# Investigating the separate correlations between acute and chronic stress with cognitive skills: reasoning and working memory

By Jude Anderson

Mentor/Consultant:
Suzanne Manning

Representative Teacher:

Reece Geursen

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# Abstract:

In the demanding and fast-paced environment that is college, it is easy for students/ākonga to become stressed. Cognitive skills/pukenga such as working memory/maumaharatanga and reasoning are the basic requirements for mental processes such as thinking, remembering, talking, learning/akoranga, reading and listening, and therefore are crucial for performing well in assessments and examinations. This study investigated if, and at what intensities, acute and chronic stress/kohuki become detrimental to the short-term cognitive performance of college students/ākonga. Participants were all taken from Year 12 in college, and data was collected on three different weeks. During each of the testing sessions, participants were asked to identify which type of stress/es – acute and/or chronic – they were experiencing, what type was most intense, and were given a perceived stress score form to determine their stress severity in the then current week. The assessment of participants' working memory was done using a reversed digit span test, and their reasoning was assessed using a specialised grammatical reasoning test. The results of this study suggest that acute stress (whether being the only or most prominent stress experienced) has very little impact on the working memory and grammatical reasoning of college students. Comparatively, results suggest that an inverted "U" relationship/piringa is present between chronic stress and both grammatical reasoning and working memory, with performance peaking at moderate levels/taumata of chronic stress, especially for working memory. The results of this study could benefit the development of current assessment and testing methods in colleges. Future research could further investigate the relationship/piringa between chronic stress severities and cognition in college students, especially considering some inconsistency with past research and the small sample size of the study.

# Intro/Background:

Stress/kohuki is the emotional or physical tension you feel during challenging situations in life/koiora[1]. There are multiple types of stresses depending on their duration/roa. The most common of which are acute and chronic stress[1,2,3,4]. Acute stress occurs in situations where a danger or challenge occurs for a short period of time, such as a preparing for and delivering a speech, an exam, or a job interview[4]. The experience is an intense but brief "fight-or-flight response"[4], which may involve sudden and short-lived increases in heart rate, respiratory rate, and blood pressure[4,5,6,7]. On the other hand, chronic stress occurs when emotional or physical tensions persist over a long period of time[4,7]. Chronic stress could be caused by situations such as a long-term illness, job or school/kura issues[4], or significant family problems. These cause the fight or flight response to be activated frequently and for extended periods. Importantly, the longevity/type of stress which we suffer from greatly impacts its effects[7,8,9].

The relationship/piringa between stress and cognitive performance, which is also a series of complex processes, has been thoroughly studied for decades[2]. Yet, even current knowledge/mōhio of the subject is limited[3]. It is known that the relationship depends greatly on the type and severity of stress, and the individual suffering[7,8,9]. Furthermore, studies have shown an importance in investigating the impact of stress on the individual skills/pukenga which make up cognition separately[3,4,9,10,11]. Some of these many skills/pukenga include short and long-term memory, logic, reasoning, multiple types of attention, and processing speed[4,10]. Together, cognitive skills are the basic requirements for mental processes such as thinking, remembering, talking, learning/akoranga, reading and listening. This means that they are not only crucial for everyday life/koiora, but especially for school/kura and work/mahi.

When mild, acute stress is usually beneficial to cognition[4]. Our response to it – sudden increases in respiratory rate, blood pressure and heart rate – cause us to become more focused and well adapted to overcome difficult situations. On the other hand, chronic stress generally causes detrimental effects to both our physical and mental health/hauora. This is because it impacts cognition and memory differently[8], due to the prolonged stress response. However, these general outcomes are not always the case. Many studies show both beneficial and detrimental effects of stress depending on their severity[7]. As noted by McIntosh and Horowitz, "Experiencing acute stress now and then is unlikely to harm you unless it is very extreme"[4]. Additionally, many researchers believe that the relationship/piringa between stress and cognition follows an inverted-U curve[4,12,13,14] with an optimal range of stress severity where cognitive performance is at its peak, outside of which cognitive performance is detrimentally impacted. However, this model mainly describes the relationship/piringa between acute stress and cognition as a whole - when the enhancing and disruptive effects on different/rerekē cognitive abilities of acute stress are combined. This is because most studies that mention the inverted 'U' shape seem to be mainly based on research of the effects of acute stress[12,13,14], as acute stress seems to affect cognition positively - at mild levels/taumata, and negatively - when extreme. Comparatively, chronic stress only seems to have significant negative affects – which occur more as the intensity increases[14,15]. Furthermore, studies investigating the relationship/piringa between acute stress and certain cognitive skills/pukenga have found that the relationship/piringa differs from this model (therefore the model refers to general cognition)[12,13,14]. For these reasons, research suggests that acute stress can impact separate cognitive skills in many different ways, while chronic stress seems to only impair cognitive skills significantly, and in a linear fashion - as the intensity increases, cognitive skills are typically impaired.

Many studies which investigate the correlation between stress and cognition focus on long-term effects of stress (monthly to yearly) by correlating early childhood stress and trauma with adult cognition[17,18]. This is especially evident with chronic stress. Furthermore, there are limited studies that investigate short-term or long-term impacts of stress on cognition in teenagers/college students, as they usually test on adults[19,20], the elderly[21,22] or university students[23,24]. This is surprising considering the constant source of stress that exams cause students and the cognitive function necessary to perform well.

With all of this said, it is clear that there is a need for studies investigating the short-term effects of stress on the cognitive performance of college students, particularly in understanding how its severity impacts individual cognitive skills/pukenga.

For this reason, the aim of this study was to investigate if, and at what intensities, acute and chronic stress become detrimental to the short-term cognitive performance of college students – specifically reasoning and working memory. The reasoning and motivation for this study was to better understand how stress may impact schooling[*Appendix: Logbook - a]; for example, through performance in tests/whakamātautau and studying behaviours. While many previous studies focused on the *long-term* impacts of stress on cognitive performance, (such as how childhood trauma affects adult cognition[17,18]) there are a lack of reliable/haepapa studies examining how stress severity and type influences *short-term* effects on cognition, particularly in college students. As existing knowledge/mōhio and past studies indicate that the impacts of stress depend on its longevity and severity[7,8,9], this study investigated the effects of both acute and chronic stress separately. There has also been limited examination of how stress impacts various cognitive skills/pukenga differently, which is why grammatical reasoning and working memory was examined separately in this study.

# Methods:

## Participant selection:

Participants within the study were from Year 12 of college[*Appendix: Logbook - b]. All participants were given information about the project -including its aim and their role in it – and decided to take part by themselves (they were not chosen randomly).

## Testing:

To minimize the stress induced onto the participants, the tests/whakamātautau were treated less as traditional 'tests' and more like enjoyable games, as the tests weren't assessing specific knowledge/mōhio on a predetermined topic. As this meant that they shouldn't have caused substantial stress to the participants[*Appendix: Logbook - b], due to their insignificance and more enjoyable nature, it meant that the study relied on pre-experienced or unrelated stress.

All the data used further in the report is from participants who attending three sessions of testing. The sessions took part over two months (due to Covid-19 interruptions), although were originally intended to be taken three weeks in a row, with each session being one week apart[*Appendix: Logbook - b]. During each testing session, participants filled out a stress type and severity form, a grammatical reasoning test, and some working memory tests. The cognitive tests/whakamātautau were piloted before the testing to decide on the best tests/whakamātautau to use, their difficulties, and the reason test's time limit[*Appendix: Logbook - c].

## Stress Type and Severity forms:

During every testing session, the participants started by completing a form to identify which stress type/s they were experiencing. They were asked two questions:

A) *In the last year, have you experienced stress that persisted for three months or more?*

and

B) *In the last 6 months have you experienced stress that lasted more than a week but less than three months?*

If participants answered 'yes' to both statements, they identified the stress type that they experience as most severe in the following question.

C) *If you answered 'yes' to both, of A or B, which type of stress have you experienced as most severe?"*

Acute stress was defined as stress which lasts less than three but more than a week, while chronic stress was defined as stress which lasts more than three months*Appendix: Logbook - d.

From this data, it was possible to differentiate which participants experienced neither acute nor chronic stress, those that experienced predominantly acute stress (whether solely or otherwise), and those that experienced predominantly chronic stress. Those that experienced solely acute or chronic stress could also be identified.

Participants then took a test/whakamātautau called the perceived stress scale (PSS)[25], which estimated the severity of their stress by asking four simple questions about their lives in the previous 7 days (for example, "In the last 7 days, how often have you felt confident about your ability to handle your personal problems?"). Although the PSS usually asks questions about one's life/koiora in the past month, this was changed to 7 days in order to allow for scores to be able to differentiate over sessions, as they were initially intended to be only 7 days apart (but only two sessions where run like this) *Appendix: Logbook - b. Participants were able to respond to these statements from one of the following options: Never, Almost Never, Sometimes, Fairly Often, and Very Often.

In order to calculate the participants stress severity, the PSS guide[25] was used, which rated/estimated the stress severities on a scale from 0-16 (only whole numbers, with 0 being the lowest stress severity and 16 being the highest).

## Working memory testing

In order to test the participants' working memory scores, a resource called the digit span was used. During each level of this test/whakamātautau, you are required to remember a sequence of numbers. As the test progresses, the length of the sequence increases by one number at a time. Furthermore, after being told each sequence you are then asked to write it in order either normally or backwards – with the normal/forward span predominantly testing attention, while the backwards test requires working memory. For this study, an online digit span resource was used as it was most ideal and simple (link - https://tools.timodenk.com/digit-span-tes https://tools.timodenk.com/digit-span-test), though there were many similar resources to choose from[26,27]. Participants were asked to set the span onto the reversed setting and start with 3 digits (keeping the speed as 1000 milliseconds). A participant's score was the number of numbers in the sequence which they made their first error on minus one. During each session, they took the digit span three times.

## Reasoning testing

A reasoning test was specially created based on grammatical transformation. The test took a lot of inspiration from online resources, especially a 3-minute reasoning test source [28](https://link.springer.com/article/10.3758/BF03331551) where various short sentences are followed by a pair of letters – AB or BA. The sentence before the pair attempts to describe the order of the two letters. This description can come in several different/rerekē ways. For example: A precedes B, B follows A, B does not precede A, and A does not follow B, are all statements valid for the pair AB, but not for the pair BA. Throughout the test, participants must decide whether the claim is true or false for the provided pair of letters.

For this project the grammatical reasoning tests were slightly more realistic[*Appendix: Logbook - e]. For all of the grammatical reasoning tests the participants took there were two parts. At the top of both parts, there was an explanation of a situation. One of these explanations was:

"***In a paddock of livestock, there are sheep and cows.***
***Interestingly, all of the sheep are blue, and all of the cows are pink***
***Answer the following questions provided these statements hold true."***

Underneath this explanation, there were 16 different/rerekē sentences which attempt to describe this situation. These descriptions came in several different/ rerekē styles. However, they were not all correct. Participants had to read each sentence and decide whether the claim was true or false for the provided statement, and they identified their decision by putting a tick in either the true or the false box.

# Results:

This section of the report will display and discuss the results of the study. There are 4 main graphs which will be discussed, with further results, including tables, available in the appendix.

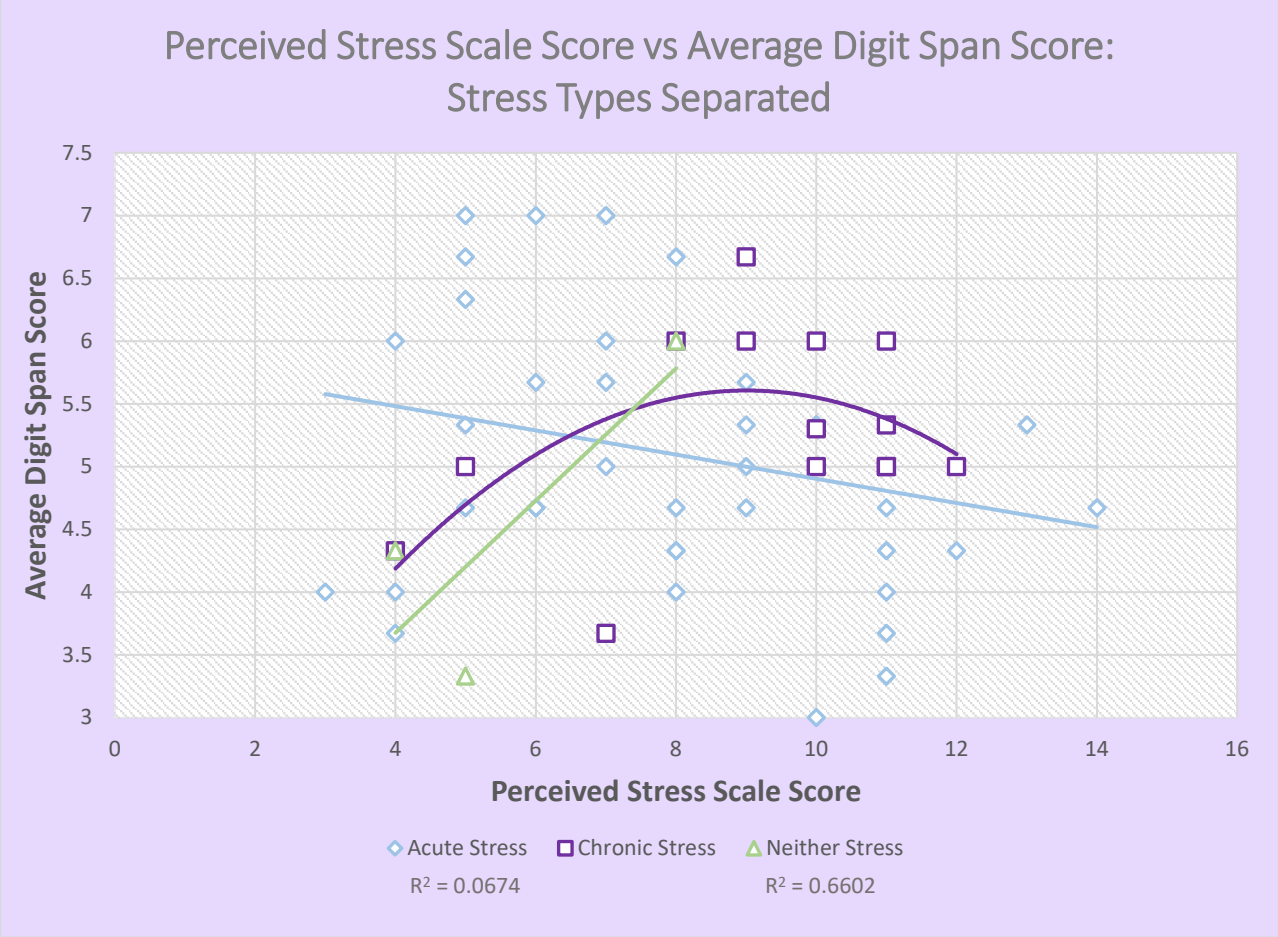


*Figure 1, This graph shows the separate relationships between college students' most severely experienced stress - acute, chronic or other (neither) - perceived stress score and their average digit span score (with each stress longevities' data and trendline differentiated by colour and shape). The data that was used to create this graph can be found in tables in the Appendix, separated by the week of testing* [*Appendix: Tables A1, A2, and A3]

For predominantly acute stress data, PSS scores ranged from 3-14, with no data for PSS levels of 0, 1, 2, 15, or 16. Most data lies within the range 5-11. As for the vertical range, digit span averages ranged from 3-7, with 3 being the lowest possible score. The relationship shown between acutely stressed participant's perceived stress score and their average digit span score is negative and linear (the linear trendline the data fits best, shown from the residual graphs *Appendix: Figure A1). This means that as acute stress increases, the average digit span score tends to decrease in a linear fashion. However, this relationship is weak, which shows that PSS levels didn't majorly influence average digit span scores.

For predominantly chronic stress data, PSS levels ranged from 4-12, although 9/14 of the participants lie between range of 9-11, with only a singular participant reporting the other PSS values within this range excluding 6. On the other hand, the vertical range (digit span averages) is from 3.67 – 6.67. The best fitting relationship shown between chronic stress severity and digit span score is quadratic and appears to be moderately strong from residual graphs*Appendix: Figure A1. More specifically, it has an upside-down U shape, which suggests that those with PSS levels within the range 7-11 perform the best in the digit span, while those outside of this range (those with higher or lower chronic stress) perform worse. The most evident outlier is a participant with a PSS score of 7 and an average digit span score of 3.67. Although this participant may stray far from what would be predicted – significantly under the trendline, the fact that the participant received and average digit span score of 3.67, only 0.67 more than the absolute minimum score possible and they also typically scored lowly in other weeks' session, with a maximum score of 4.67, this shows that there is likely other reasons (other than stress type of perceived stress scale score) that resulted in their low score. Although there does seem to be a moderately strong relationship between chronic PSS and digit span scores, there is overall not much data.

Finally, the data for 'neither stress' is very limited, with only three participants experiencing neither chronic nor acute stress during one of the sessions. For this reason, a relationship cannot be investigated due to a lack of evidence/data – a linear relationship is shown on the graph, although insufficient data is present to prove a positive linear relationship.

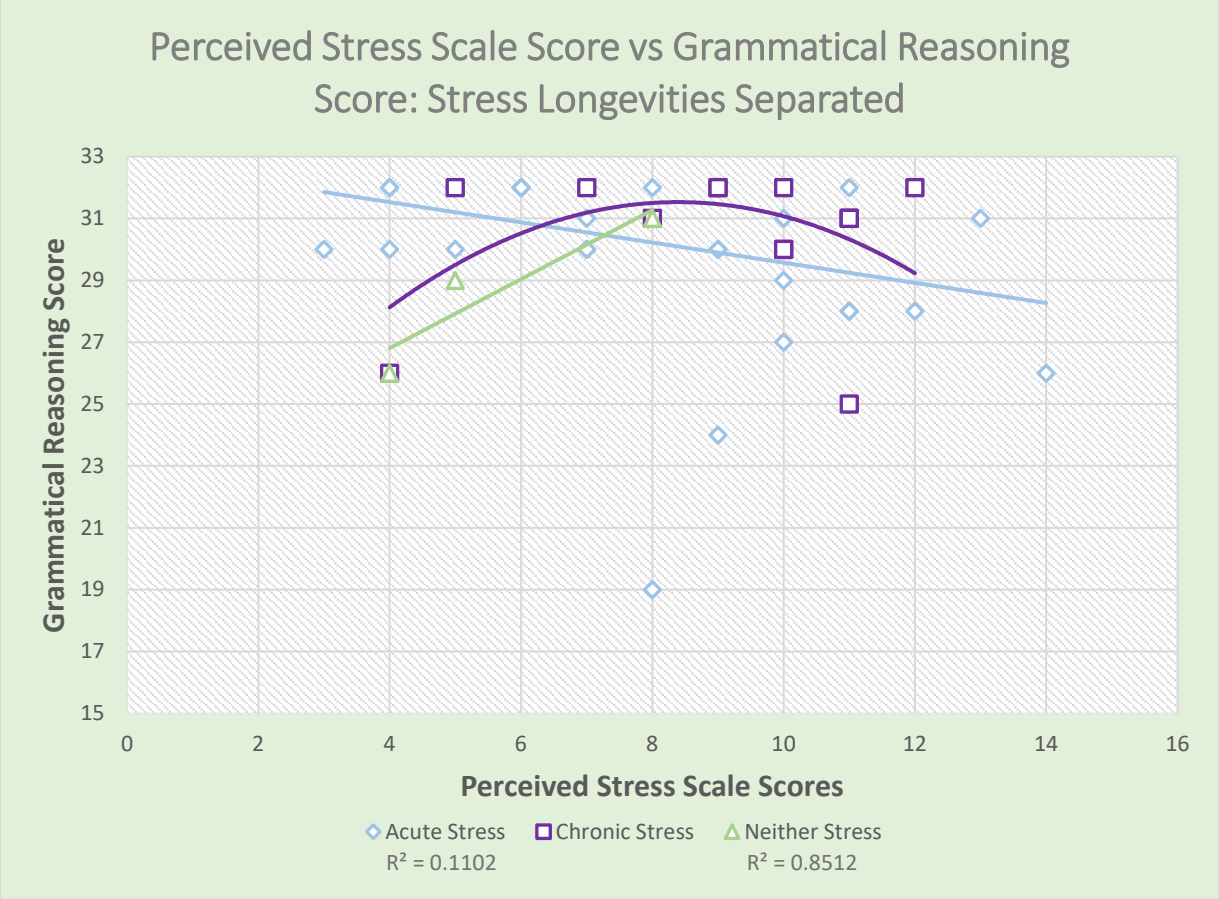


*Figure 2, This graph shows the separate relationships between college students' most severely experienced stress - acute, chronic or other (neither) - perceived stress scale score with their grammatical reasoning test score (with each stress longevities' data and trendline differentiated by colour and shape). The data that was used to create this graph can be found in tables in the Appendix, separated by the week of testing* *Appendix: Tables A1, A2, and A3

Grammatical reasoning scores ranged from 19-32, with 0 being the lowest possible score and 32 being the highest possible score. As for the average digit span scores, the relationship shown between acute perceived stress scale score and grammatical reasoning scores is weak, negative, and linear (the linear trendline the data fits best, shown from the residual graphs *Appendix: Figure A2) – meaning that as PSS Levels increases, grammatical reasoning score tends to decrease, although minimally.

For the predominantly chronic stress data, grammatical reasoning averages ranged from 25– 32. The most fitting relationship between the perceived stress scale score and grammatical reasoning scores of chronically stressed participants is quadratic and appears to be slightly weak, shown from residuals graphs *Appendix: Figure A2. Once again, it has an upside-down U shape, and suggests that those with PSS levels of 7-9 perform the best in the grammatical reasoning test, while those outside of this range (higher or lower) perform worse. There does seem to be an outlier to the trend, a participant who had a PSS of 11 with an average grammatical reasoning score of 25. With that said, this participant's score demonstrate how at extreme levels of chronic stress grammatical reasoning can be influenced.

Finally, once again, the data for neither stress is very limited, so there is insufficient data to prove what appears to be a positive linear relationship.

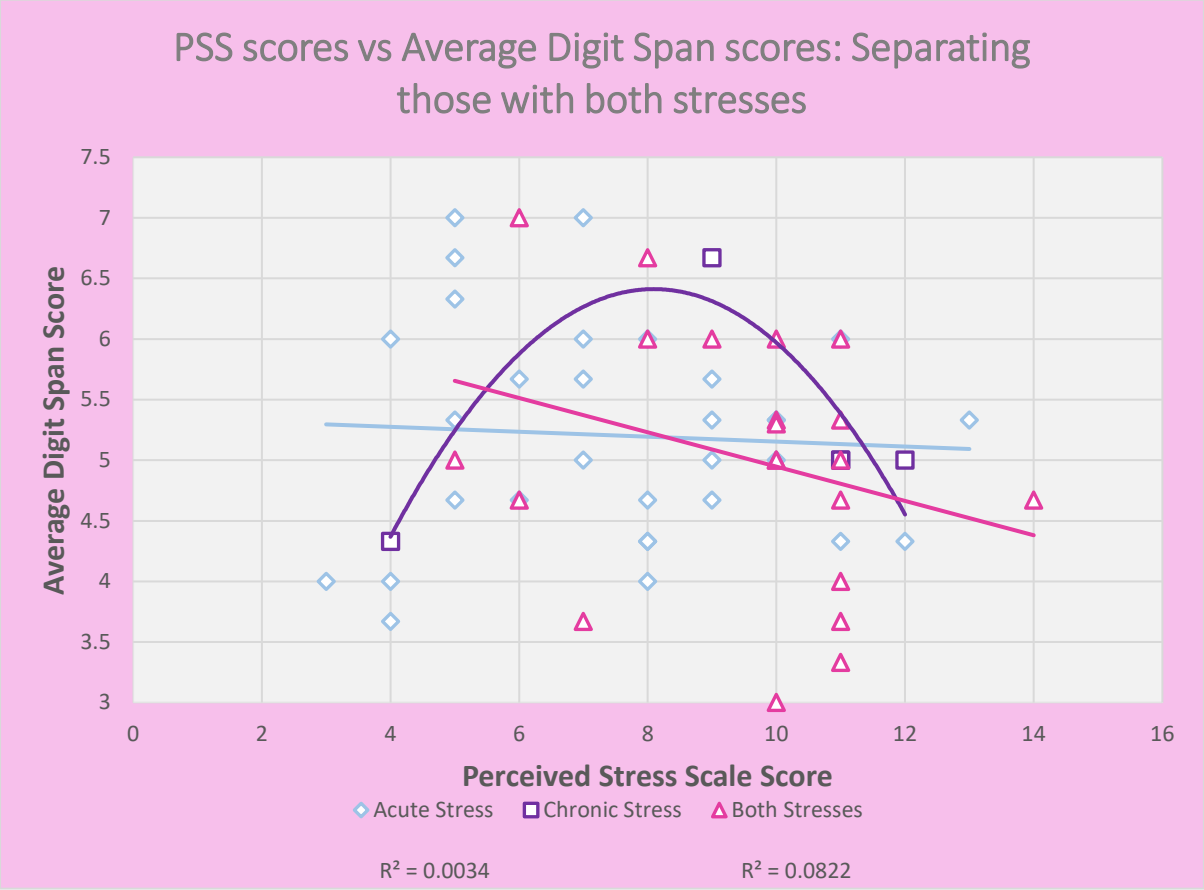


*Figure 3, This graph shows the separate relationships between the PSS scores and average digit span score of participants with solely acute stress, solely chronic stress, or both stresses. The data that was used to create this graph can be found in tables in the Appendix, separated by the week of testing* *Appendix: Tables A1, A2, and A3

For participants with solely acute stress, perceived stress scale scores range from 3 - 13, and digit span averages range from 3.67 - 7. The relationship is very weak, extremely minimally negative, and linear, which shows how the relationship between the variables is low and essentially non-existent, as perceived stress scores clearly don't affect digit span scores.

For participants with solely chronic stress, perceived stress scores range from 4 – 12 as there were only 5 participants with solely chronic stress. The relationship shown is quadratic, with an upside-down U shape and a peak at PSS scores around 7-9. Although the data sticks close to the trendline – and therefore seems strong, there is a lack of data and therefore insufficient data to prove any relationship.

Finally, for those with both stresses, perceived stress scale scores ranged from 5-14, and digit span scores ranging from 3-7. The relationship is weak, negative, and linear, which shows how the relationship between the variables is low.

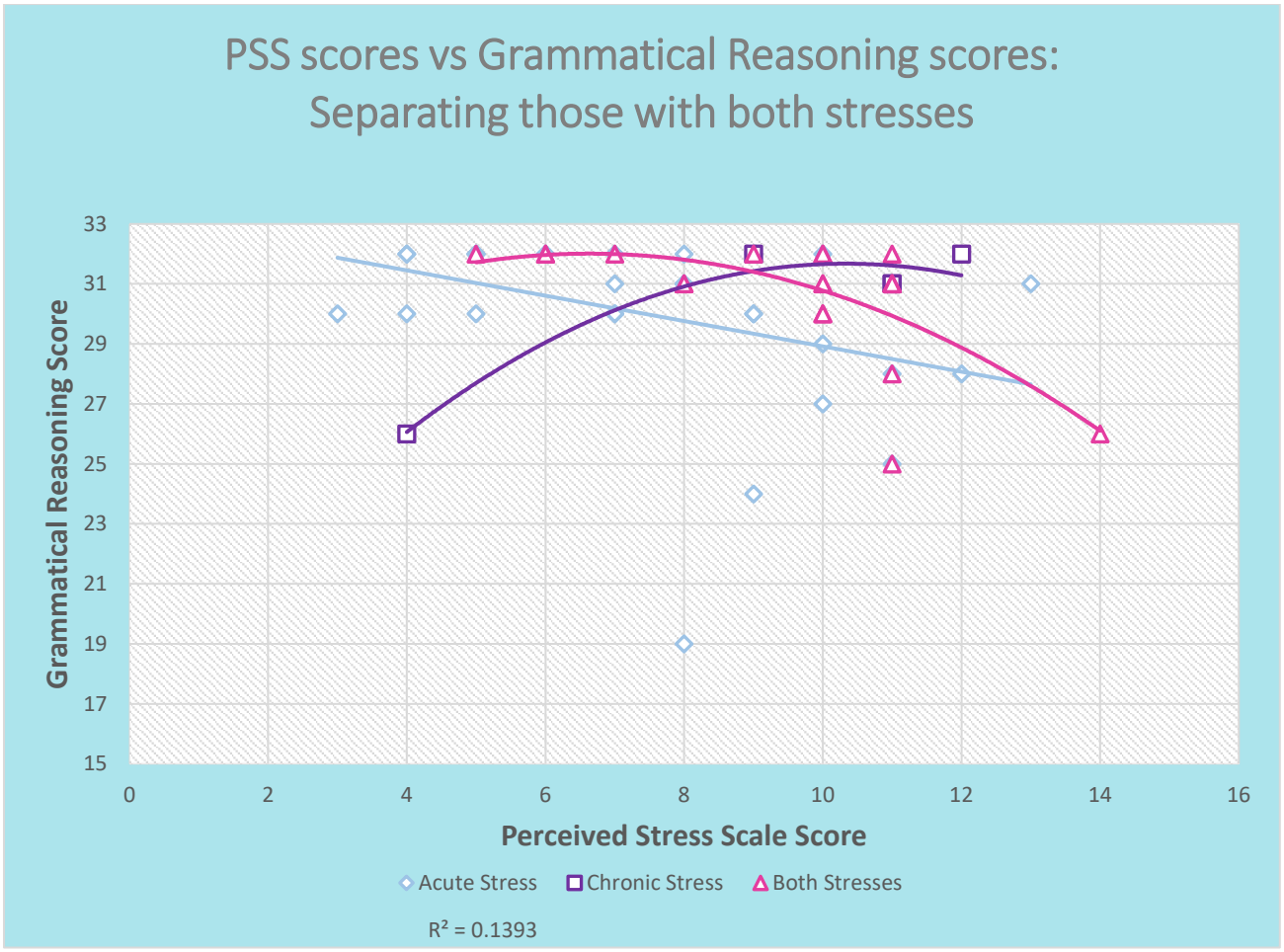


*Figure 4, This graph shows the separate relationships between the PSS scores and grammatical reasoning scores of participants with solely acute stress, solely chronic stress, or both stresses. The data that was used to create this graph can be found in tables in the Appendix, separated by the week of testing* *Appendix: Tables A1, A2, and A3

For participants with solely acute stress, grammatical scores range from 19-32. The relationship is very weak and linear, which means that the perceived stress scale scores don't seem to affect average digit span scores significantly. There are significant outliers to this trendline – especially underneath. For example, one participant had a PSS of 8 and a grammatical reasoning score of 19, roughly 10 less than predicted from the regression line. This further shows the weakness of this relationship.

For participants with solely chronic stress, grammatical reasoning scores ranged from 26 -32. Furthermore, there were only 5 participants with solely chronic stress. The relationship shown is quadratic, with an upside-down U shape, and suggests that those with PSS scores around 10-11 perform better. Unfortunately, there is a lack of data and therefore insufficient data to prove any relationship.

Finally, for those with both stresses grammatical reasoning scores ranged from 25-32. The relationship is quadratic, has an upside-down u shape, and suggest those with PSS scores around 6-8. However, this relationship doesn't appear to be very significant nor strong.

# Discussion:

The findings of this study suggest that acute stress (whether being the only or most prominent stress experienced) has very little impact on the working memory/maumaharatanga and grammatical reasoning of Year 12 college students, regardless of its severity. Likewise, moderate levels/taumata of chronic stress also do not appear to affect working memory or grammatical reasoning. However, the findings suggests that mild and extreme levels/taumata of chronic stress may impair these cognitive skills/pukenga – particularly that of working memory.

From current theory, extreme levels of acute stress are thought to harm our performance in cognitive tasks which are related to long-term declarative memory[8], with less importance on tasks requiring other skills like working memory. Furthermore, although mild stress has also been shown to be important/rahi for long term implicit memory, it is less significant for non-hippocampal dependent cognitive skills, such as working memory[8,14,29]. For this reason, the results of the study surrounding acute stress severity and working memory seem to make sense and are consistent with other recent studies. Considering that reasoning is thought to be predominantly dependent on the frontal lobe, which includes prefrontal cortex but not the hippocampus[30,31], the insignificance of acute stress severity on grammatical reasoning found also seems to be justified.

On the other hand, years of research have shown that chronic stress can have a more significant impact on cognition and produce long-term physical changes to the brain/wairoro, such as a loss of spines within the prefrontal cortex[32]. Evidence has also shown that chronic stress likely has the same impact on teenagers/adolescents[16]. Although even mild acute uncontrollable stress has been shown to affect pre-frontal cortex dependent cognition as well, these changes are rapid and short-term[32], which makes sense with our findings considering acute stress had to last at least a week. For this reason, it would be expected/hypothesized for chronic stress to be more influential for both cognitive skills, particularly in such a way that an increase in chronic stress would relate to a worsened working memory and reasoning – as it would likely cause increased changes to the prefrontal cortex, and past studies have shown this[16]. This theory was not supported by the findings.

One cause for the unexpected findings may be the pandemic. Due to the nature of the questions participants were asked surrounding their stress, it was assumed that the severity of stress they had been experiencing the week of testing would reflect the overall severity of that stressor throughout its duration/roa. Considering that chronic stress is typically caused due to matters such as family, school/kura, or health/hauora issues, which are more persistent stressors that typically induce relatively constant levels of stress, this may have been a justified assumption in previous years. However, the Covid-19 pandemic, which has rightfully caused distress throughout the whole world, is an example of a chronic stressor that in New Zealand has remained much less constant. Although New Zealand was able to avoid the extreme Covid-19 breakouts and lockdowns most of the rest of the world experienced during the first year of the pandemic, its effects were prominent during the study's testing period, causing testing dates to be changed for example[*Appendix: Logbook - b]. For this reason, although some students may have been experiencing relatively low levels of chronic stress throughout the pandemic prior to this study, that may have increased to moderate levels of chronic stress concurrent with the increasing prominence/danger of Covid in New Zealand when testing occurred. This variability might have invalidated our assumption that participants' current stress was reflective of the preceding months may be why the findings didn't fit with past research.

Another potential cause for these findings is attention. Research suggests that those with chronic stress have impaired attention control[33]. For this reason, it would make sense for those even with milder chronic stress to score lower than a non-stressed person on the two tests – considering that

they both required quite a lot of attention. In addition, those with mild chronic may also be less engaged in cognitive tasks, as they feel less pressured throughout their day. Likewise, someone experiencing extremely high levels of chronic stress may also have impaired attention control, as their stressor is likely very serious and too overwhelming to concentrate on other tasks. However, those with moderate levels of chronic stress may actually be stimulated adequately to be able to engage in and perform decently in other cognitive tasks without becoming overwhelmed, at least during teenage years. With this said, once again past research does not seem to support these findings and this is simply a theory.

Finally, these findings could have been caused solely due to differences in cognitive ability between individuals - if the severity of chronic stress participants were experiencing didn't change and those that had moderate levels of chronic stress just happened to have better reasoning and working memory. However, this is unlikely as very few participants had the same chronic stress severity in all weeks.

It is also important to note that the relationship/piringa between chronic stress severities and grammatical reasoning, although similar to the relationship/piringa between chronic stress severities and working memory, was not as strong. It appears that the grammatical reasoning test that was made for this study may have been too easy, with most participants scoring above 25, no matter their stress severity. Weekly graphs confirm there was not a significant difference in the difficulty of the various tests. Thus, the findings for acute stress severities and grammatical reasoning may be inaccurate.

Thankfully, due to the fact that the same digit span was used for all of the sessions, there couldn't have been certain weeks where the digit span was easier. Furthermore, there was a great range of scores, so it wasn't too easy or too difficult and allowed for a relationship/piringa to be shown. Participants also didn't appear to get better as the weeks went on, as there were participants who still got low scores in the later weeks, which suggests that they didn't get used to the test or only very minimally. Overall, this suggests that the results from the digit span are reliable/haepapa. The only aspect of the digit span results to note is that they varied significantly even throughout a single PSS level. However, this does not necessarily mean that it was inaccurate, because of the likely difference between individual participant's cognitive functioning mentioned prior.

There were some participants that reported that they experienced neither acute nor chronic stress, however, they still participated in the cognitive ability tests and took the PSS forms. Interestingly, all the participants who reported neither stress, still had a perceived stress score of more than 0. One participant in particular even had a PSS of 8. Although there are not enough participants within this group to makes a detailed analysis, this group does show how different/rerekē individuals perceive or deal with stress differently – as although their lives may be considered quite stressful, they either do not perceive it as stressful and/or are able to deal with the problems to eliminate stress. This concept is important to note when considering all of the results in this investigation and could explain the differences between the results of this study and those of previous studies who used other methods of evaluating stress intensity.

# Conclusion:

In conclusion, in this study acute stress/kohuki does not appear to impact reasoning nor working memory of college students/ākonga at any severity/taumata. Comparatively, chronic stress/kohuki seems to become detrimental to reasoning and especially working memory when mild or extreme,

while moderate levels/taumata of chronic stress seem do not appear to affect either of these cognitive abilities.

The results of this study surrounding the insignificance of acute stress on the cognitive skills of reasoning and working memory, could prove useful for developing testing and assessment methods in the future. For example, NCEA, which refer to the national qualifications for senior secondary school students/ākonga, have two different/rerekē kind of assessment standards, internals and externals (https://www.nzqa.govt.nz/assets/About-us/Publications/Brochures/NCEA-factsheet-4-July-FINAL.pdf). Internals are typically reports, investigations or speeches, and can occur at any time throughout the year. Comparatively, with the exception of certain subjects, externals are examinations held towards the end of the year, where students answer questions based on their learning/akoranga throughout the year. As external examinations only take part at the end of the year, and therefore likely only produce acute stress, the study could suggest that the working memory and reasoning of students may be less affected during external examinations.

On the other hand, the findings surrounding chronic stress severities suggest that internal examinations, due to the constant source of assessments likely causing chronic stress, may be less preferred, as the chronic stress severities appeared to be more impactful than acute stress severities. Perhaps in the future, to allow for stress intensity to be less of a determining factor to assessment performance, assessments could become more organized – similar to how external assessments currently only occur at one set period - as to allow for stress induced to be acute instead of chronic. The fact that chronic stress seemed to be able to impair the reasoning and working memory at certain stress severities could also show how important/rahi it is for proper counselling to be available in schools/kura, so that stress does not become prolonged and potentially impact the cognitive performance of students.

With that said, although chronic stress did seem to impact the reasoning and working memory of the students, it was not in the manner that would be expected from past research and theory. A potential reasoning for this may have been due to the nature of the questions asked, as it was assumed that the stress severity experienced during the weeks of testing would be similar to the overall stress intensity of the stressor, which although may have been a justified assumption for acute stress (as it is shorter term) and for chronic stress in previous years, the varied danger of the covid-19 pandemic may have caused variability in chronic stress severities and therefore impacted results.

For future studies, in order to make an accurate conclusion on how the ***overall*** severity of chronic stress/long-term stressors impacts the cognition of college students, instead of how weekly stress severity caused by long-term stressors impacts the cognition of college students, it would be advised that students suffering from chronic stress complete PSS forms throughout a longer period of their chronic stress to find an estimate of the stressor's severity and then complete cognitive tests at the end of the period, or for the participants to self-evaluate the overall intensity of their chronic stress throughout its entire duration/roa instead of taking a PSS to assess their stress intensity of that week.

Furthermore, the study utilised a perceived stress score form to measure stress severities instead of other measures such as cortisol. Future studies could utilize other methods of measuring stress intensity such as cortisol measurements, as even this study seemed to show that different individuals perceive stress differently. Future studies would also be advised to use a different grammatical reasoning test or increase the difficulty of the questions, as the tests appeared to be too easy, and this may have impacted the accuracy of the findings. Finally, an increased sample size

– especially for those with chronic stress – would be preferred, as the strange findings may have been due to the small sample size of chronically stressed students/ākonga.

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# Appendix:

**Important log-book pages (with evidence or reasoning of decisions made):**

a) Page 2
b) Pages 16-18 and 30
c) Pages 28-29
d) Pages 7 and 12
e) Page 24

**Table A1 - Week 1 Data**

| **Participant Number:** | Primary stress type (Primary or Solely) | Perceived stress score | Grammatical Reasoning score | Digit Span Average |
|---|---|---|---|---|
| 1 | Acute (Solely) | 5 | 32 | 6.33 |
| 2 | Acute (Solely) | 5 | 32 | 4.67 |
| 3 | Acute (Solely) | 3 | 30 | 4 |
| 4 | Acute (Solely) | 4 | 32 | 4 |
| 5 | Acute (Predominantly) | 14 | 26 | 4.67 |
| 6 | Acute (Solely) | 8 | 31 | 4.67 |
| 7 | Acute (Solely) | 7 | 30 | 5 |
| 8 | Acute (Predominantly) | 10 | 31 | 3 |
| 9 | Acute (Predominantly) | 6 | 32 | 4.67 |
| 10 | Acute (Solely) | 8 | 31 | 4.33 |
| 11 | Acute (Solely) | 8 | 19 | 4.33 |
| 12 | Acute (Predominantly) | 11 | 32 | 5 |
| 13 | Acute (Solely) | 11 | 25 | 6 |
| 14 | Chronic (Predominantly) | 11 | 25 | 5.33 |
| 15 | Chronic (Predominantly) | 5 | 32 | 5 |
| 16 | Chronic (Solely) | 12 | 32 | 5 |
| 17 | Chronic (Predominantly) | 11 | 31 | 6 |
| 18 | Chronic (Solely) | 11 | 31 | 5 |
| 19 | Neither | 8 | 31 | 6 |
| 20 | Neither | 5 | 29 | 3.33 |

**Table A2 - Week 2 Data:**

| **Participant Number:** | Primary stress type (Predominantly or Solely) | Perceived stress score | Grammatical Reasoning score | Digit Span Average |
|---|---|---|---|---|
| 1 | Acute (Solely) | 5 | 32 | 6.67 |
| 2 | Acute (Solely) | 9 | 30 | 5.67 |
| 3 | Acute (Solely) | 5 | 30 | 5.33 |
| 4 | Chronic (Solely) | 4 | 26 | 4.33 |
| 5 | Acute (Predominantly) | 11 | 31 | 3.33 |
| 6 | Chronic (Predominantly) | 10 | 30 | 5.33 |
| 7 | Acute (Solely) | 7 | 32 | 6 |
| 8 | Acute (Predominantly) | 11 | 31 | 3.67 |
| 9 | Acute (Solely) | 4 | 32 | 6 |
| 10 | Acute (Solely) | 9 | 30 | 5 |
| 11 | Acute (Solely) | 11 | 28 | 4.33 |
| 12 | Acute (Predominantly) | 10 | 31 | 5.33 |
| 13 | Acute (Solely) | 13 | 31 | 5.33 |
| 14 | Acute (Solely) | 9 | 24 | 5.33 |
| 15 | Acute (Predominantly) | 11 | 31 | 4.67 |
| 16 | Chronic (Solely) | 11 | 31 | 5 |
| 17 | Acute (Predominantly) | 6 | 32 | 7 |
| 18 | Acute (Predominantly) | 10 | 32 | 5 |
| 19 | Acute (Solely) | 10 | 29 | 5.33 |
| 20 | Acute (Solely) | 4 | 30 | 3.67 |

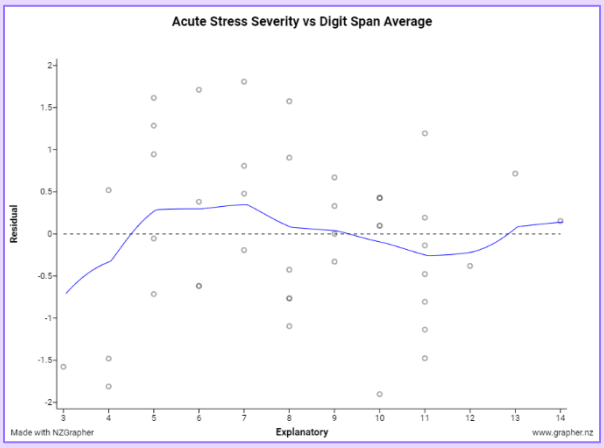
**Table A3 – Week 3 Data:**

| **Participant Number:** | Primary stress type (Predominantly or Solely) | Perceived stress score | Grammatical Reasoning score | Digit Span Average |
|---|---|---|---|---|
| 1 | Acute (Solely) | 7 | 31 | 7 |
| 2 | Acute (Solely) | 5 | 32 | 7 |
| 3 | Acute (Solely) | 7 | 30 | 5.67 |
| 4 | Neither | 4 | 26 | 4.33 |
| 5 | Chronic (Predominantly) | 7 | 32 | 3.67 |
| 6 | Chronic (Predominantly) | 9 | 32 | 6 |
| 7 | Acute (Solely) | 6 | 32 | 5.66 |
| 8 | Acute (Predominantly) | 11 | 28 | 4 |
| 9 | Acute (Solely) | 8 | 32 | 6 |
| 10 | Acute (Solely) | 8 | 31 | 4 |
| 11 | Acute (Solely) | 10 | 32 | 5 |
| 12 | Acute (Predominantly) | 8 | 31 | 6.67 |
| 13 | Acute (Solely) | 12 | 28 | 4.33 |
| 14 | Chronic (Predominantly) | 10 | 30 | 6 |
| 15 | Chronic | 10 | 32 | 5 |

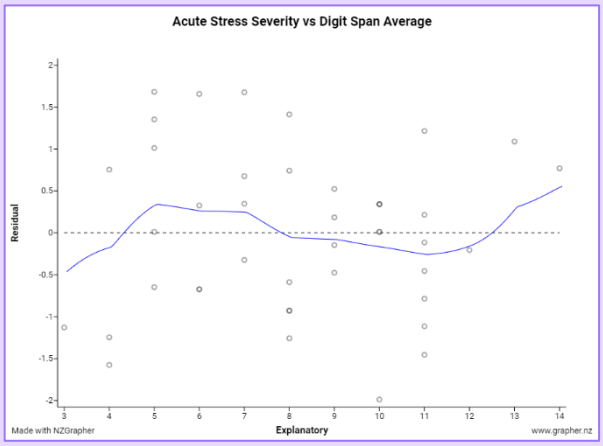
| | | | | |
|---|---|---|---|---|
| | (Predominantly) | | | |
| 16 | Chronic (Solely) | 9 | 32 | 6.67 |
| 17 | Chronic (Predominantly) | 8 | 31 | 6 |
| 18 | Acute (Solely) | 10 | 27 | 5.33 |
| 19 | Acute (Solely) | 9 | 32 | 4.67 |
| 20 | Acute (Solely) | 6 | 32 | 4.67 |

**Figure A1:**

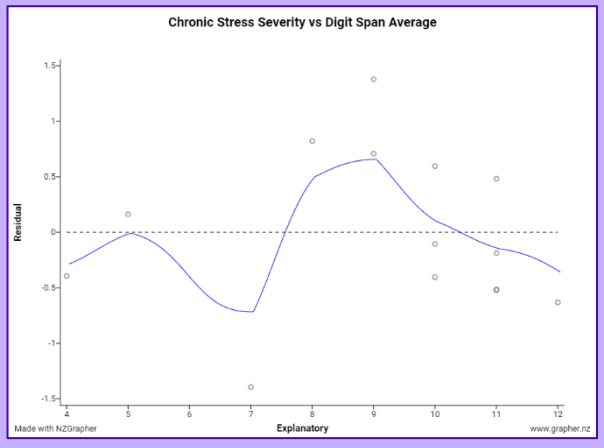
**Linear Residuals of Graph 1 – Acute Stress vs Digit Span**




**Quadratic Residuals of Graph 1 – Acute Stress vs Digit Span**




**Linear Residuals of Graph 1 – Chronic Stress vs Digit Span**




**Quadratic Residuals of Graph 1 – Chronic Stress vs Digit Span**

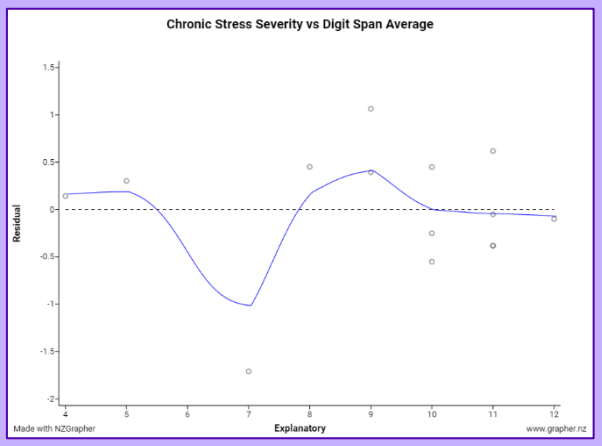
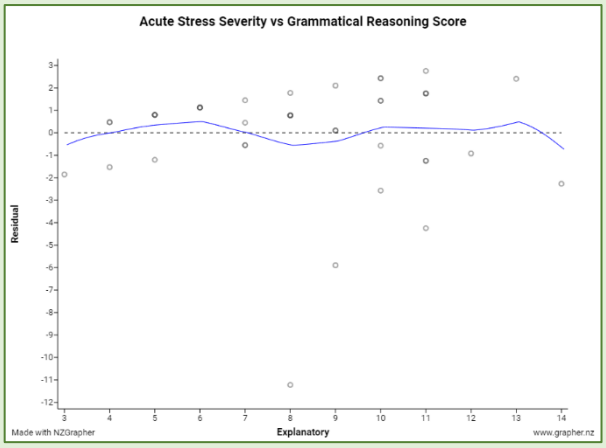
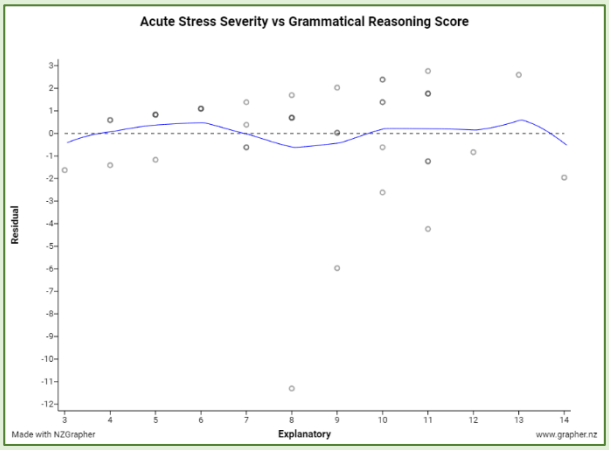


Figure A2:

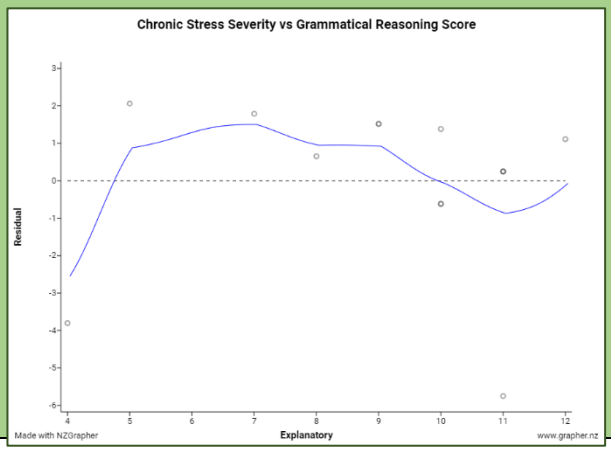
**Linear residuals of Graph 2 – Acute Stress vs Grammatical Reasoning**



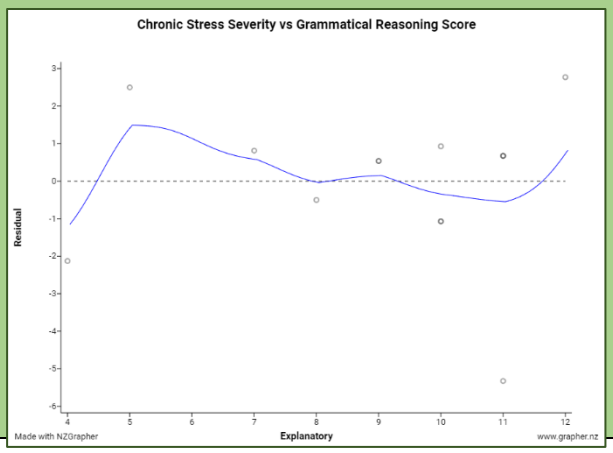

**Quadratic residuals of Graph 2 – Acute Stress vs Grammatical Reasoning**




**Linear residuals of Graph 2 – Chronic Stress vs Grammatical Reasoning**




**Quadratic residuals of Graph 2 – Chronic Stress vs Grammatical Reasoning**



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|---|---|
| | |