | (SE) | β | (SE) | β | (SE) |
| Fixed effect | | | | | | | | |
| γ00 = Intercepts | 5.008*** | 0.122 | 5.011*** | 0.117 | 6.121** | 2.040 | -0.519 | 3.617 |
| γ10 = Class time | | | | | | | 1.169** | 0.382 |
| γ20 = Air pollution | | | | | | | 0.535* | 0.226 |
| γ30 = Sleep quality | | | | | 0.235 | 0.229 | 0.414 | 0.251 |
| γ40 = Morning ego depletion | | | | | 0.126 | 0.377 | 0.386 | 0.397 |
| γ01 = Self-control trait | | | -0.812** | 0.301 | -0.441 | 0.624 | 1.429 | 1.125 |
| γ11 = Self-control trait×Class time | | | | | | | -0.320** | 0.119 |
| γ21 = Self-control trait×Air pollution | | | | | | | -0.158* | 0.070 |
| γ31 = Self-control trait×Sleep quality | | | | | -0.064 | 0.073 | -0.115 | 0.080 |
| γ41 = Self-control trait×Morning ego depletion | | | | | -0.018 | 0.118 | -0.085 | 0.124 |
| Random effect | | | | | | | | |
| $\sigma^2$ = Residual variance at Level 1 | 2.474*** | 0.228 | 2.473*** | 0.228 | 2.317*** | 0.242 | 2.164*** | 0.236 |
| $\tau^2$intercept= Residual variance at Level 2 for intercept | 1.336*** | 0.195 | 1.215*** | 0.183 | 2.767*** | 0.767 | 3.176** | 1.151 |
| $\tau^2$slopeγ10= Residual variance for class time | | | | | | | 0.021 | 0.038 |
| $\tau^2$slopeγ20= Residual variance for air pollution | | | | | | | 0.004 | 0.017 |
| $\tau^2$slopeγ30= Residual variance for sleep quality | | | | | 0.004 | 0.009 | 0.006 | 0.011 |
| $\tau^2$slopeγ40= Residual variance for morning ego depletion | | | | | 0.044* | 0.021 | 0.049* | 0.023 |
| -2*log | 4877.086 | | 4868.328 | | 3475.86 | | 3438.128 | |
| Diff-2*log | | | 8.758** | | 1392.468** | | 37.732** | |
| Number of parameters | 3 | | 4 | | 12 | | 20 | |

Note. Trait is person-level (Level 2) variables; all other predictor variables are day-level (Level 1) variables. * p < .05, ** p< .01, *** p< .001.

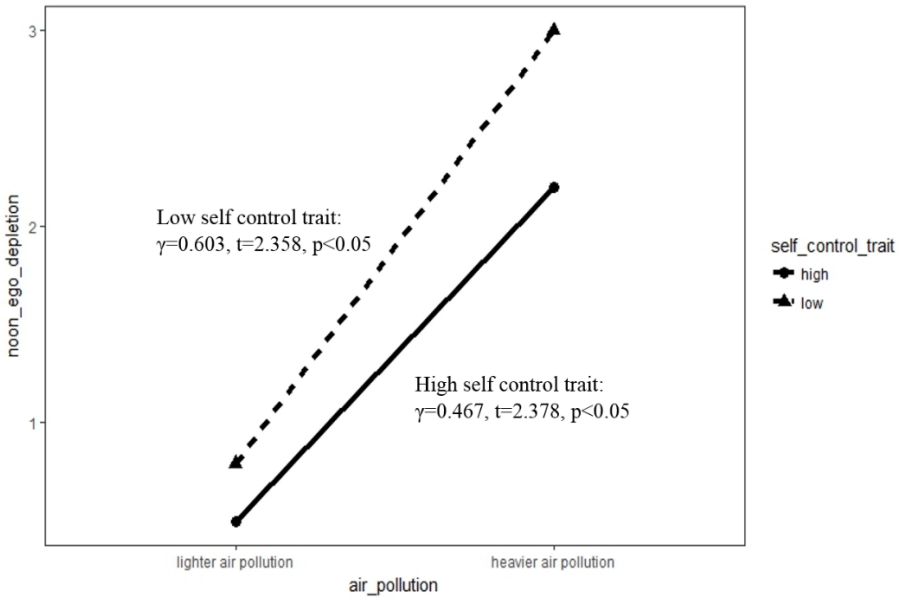


Figure 3

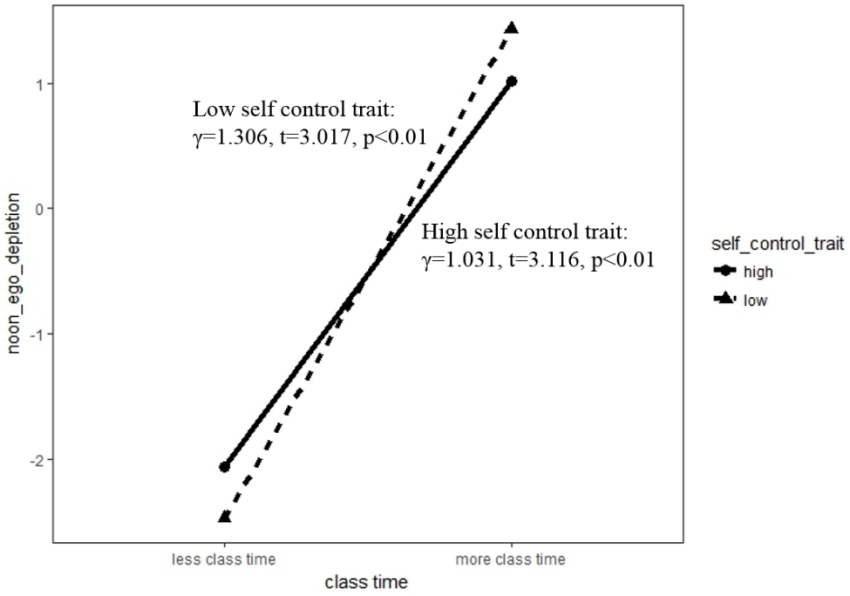


Figure 4