# BIOST 579 Final Project: An Exploratory Analysis of the Association Between Paranoia and Insomnia

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## Abstract

### Background

Insomnia and paranoia have been linked in previous studies; however, the relationship between these two variables is obscured and likely mediated by negative affectivity. The goal of this report is to further understand the relationship between these three variables, a process that formally began in a previous 2009 study and was continued in the 2017 study from which this dataset was procured (Freeman, et al., Scott, et al.).

### Methods

All participants were categorized as either experiencing paranoia or not, as experiencing insomnia or not, and as experiencing low, medium, or high negative affectivity. Descriptive statistics and multiple logistic regression with Wald tests were used to describe the relationship between paranoia symptoms and insomnia symptoms while adjusting for negative affectivity as a confounder. Secondary models used for analysis of subgroups based on age and sex were similarly conducted, and simple logistic regression was utilized to investigate the association between individual insomnia symptoms to paranoia.

### Results

We fail to reject the null hypothesis that the odds of experiencing paranoia given insomnia is the same for those who do not experience insomnia when adjusting for negative affectivity, which confirms the findings of the 2017 study.

### Conclusions

Because there are many limitations to using cross sectional data, future longitudinal studies should be conducted to learn more about insomnia and paranoia. More thought needs to be given to potential confounders or effect modifiers, such as age, and the association between these variables with insomnia and paranoia.

# Introduction

A possible link between insomnia and paranoia was established in a 2009 article studying insomnia symptoms within 300 individuals who were attending psychiatric sessions (Freeman, et al.). This study found that "moderate or severe insomnia was present in more than 50% of the delusions group" (Freeman, et al.). However, it has been shown that paranoia and insomnia are linked with negative affectivity (that is, internal feelings of dissatisfaction and/or lack of self-concept), which was acknowledged by the 2009 study (*APA Dictionary*). The goal of this report is to analyze the link between insomnia and paranoia while accounting for negative affectivity. Additional aims include conducting subgroup analyses by age and sex and investigating the individual association that insomnia symptoms have with paranoia. This information is intended to be used to create future hypotheses about the relationship between these variables.

# Data Set Description

The data was collected as part of a 2017 study that took place in the United Kingdom, which was published in the journal PLOS ONE (Scott, et al.). This sample included 439 participants aged 18 to 77, who were primarily female (76%) with an average age of 35.1. All individuals were recruited through a university email list.

This was a cross-sectional study that collected data via an online survey. All participants completed an Electronic Consent Form before filling out the survey. The survey asked individuals to fill out demographic information and to rank their experiences of symptoms relating to paranoia, insomnia, and negative affectivity. Questions related to paranoia were adapted from the Green Paranoid Thoughts Scale and used a scale of 1 to 5 points. Insomnia questions were taken from the SLEEP-50 Questionnaire and used a scale of 1 to 4. Lastly, negative affectivity questions came from a shortened form of the Depression, Anxiety, and Stress Scale (DASS), which uses a point scale of 0 to 3. Investigators excluded incomplete surveys, so there is no missing data. For confidentiality reasons, all other demographic information was removed from the dataset and therefore cannot be analyzed.

A subset of 91 participants (20.7%) volunteered to collect objective sleep data through the week-long use of a sleep monitor. These individuals met with a researcher to give consent, receive training on using the sleep monitor, and to ask any relevant questions. These participants completed the survey before agreeing to collect further sleep data.

# Statistical Methods

## Sample Size Calculation

The research team determined that the minimum sample size required for their analyses in order to detect "medium sized relationships" with 80% power was 241; they used the recommendations from a 2010 paper on sample size (Westland). Ultimately, 439 participants were enrolled.

## Variables

The outcome in this analysis is a composite variable capturing the severity of paranoia symptoms and is represented by a binary variable, with 1 indicating moderately severe symptoms of paranoia and 0 indicating a lack of moderately severe paranoia symptoms. A survey with 16 questions relating to paranoia was used for participants to self-identify severity of symptoms, with individuals having a potential range of scores from 16 to 80. Over 53% (233 of 439 participants) scored 16 points, indicating a complete lack of paranoia symptoms (see Figure 1 for the spread of scores). One individual has a score of 76, which is 32 points higher than any other participant. However, this data point was not excluded from analyses as this person is representative of

those with extreme symptoms of paranoia, a population that is imperative to the answering of this scientific question. In order to categorize participants as having or not having paranoia, this range of scores was dichotomized at 34 points, a score than indicates an individual experiences a moderate level of at least 9 of the 16 symptoms captured in this questionnaire. This is a simplified version of categorization that aims to emulate the DSM-5 criteria for diagnosis ("Paranoid Personality Disorder"). There are 17 participants in this study (3.9%) who experience a moderately severe level of paranoia by this definition, which is consistent with the estimate that between 2.3 and 4.4% of individuals are affected by paranoia ("Paranoid Personality Disorder (PPD)...").

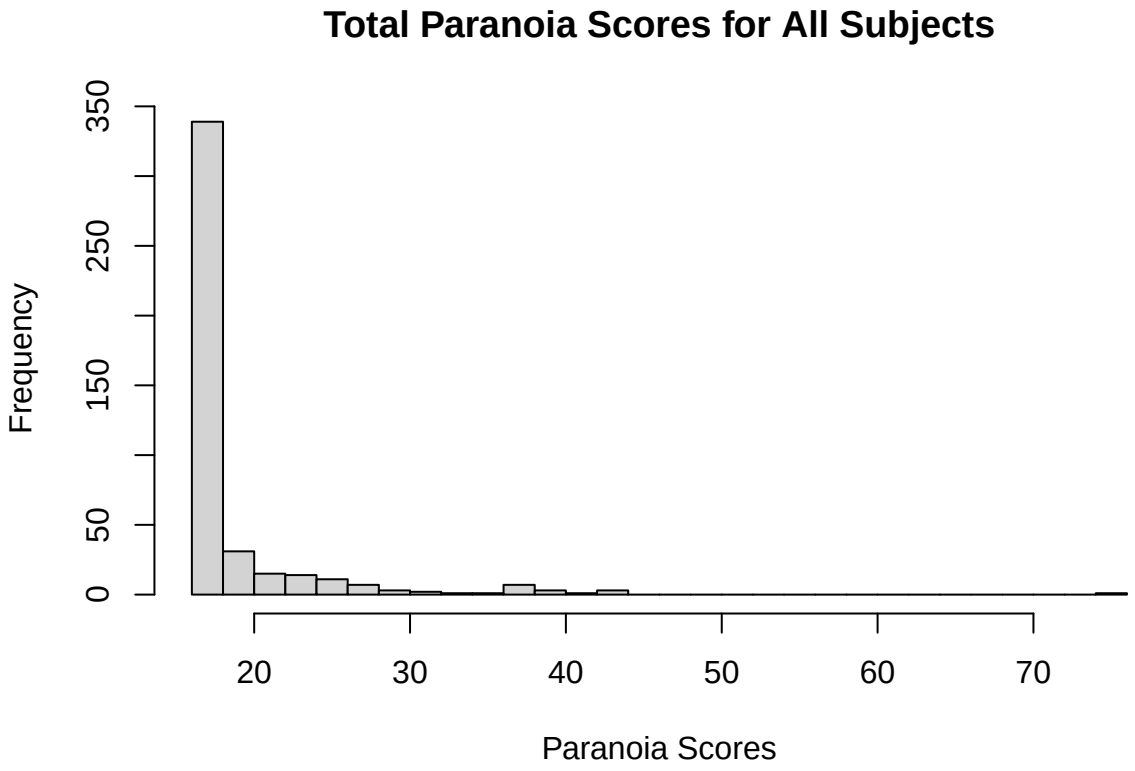


Figure 1: Range of total paranoia scores for all individuals in the study

Predictor variables include an indicator of insomnia, which is similarly created using self-ranked scores for questions related to insomnia symptoms. There are 8 total questions, with a potential range of scores from 8 to 32. These questions come from the SLEEP-50 Questionnaire, which considers any score at or above 19 to indicate insomnia, and this guideline is mirrored in these analyses. Individuals in this study have a mean score of 17.7, with 184 subjects who experience insomnia by the SLEEP-50 definition. This comprises 42% of individuals in the study, which is fairly consistent with the estimate that 33 – 50% of adults experience insomnia symptoms ("Insomnia..."). See Figure 2 for the overall spread of insomnia scores. Of the 91 adults who agreed to provide sleep monitor data, there is a mean sleep time of 418 minutes per night. While an insomnia diagnosis depends on more than the amount of sleep one gets at night, getting less than 7 hours of sleep can be dangerous and may be caused by insomnia, so for these participants, a secondary insomnia variable was created, and individuals were dichotomized into a separate insomnia group (those who get less than 7 hours of sleep per night on average) as compared to those who do not experience insomnia (those who get 7 or more hours of sleep on average) (Watson).

The final variable is a categorical variable indicating low, medium, or high presence of symptoms of negative affectivity, which will be adjusted for as a confounder in analyses. There are 21 relevant questions, each

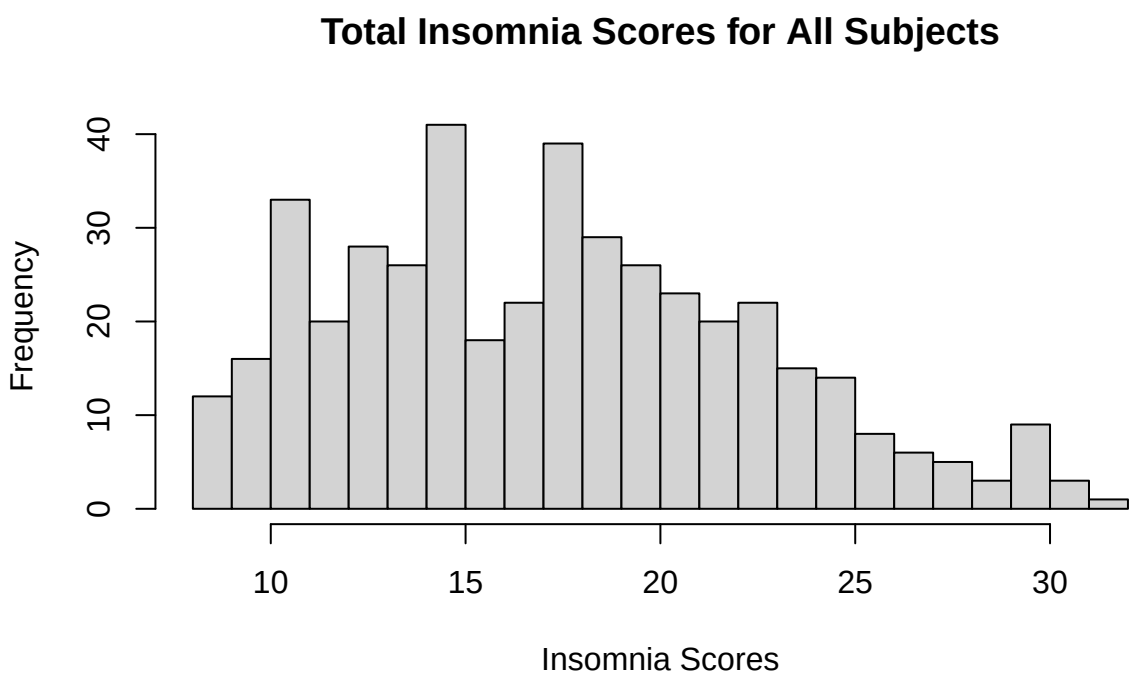


Figure 2: Range of total insomnia scores for all individuals in the study

ranked by participants on a scale of 0 to 3. Scores range from 0 to 63, with a mean score of 12.6. Three categories were created (low, medium, and high) to represent those scoring between 0-21, 22-42, and 43-63 points. This leads to 355 people who experience no/low negative affectivity symptoms, 72 who experience medium levels of symptoms, and 12 who experience high levels of symptoms.

Since negative affectivity encompasses depression, anxiety, and more, this variable is not binary. However, for paranoia and insomnia, one is either diagnosed or not diagnosed with these disorders, leading to the choice to represent these with binary variables.

## Statistical Methods: Descriptive Statistics

Information about demographic variables for the entire study and subgroups are displayed in the *Descriptive Statistics* section below. The proportion of individuals considered to have insomnia, paranoia, and each category of negative affectivity is also displayed. The total number of participants and percentages are included for each demographic variable, and the mean, standard deviation, and range for each overall score are reported. A scatterplot of total paranoia scores versus total insomnia scores is also included. These methods help illustrate who is in the study population and assist in visualization of the potential relationship between the outcome and predictor variables.

## Statistical Methods: Exploratory Analyses

Logistic regression with a Wald test at the 0.05 significance level are used to conduct the following analyses. Three particular models were prespecified for use in this analysis to describe:

- The relationship between paranoia symptoms and insomnia symptoms while adjusting for negative affectivity as a confounder

- The same relationship as above, but for those subgroups consisting of participants who differ by sex or by age (broken into three categories) or who allowed investigators to collect sleep monitor data
- The relationship between paranoia and individual symptoms of insomnia

The first model corresponds to the overall scientific question of interest. This question is answered using multiple logistic regression in order to test against the null hypothesis that the odds of experiencing paranoia symptoms given participants experience insomnia symptoms is equivalent to those who do not experience insomnia symptoms, both adjusting for negative affectivity. This is also compared to the results from a simple logistic regression model that does not include negative affectivity as a predictor in order to examine the role of negative affectivity as a potential confounder in this relationship.

The second model involves subgroup analysis based on the demographic information available from the dataset (age and sex) and based on sleep monitor data. For the variable age, the sample is divided into three age categories (18 – 37, 38 – 57, and 58-77). The same multiple logistic regression model as above was conducted on each age subgroup. Similarly, the sample can be divided into those identified as male and those identified as female, and the multiple logistic model described previously was conducted. Additionally, for the subgroup of individuals who agreed to collect sleep monitor data, model one was conducted for this subgroup using self-reported sleep data and will be compared to a separate model that is the same in all ways, except using the data collected by sleep monitor to determine those who are considered to have insomnia to see if the results differ. These subgroup analyses are included in order to look at the differences between groups and as a means of hypothesis generation.

Finally, the last model looks at the relationship between paranoia and individual symptoms of insomnia. Each symptom is used as a predictor in a simple logistic regression model, with paranoia as the outcome. These symptoms are not dichotomized, but rather kept on the original point scale of 1 to 4. Significance tests were conducted using Wald tests at the 0.05 significance level. These models allow us to explore the relationship between paranoia and individual symptoms of insomnia to indicate which symptoms might be the most indicative of paranoid personality disorder.

### Assumptions

While logistic regression does make assumptions about the data, this method is appropriate for these analyses for a multitude of reasons: first, the outcome variable (paranoia) is binary. This is justifiable, as individuals are either diagnosed with paranoia or they are not. It is not as relevant to the overall scientific question to investigate the relationship between insomnia symptoms and point increases in overall paranoia scores. Secondly, this study has a large sample size. Conclusions are not extrapolated based on little information. Finally, observations are also likely to be independent, which is necessary when conducting logistic regression. Because we do not have longitudinal data and subjects completed a maximum of one survey, there should be no reason to believe this data is dependent. Logistic regression is a natural choice when dealing with binary response variables like in this study.

## Results

### Descriptive Statistics

Table 1: Descriptive statistics for total paranoia, insomnia, and negative affectivity scores

| | Paranoia (range from 16-76) | Insomnia (range from 8-32) | Negative affectivity (range from 0-63) |
|---|---|---|---|
| Mean | 18.60 | 17.70 | 12.6 |

| | Paranoia (range from 16-76) | Insomnia (range from 8-32) | Negative affectivity (range from 0-63) |
|---|---|---|---|
| SD | 5.68 | 5.28 | 11.5 |

Table 2: Proportions of individuals with paranoia, insomnia, and negative affectivity (by category)

| | Paranoia | Insomnia | Low NA | Medium NA | High NA |
|---|---|---|---|---|---|
| Proportion | 0.04 | 0.42 | 0.81 | 0.16 | 0.03 |

Total paranoia scores are very low on average, with only 17 people (4%) of the study participants being considered to have paranoia. Comparatively, there are many more people in this study (184, making up 42%) who are considered to have insomnia. Finally, over 4/5ths of individuals experience low levels of negative affectivity, with 16% having medium levels of negative affectivity and only 3% of participants experiencing high levels.

Table 3: Proportions of individuals with paranoia, insomnia, and negative affectivity across three age groups

| | Age 18-37 (n=266) | Age 38-57 (n=146) | Age 58-77 (n=27) |
|---|---|---|---|
| Paranoia | 0.045 | 0.034 | 0.00 |
| Insomnia | 0.360 | 0.510 | 0.56 |
| Low NA | 0.780 | 0.840 | 0.96 |
| Medium NA | 0.180 | 0.150 | 0.04 |
| High NA | 0.040 | 0.010 | 0.00 |

When looking at age subgroups, it is notable that those in the youngest age group have higher proportions of individuals who experience paranoia and medium/high negative affectivity as compared to the other age categories. Yet when analyzing the insomnia variable, it is clear that the oldest age group has the largest proportion of people who experience insomnia, with 20% more individuals experiencing insomnia than in the youngest age bracket. Interestingly, none of the 27 participants in the oldest age group experienced paranoia or the highest category of negative affectivity.

Table 4: Proportions of individuals with paranoia, insomnia, and negative affectivity across sex subgroups

| | Female (n=336) | Male (n=103) |
|---|---|---|
| Paranoia | 0.042 | 0.029 |
| Insomnia | 0.420 | 0.410 |
| Low NA | 0.810 | 0.800 |
| Medium NA | 0.160 | 0.170 |
| High NA | 0.020 | 0.040 |

It is also of interest to separate the participants into subgroups by sex. There are only small differences between the groups of female and male participants, although there is a slightly higher proportion of female participants who experience paranoia than male participants (a difference of 1.3%). While this sample consisted of 76% female participants, the research team utilized anova tests to investigate associations between variables of interest and gender and found no significant differences, thus assuming it unlikely that this gender imbalance would impact further analyses.

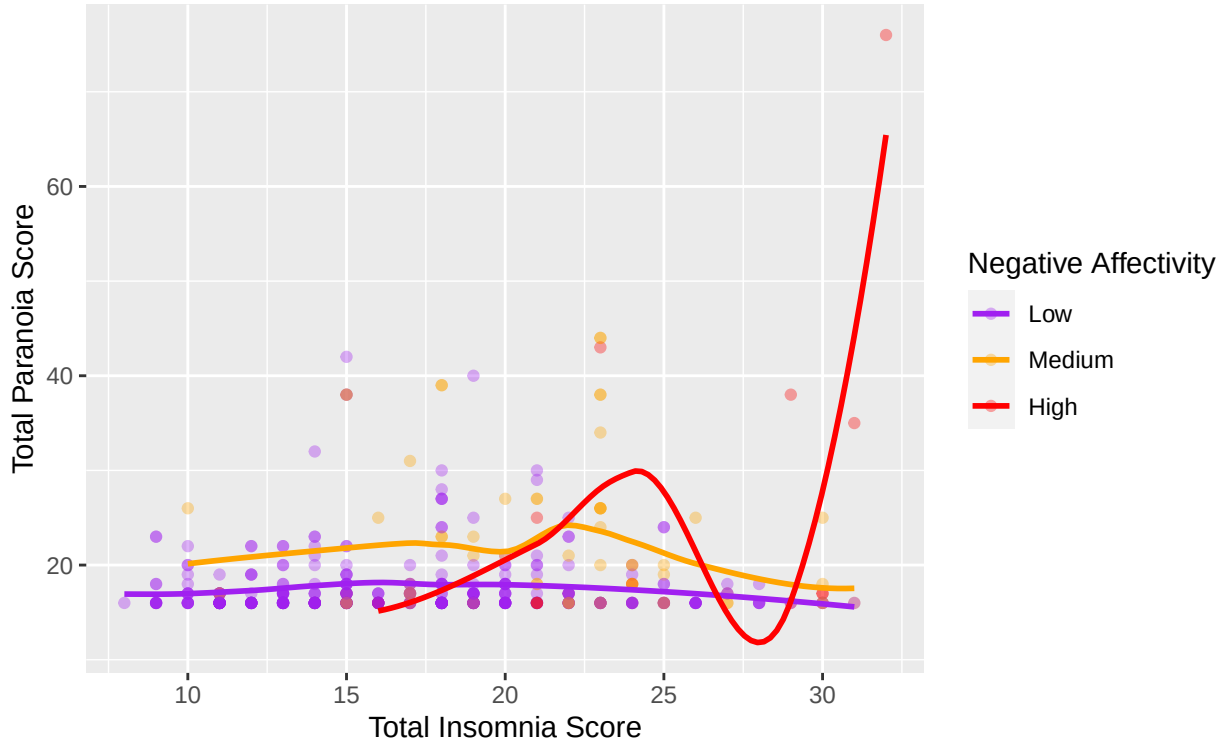


Figure 3: A scatterplot of total insomnia scores and paranoia scores, with loess smoothers capturing trends across negative affectivity categories

This scatterplot illustrates the relationship between overall paranoia and insomnia scores, as well as potential effects that negative affectivity level has on this relationship. Loess smoothers are employed for each negative affectivity category to indicate the average trend within each category. While higher insomnia scores do seem correlated to high paranoia scores, we can see that negative affectivity plays a role in this relationship as well, with those with high negative affectivity experiencing both higher insomnia and paranoia scores on average.

## Primary Analysis

Multiple logistic regression was performed at the 0.05 significance level with paranoia category as the outcome and insomnia category as a predictor, adjusting for negative affectivity level as a confounder. A simple logistic regression model was also performed without adjusting for negative affectivity. The results from these models are as follows.

Table 5: Multiple logistic regression model coefficient estimates

| | Estimate | 95% CI | P-value |
|---|---|---|---|
| Intercept | 0.013 | (0.005, 0.037) | <0.001 |
| Insomnia level | 0.63 | (0.19, 2.05) | 0.44 |
| Medium NA | 14.81 | (4.01, 54.68) | <0.001 |
| High NA | 58.34 | (10.15, 335.2) | <0.001 |

Table 6: Simple logistic regression model coefficient estimates

| | Estimate | 95% CI | P-value |
|---|---|---|---|
| Intercept | 0.028 | (0.013, 0.06) | <0.001 |
| Insomnia level | 2.04 | (0.76, 5.48) | 0.16 |

As seen in Table 5, for those with insomnia, the expected odds of having paranoia are 37% lower (OR=0.63, 95% CI: 0.19-2.05, p=0.44) than those without insomnia when adjusting for negative affectivity. Based on these results, we fail to reject the null hypothesis at the 0.05-level that the odds of experiencing paranoia given participants experience insomnia is equivalent to those who do not experience insomnia, either adjusting for negative affectivity or not. However, we do note a significant association between both medium and high negative affectivity and paranoia when adjusting for insomnia, which may help inform future hypotheses and work to elucidate the true relationship between these variables.

Simple logistic regression shows different results: for those with insomnia, the expected odds of experiencing paranoia are 104% higher (OR=2.04, 95% CI: 0.76-5.48, p=0.16) - see Table 6. These results are included for comparison purposes, as based on what is known about the casual pathway of paranoia and insomnia, this is not indicative of the true relationship between insomnia and paranoia.

### Secondary Analysis

Subgroup analyses were also performed using the same multiple logistic regression model used above. The first subgroup analysis was based on sex; for female participants, there is a lack of evidence to suggest a significant association between insomnia and paranoia when adjusting for negative affectivity. However, for the male subgroup, a significant association is noted (p<0.001).

Next, analyses based on age were conducted on each of the three pre-specified age groups. Results for these analyses were fairly similar, and no significant associations were found. Notably, the oldest age group did not include any participants who experienced severe paranoia symptoms, and as such the analysis on the oldest age group was not very informative.

Additionally, an analysis was conducted on the 91 participants who consented to wear a sleep monitor to collect objective sleep data. These individuals were categorized into insomniacs and non-insomniacs based on the amount of time they slept on average per night, rather than by their survey questions. When performing multiple logistic regression substituting this variable for the original insomnia variable, it is estimated that for those with insomnia, the expected odds of having paranoia are 67% lower (OR=0.33, 95% CI: 0.03-3.72, p=0.37) than those without insomnia when adjusting for negative affectivity.

Ultimately, there is little evidence for a significant association between insomnia and paranoia when adjusting for negative affectivity in any subgroup, other than the male subgroup, which is based off of a fairly small sample and may be due to random chance.

An exploratory analysis was also conducted on individual insomnia symptoms using simple logistic regression. The significant symptoms (i1, i2, and i3) represent the following phrases: I find it difficult to fall asleep; I worry so much it prevents me from falling asleep; I find it hard to relax. Notably, symptom 8 (I sleep too little), which is highly correlated with insomnia, is not significantly associated with paranoia. Odds ratios and the associated 95% confidence intervals and p-values are displayed for each insomnia symptom in Figure 4.

## Discussion

Similarly to the original 2017 study, there is no evidence for an association between paranoia and insomnia when adjusting for negative affect (Scott, et al.). A potential association was found within the male subgroup,

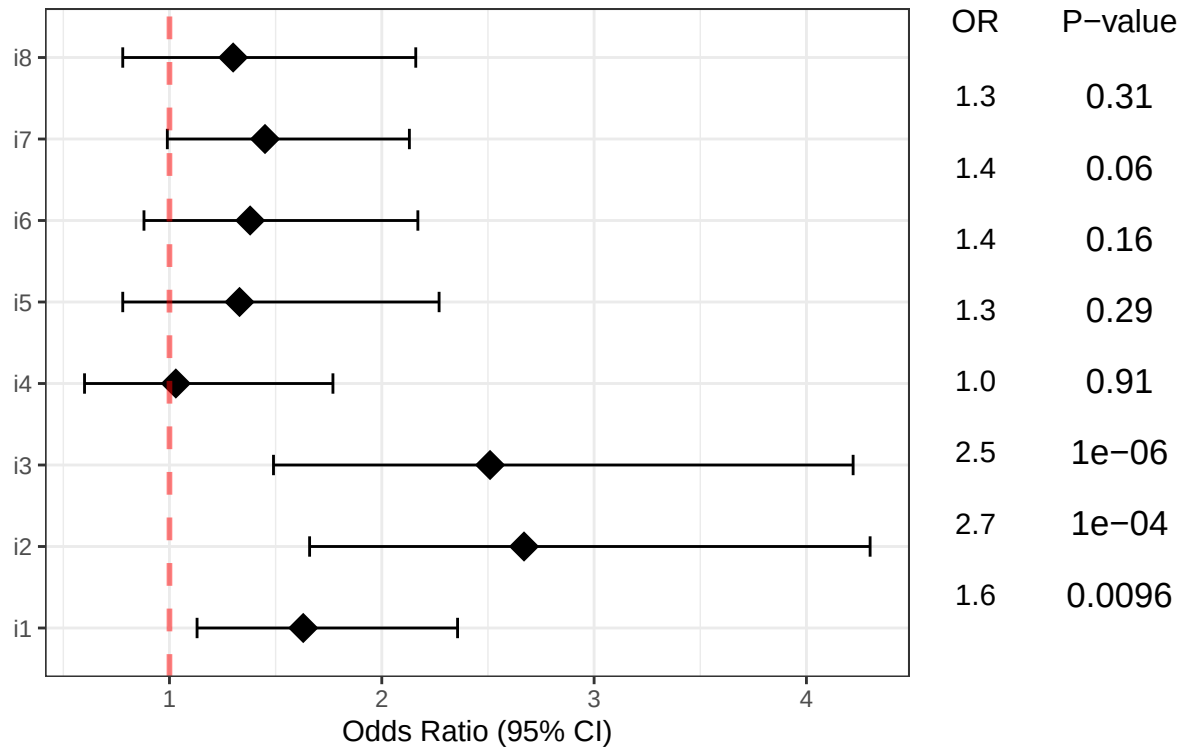


Figure 4: Odds ratios, 95% CIs, and p-values for simple logistic regression analyses between individual insomnia symptoms and paranoia

but this may have been due to chance or limitations of the data. Ultimately, the results of this study reinforce the findings from the 2017 report for which this data was collected.

## Limitations

Because all analyses were conducted using cross sectional data, it would be misguided to make causal claims. Also, the data itself may not be completely accurate: data was collected via online survey, which could easily be misread or misinterpreted by subjects. Someone could also have disingenuously filled out this survey, which would be hard for investigators to determine and exclude.

Secondly, because there is no definitive literature regarding the casual pathway between insomnia, paranoia, and other mental health concerns, negative affectivity is treated as a confounder in these analyses, but it could be a mediator, effect modifier, or other type of variable. As such, all conclusions are subject to limitations of the study population and model designs, which are based on limited scientific knowledge of the true relationship between the variables of interest. There are also certainly unmeasured variables that play a part in this relationship that cannot be accounted for using this data.

The study participants themselves are also distinct from the population of interest. Participants skew young, are majority female, and are likely to be highly educated, as individuals were recruited through a university email list. Because of these factors, it is difficult to know if results can be generalized to other populations. While a significant association was found within the male subgroup, this was likely due to the fact that this subgroup included a relatively small number of individuals, with only 3 people included in the paranoia group. Similarly, the oldest age group only included 27 individuals, so results may be invalid. More information should be collected on both male and older participants in order to corroborate or debunk these findings.

It would be useful to have more objective information as well. No objective sleep data was collected for over

75% of participants, meaning there is a relatively small sample size for which secondary analyses on objective sleep were conducted. While understandable that many individuals would not want to engage in a sleep study, this data would have been useful in further understanding the relationship between self-perceived symptoms of insomnia and objective amounts of sleep, as well as the association of the amount of sleep received with paranoia.

Lastly, the dichotomization of paranoia as a variable was done in an attempt to mimic the diagnosis criteria within the DSM-5 ("Paranoid Personality Disorder"). However, this is a crude imitation and is not meant to imply that any of the subjects within this study who are considered to experience paranoia have been or ever will be diagnosed with paranoia. This diagnosis should be done by a trained psychiatrist based on a multitude of factors that are not all captured within this survey.

For these reasons and many others, there is much more work to be done in order to improve the scientific understanding of mental health disorders and sleep.

## Future Steps

This analysis is meant to be hypothesis generating; while there was no significance between insomnia and paranoia while adjusting for negative affectivity in either primary or secondary analyses, more information is now known about the relationship between individual insomnia symptoms and paranoia. Future work should continue to attempt to illustrate the relationship between insomnia and paranoia symptoms to try to determine the causal relationship between these variables. Additionally, more work needs to be done to understand the relationship between age and mental health disorders. Age should be considered as a potential effect modifier, as individuals are known to sleep less as they age (Watson), and many mental health symptoms tend to appear in one's youth rather than later in life (Jurewicz). It would also be useful to further analyze the relationship between gender and mental health disorders, as well as the impact made by many other demographic variables that were unmeasured in this study. Much is left to be done in order to fully understand how paranoia symptoms relate to insomnia symptoms.

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