The Impact of ADHD on Narrative Discourse in Young Adults in University

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Abstract

Despite the extensive research done on narrative production in children and older adults with ADHD, there is little research done that focuses on young adults with ADHD, specifically those attending university. The literature on narrative production discusses problems with organisation, planning and monitoring, resulting in ADHD individuals' narratives lacking organisation, linearity, and fluidity. Studies on the brain have connected this possible deficit in narrative production to the frontal regions of the brain and executive function deficits which is commonly linked to those with ADHD. The methodology used to elicit narratives has been reproduced from other studies that focused on children, older adults and Brazilian-Portuguese speaking adults. It required participants to read from a word-less picture book. Transcribed narratives were processed using a Speech Graph Software that produced graphs and data to represent the organisation and linearity of the narratives. The data produced by the ADHD participants mirrored the results of other studies, but were less severe, suggesting that ADHD still does impact narrative discourse in young adults in university but perhaps to a lesser extent than more severe cases of ADHD. Results for control participants were not expected, with control participants creating disorganised narratives that lacked linearity. However, the data indicated that despite still lacking linearity and organisation, the control participants produced more organised narratives than the ADHD participants. While this study has helped to provide evidence that narrative production deficits are present in young adults with ADHD who attend university, it also has led to the possible theory that the brain maturation of the frontal lobes impacts neurotypical young adults' narrative production, causing them to create narratives that are disorganised despite not having any other language problems.

Keywords ADHD, brain maturation, deficits, disfluencies, executive function, frontal lobes, language, linearity, narrative discourse, narrative production, temporal lobe, young adults

1. Introduction:

Attention-Deficit-Hyperactivity-Disorder (ADHD) is a common neurodevelopment disorder that develops from childhood (Furman 2005). While there are many behavioural and neurological symptoms associated with this disorder, language is another aspect of development that is impacted from childhood. During studies, it has been found that children with ADHD struggle with sentence imitation, word articulation, speaking quotient and more inappropriate pragmatic behaviours than their undiagnosed peers, as well as problems with organising and monitoring their story retelling skills (Kim and Kaiser 2000). It has also been found that children with ADHD have difficulties in constructing coherent, goal-based narratives due to deficiencies in skills such as the planning of key events in stories, working memory and the ability to create connections between events (Freer et al 2011). This information has allowed more intervention into supporting children in schools who have ADHD, with many of them able to be identified as having the disorder early on so that they can be prescribed the necessary medication to facilitate their time in education. This allows those children to be successful in their academics without being heavily impacted by their ADHD symptoms (Daley and Birchwood 2010).

While this topic has been studied extensively in children with ADHD, the area of research is limited when it comes to adults with ADHD. Not enough research has been done to determine whether the problems presented in childhood persist through an individual's life. Is it only during the developmental stage of learning language that individuals with ADHD struggle to match their peers?

There have been a few studies that have begun to address this question. Studies that employ a narrative task using the book "Frog, where are you?" will be discussed in further detail in the

literature review and method section as I will be mirroring the methodologies of other studies using that book to gather data on narrative linearity and organisation in my set of participants (Coelho et al 2021; Flory et al 2006; Renz et al 2003; Tannock et al 2018; Zenaro et al 2019). Despite these studies addressing narrative production in a range of age groups, there is still a gap when it comes to young adults with ADHD. The group of individuals with ADHD with the least research done are those that are currently in university education. My study will hopefully begin to breach this gap in the research to provide more data on the language of young adults with ADHD when they are constructing a narrative. The results of my data could help better the understanding of ADHD and narrative production and to also provide more research on ADHD adults' language problems.

Research surrounding the difficulties in narrative production in individuals with ADHD navigate theories of executive functioning causing deficits in organisation, planning, monitoring skills, working memory and coherence during conversation (Barkley 1997; Castellanos and Tannock 2002; Green et al 2014; Hawkins et al 2016; Ingerith and McDonald 2003; Parigger 2012; Papaeliou et al 2015; Van Lambalgen et al 2008; Willcutt et al 2005). Research from these studies suggest that the majority of narrative production and comprehension deficits in children with ADHD are associated with executive dysfunction and it is theorised that these language production problems persist into adulthood for individuals with ADHD (Engelhardt et al 2011). A study done by Troiani et al (2008) was also performed using the wordless picture book "Frog, Where Are You" which was also used in my methodology. This study was conducted on young adults with no brain abnormalities or any cognitive disorders to see which parts of the brain were involved in narrative production. The results indicated that narrative production elicits activation in the frontal and temporal lobes of the brain and that certain areas of the brain are also involved in working memory and semantic memory which are required to produce an organised narrative.

These areas of the brain that the study associated with narrative production are also associated with executive function (Levin et al 2001; Metin et al 2016). Therefore, if there are any deficits to these regions of the brain, then it may have a negative impact on the individual's ability to produce linear and organised narratives.

Therefore, to hopefully provide more research in this field and to further support research into how ADHD continues to impact young adults, even those who are able to achieve academic success, my paper will be answering the question: does ADHD have an impact on narrative discourse in young adults in university?

2. Literature Review:

Attention-Deficit/Hyperactivity-Disorder (ADHD) is a neurodevelopmental disorder commonly diagnosed in children and is characterised by inattentive, hyperactive and impulsive behaviours (Ayano et al 2023). While ADHD is primarily associated with children, more than 80% of children diagnosed with ADHD continue to have symptoms throughout their adolescence and adulthood which in turn negatively affects them throughout their academics and impairs them in their professional working life, their personal relationships and they are more likely to fall into substance abuse (Faraone et al 2003). Ayano et al (2023) produced a systematic review that identified articles that discussed the prevalence of ADHD in adults. Through this systematic review, it was found that the prevalence of persistent adult ADHD from childhood was 2.58% globally, while that of a symptomatic adult ADHD (ADHD that was diagnosed in adulthood) was 6.76% in 2020.

It has been found in studies that ADHD impacts children's ability to succeed in their academics. Many children with ADHD are reported to achieve lower grades than their peers, struggle with homework completion and university application submission as well as struggling with the social aspect of education such as group projects (Arnold et al 2020). ADHD doesn't only affect children's education, as it also impacts young adults in university education. Research has shown that university students with ADHD struggle with completing tests on time, they require more time to complete assignments and they are more likely to withdraw from classes and have poor study habits (Prevatt and Young 2014). Despite these academic struggles however, many students with ADHD still enrol in university and achieve places in a range of universities across the UK. Hence, my study will be focusing on university students with ADHD to identify whether their ability to construct narratives is similar to peers without ADHD who have achieved similar places in university.

Studies on children with ADHD, have returned the results that they struggle with a wide range of language problems. These language difficulties include deficits in structural components of communication such as syntax and phonology as well as pragmatic communication problems that impact their ability to converse with peers and adults (Hawkins et al 2016; Kim and Kaiser 2000). Language production is another aspect of language that researchers have suggested is impacted by ADHD as it affects an individual's ability to produce coherent narratives but also impacts the fluidity of their conversational speech. Studies that have taken conversational samples of ADHD children and have analysed them for number of interruptions, grammatical mistakes, disfluencies, and repetitions have found that children with ADHD produce longer disfluencies, interrupt often and produce more repetitive speech (Engelhardt et al 2011).

In one study by Purvis and Tannock (1997), they performed three separate tasks on children with ADHD to measure language ability. The first task was a story retelling task that required a

child to listen and comprehend the folk tale "The Father, His Son and Their Donkey". Children were tested on the total amount recalled of the narrative and the adequacy of the child's organisation of the narrative. The second task was a standardised word test that tested the children on their expressive vocabulary as well as testing them on synonyms, antonyms and their ability to provide multiple definitions for a single word. The final test done by Purvis and Tannock (1997) involved the standardised Language Processing Test (LPT, Richard & Hanner, 1985) which measures the semantic aspects of language. These aspects include the ability to analyse, organise and associate linguistic units. It was found through these three studies that children with ADHD had difficulties in organising and monitoring their verbal productions, exhibited a higher frequency of sequence errors and produced more ambiguous references during the organisation of sentences and overall produced a disunity to their discourse.

Studies have also shown that individuals with ADHD also struggle to provide goal orientated narratives, have difficulties in story coherence due to a higher volume of errors than non-ADHD peers as well as struggling with overall story comprehension (Renz K., Lorch E.P. and Milich, R. et al 2003; Purvis and Tannock 1997). It has been found in studies that children with ADHD recall significantly less story units than neurotypical children when presented with a narrative task (Papaeliou et al 2015). These initial studies are important pieces of literature as they create a foundation of knowledge on language difficulties, providing us a base line to understand the complexities of language for individuals with ADHD.

Story comprehension is important for not only the understanding of a narrative but also the construction of one. The understanding of the necessity for goal based narratives, and the ability to casually relate elements of stories together are capacities that develop in children as they age. However, those with ADHD struggle with this sort of comprehension (Lorch et al 1998). Lorch et al (2006) found that when children were presented with a cognitive engagement and story

comprehension task that involved watching television, it was found that the children with ADHD showed lower comprehension rates than the control group who were matched on age. This highlights not only the problem of concentration on the task with children with ADHD, but also how this impacts the overall comprehension of the story.

However, many of these studies haven't separated the comorbidity of ADHD with specific language impairments (SLI). Comorbidity refers to when there is the presence of more than one distinct condition in an individual (Valderas et al 2009). This lack of separation results in studies that haven't focused on the possibility of other language impairments impacting individuals with ADHD (Cohen et al 2000). Therefore, it is crucial that any further studies take this into consideration and ensure that their participants have solely been diagnosed with ADHD and no other disorder or impairment which may impact their language abilities.

In more recent studies, researchers have also discussed the possibility that difficulties in language may be a result of a deficiency in executive functioning in children with ADHD. Executive dysfunction directly impacts the working memory and response inhibitions of those with ADHD, resulting in pragmatic problems linked to planning, organising and monitoring (Barkley 1997; Castellanos and Tannock 2002; Parigger 2012; Van Lambalgen et al 2008; Willcutt et al 2005). Executive functioning has been shown to impact components of working memory and the manipulation of information during complex tasks (Papaeliou et al 2015) as well as effective pragmatic communications (Hawkins et al 2016). Therefore, executive function is vital in the ability to hold a coherent and well-planned conversation in which the individual doesn't forget the content of the conversation, has appropriate turn taking and limits excessive talking (Green et al 2014; Ingerith and McDonald 2003).

A study was done by Toiani et al (2008) that investigated which specific regions of the brain were associated with narrative production. A fMRI study was performed using young adults with no known brain injuries, abnormalities or any cognitive disorder that might impact the brain activity. Participants were presented with the book "Frog, Where Are You?" in blocks that showed up for a set period of time on a screen and participants were instructed to start and stop speaking by green or red lights. Participants wore MRI-compatible headphones throughout the study and their narratives were transcribed and coded by the researchers. The study found that narrative production elicits activation in the inferior frontal cortex, dorsal inferior frontal, and lateral temporal–parietal regions of the left hemisphere. While this study was done on young adults without ADHD, it's important to note that the frontal lobes and frontal cortex are strongly associated with executive function (Levin et al 2001; Metin et al 2016). Therefore, if an individual suffers from executive dysfunction, it suggests they have a deficit in their frontal lobes (Levin et al 2001). This study, along with previous research mentioned above about executive function, supports the theory that if an individual has an executive function deficit, then they are less likely to be able to produce an organised and linear narrative.

These problems aren't only limited to children. While there is a heavy focus on the research of children with ADHD and how the disorder affects their language, there is a narrower focus on the impact of ADHD on an adult's language, despite the disorder still being heavily prevalent in adults. While ADHD is mostly spoken of in the context of children, there is an estimated prevalence of 4.4% of adults having clinically significant symptoms of ADHD in the United States (Kessler et al 2006). This statistic allows the field to move toward performing research experiments on adults with ADHD instead of solely focusing on children. Language issues are also not exclusive to developing children, with many issues still prominent in adults and adolescents which could impact adults with ADHD in university education and the workplace.

An important study that helps to breach this gap is Nigg (2009). The study aimed to determine whether poor inhibitory control affected language production in adolescents and adults with ADHD and if this affected the basic processes of sentence formation. The hypothesis was that if deficits in response inhibition affects language production, then ADHD participants would be more likely to begin speaking before having formulated a plan for grammatical continuation than the non-ADHD participants. The participants of the study were presented with two pictures and a verb, and their task was to form a sentence. Results of this study found that participants with ADHD were more likely to produce an ungrammatical sentence, suggesting that response inhibition does influence language production. The study also found that there was little difference between the performance of adolescent and adult participants with ADHD, with both age groups performing similarly on the task. This data suggests that language production problems persist into adulthood. Once more, this is a critical study in the field as it creates a greater understanding toward adults with ADHD who may struggle with language.

Another study that supports the theory that problems with language persist into adulthood with ADHD individuals is one carried out by Engelhardt et al (2011). Participants (aged 18-35) were tasked with describing networks of coloured dots that contained two branches that differed in length and complexity. Part of the study focused on the fluency of the descriptions in adults with and without ADHD. The disfluencies observed included: filled pauses, silent pauses, repetitions, and repairs. The research concluded that ADHD participants not only produce more words overall within their descriptions, which relates to the symptom of excessive talking in ADHD individuals, but also that there was a difference in disfluencies between the ADHD and non-ADHD participants. It was found that ADHD participants created more disfluencies, had

more repetitions, and pauses, leading the researchers to suggest that this increased tendency of disfluency in language shows that language production problems persist in adults with ADHD.

Since we know that adults with ADHD still display differences in their language production, it leads us onto the problems associated with narrative production in adults with ADHD. The wordless picture-book "Frog, where are you?" has been used by previous researchers to study narrative in children with ADHD (Flory et al 2006; Renz et al 2003; Zenaro et al 2019), older adults with ADHD (Coelho et al 2021) and Brazilian-Portuguese speaking adults with ADHD (Tannock et al 2018). Participants are required to use the pictures to guide themselves through the narrative that follows the plot of a boy searching for his pet frog. Using a wordless picture book is useful as it elicits a narrative naturally. Due to the flow of the book it is possible to analyse the structure regarding narrative discourse and each event occurs only once which creates the possibility of linearity (Tannock et al 2018).

When the experiment was performed on children, it was found that ADHD participants had deficits in producing a goal-based narrative and therefore contained fewer elements. It was also found that they produced a less coherent narrative than the non-ADHD participants and ADHD children struggled with the organisation of the narrative (Flory et al 2006; Renz et al 2003; Zenaro et al 2019).

While this experiment has been carried out several times with children as the focus, there aren't many studies that focus on the language and structure of narratives in adults with ADHD. Tannock et al (2018) performed the "Frog, where are you?" narrative task on three older adults (aged 59-64) who were already struggling with memory issues. The study produced results similar to those of the children in terms of a lack of organisation in their narrative as well as deficits in a goal-based narrative, suggesting that these issues persist into old age. This study also used a

Speech Graph Analysis (SGA) software to produce graphs that depicted the linearity of the adults' narratives. It was found that the control group (matched on age but didn't have any memory or attention difficulties) produced a more sequential narrative while the ADHD participants' narrative was more convoluted and less linear. It was also found that the ADHD participants produced narratives with more repeated nodes (narrative components produced) than the non-ADHD participants. These repetitions produce a more inefficient or disorganised narrative as the book doesn't contain any repeated events. This study is important for the understanding of the long-term impact of language difficulties that exist alongside ADHD. However, as this study uses participants who already suffer from memory issues, it isn't entirely conclusive that every older adult with ADHD will have the same struggles with language as memory plays an important role in the ability to string together a cohesive narrative.

Another study was done on Brazilian Portuguese speaking adults by Coelho et al (2021), where participants had to perform the same narrative task using the picture book and results were produced using the Speech Graph Software. The results suggested that ADHD participants presented issues with a poor comprehension of the main plotline, event sequencing errors, incomplete clauses, and embellishments. It was also found that ADHD participants produced narratives with a greater number of words than the non-ADHD participants. However, they found no correlations between ADHD and repetition unlike the study done by Tannock et al (2018). While this study is important as it delves deeper into the issues with language in adults with ADHD, it doesn't focus on a specific age range or English-speaking individuals.

Due to the gaps within these two studies, and the overall lack of focus on narrative production in young adults (aged 18-25) that are in university, I have conducted a narrative task experiment that focuses on this age range. The individuals will solely be diagnosed with ADHD and no other disorders or impairments which may have an impact on their language, ensuring to

the best capabilities that ADHD is the only factor affecting the construction of a narrative. This study will help to breach the gap of knowledge on language and ADHD in adults as well as providing research on whether language problems persist into adulthood, even when an individual is able to succeed in university education.

3. Method:

3.1 Design

For this study, I used the picture book "Frog, Where Are You?" that has been used in previous studies that focus on narrative discourse (Coelho et al 2021; Flory et al 2006; Renz et al 2003; Tannock et al 2018; Zenaro et al 2019). It is a wordless book that consists of a set of pictures depicting a story of a boy losing his frog and going on a hunt for it. There are two plotlines: the primary (finding the frog) and the secondary one (information not necessary to the story's overall comprehension) (Tannock et al 2018). Participants were required to produce a narrative that follows the story depicted by the pictures.

Following the methods of previous studies, participants were given the instruction as follows: "Here is a picture book. It's about a boy and his pets, a frog and a dog. You should look at each page, and then tell me the story. I'm going to record the story you produce. You can look through the whole book as many times as you want before we start. It is not necessary to memorize the book, you'll keep it with you. You should try telling the best possible story, pretending that I don't know it." (Coelho et al 2021; Tannock et al 2018). They were then recorded using an audio recording software on ZOOM as they read the book.

3.2 Participants

Participants were between the ages of 18-25 and were currently enrolled at a London-based university. All participants were native English speakers, and all ADHD participants had a clinical diagnosis of ADHD. ADHD individuals were recruited through university Neurodivergent societies and the friend-of-a-friend method. Anyone who had other disorders that could have impacted their language and narrative capabilities - such as autism, dyslexia and any other reading or learning disability - were excluded from the study in order to avoid any conflict in comorbid disorders. A couple of participants were excluded from the study due to them having a different disorder that could have played a part in their narrative production. Participants for the control group were gathered through the friend-of-a-friend method, with individuals also having to fit within the criteria of being between 18-25, having a university education and no known disorders (ADHD, Autism, Dyslexia etc.).

4. Data Analysis Procedures:

4.1 Primary Analysis

All data was extracted from the recordings and transcribed before being placed into the Speech Graph Analysis (SGA) software used in previous studies (Coelho et al 2021; Tannock et al 2018) that follow a similar methodology. The software produces a graph that that represents every word as a node and every temporal link between words as an edge (Bertola et al 2014). Stop words were extracted from the transcripts using the SGA software. Stop words included any words that acted as a connective or article – such as ('the', 'a', 'an'). The graphs for the ADHD group and the control group have been compared and analysed to observe any differences between the two groups (see Results section). As other studies have done,

there will be a focus on five parameters that are produced by the software, which include: nodes (total number of different narrative components produced); edges (the links between narrative components); the CC (Average Clustering Coefficient); and the density and diameter of the graphs to represent the linearity of the narrative produced (Tannock et al 2018).

4.2 Additional Analysis

While listening to the participants and their recordings during transcription, I observed an increased frequency of disfluencies in speech in the ADHD participants and therefore I conducted an additional analysis that focused on the disfluencies produced between different participants. In this analysis, I also gathered data on word count as it relates to narrative efficiency.

When gathering the data, the word count was calculated using Microsoft products that count total number of words in the transcript. For the disfluencies, that was manually gathered through listening and reading through the transcripts and picking out any disfluencies. Disfluencies included: unnatural silent pauses in middle of sentences, filled pauses (e.g erm, urm etc), repetition of words, exclamations that aren't part of the narrative (oh!), repairs in sentence, and questions that aren't part of the narrative. These were tallied and have been presented in a table in the Results section.

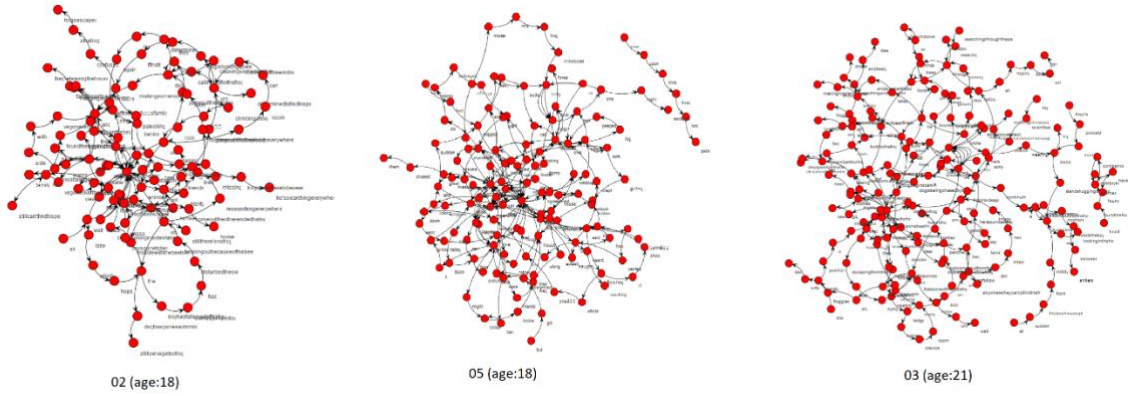
5. Results:

When interpreting the data gathered, there were several parameters that I observed in the graphs produced by the SGA software. These included: nodes (number of narrative components produced); edges (the links between the narrative components); density; diameter; CC (Average Clustering Coefficient – represents repeated nodes and is a measure for an inefficient narrative.

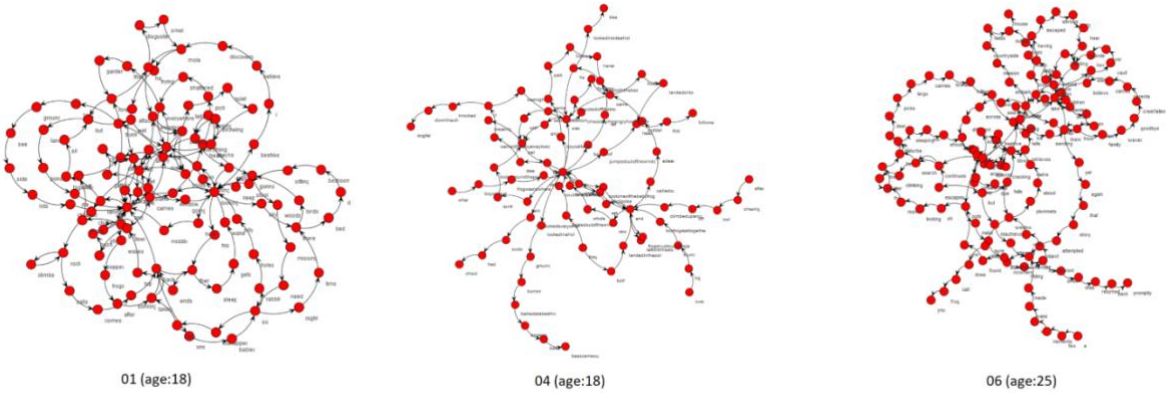
A zero value is expected as there are no repeating events in the book, a positive result indicates a disorganised narrative) (Tannock et al 2018).

5.1 Primary Analysis

The graphs produced by the SGA software are shown below to demonstrate the comparison between the two groups of participants.



(1) – ADHD participants' graphs in order of age

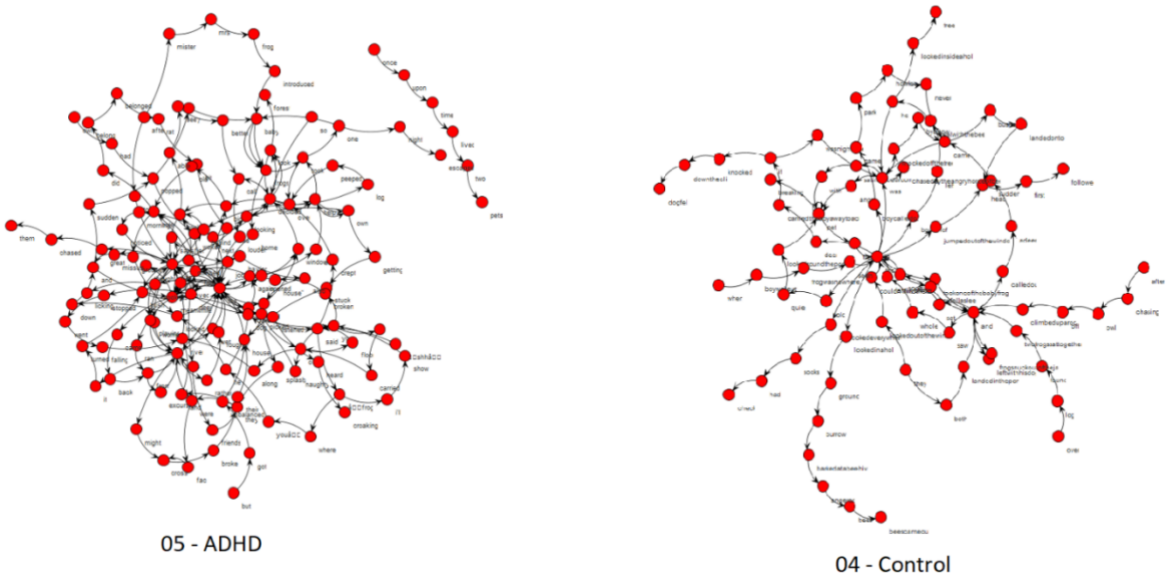


(2) – Control participants' graphs in order of age

From Figure (1) and Figure (2), we can see that there is slight variation in the visual elements of the graphs. The graphs shown in Figure (1) are much more clustered and compact and have

less linear branches than the graphs shown in Figure (2) which represent some levels of linearity in the narratives. However, the graphs in Figure (2) still have occasional clusters and are not as linear as expected. There is a slight difference in the graphs depending on the age of the participants, with the older participant in the ADHD group having slightly more distinct branches than the other participants. While in Figure (2), despite participant 04 not having as many clusters, participant 06 (the eldest of the group) has more definitive branches overall.

The figures below compare the graphs of participants 05 (ADHD) and 04 (Control) who share the same age.



05 - ADHD

04 - Control

(3) – Comparison between participant 05 and 04

In Figure (3), we can visually see the difference between the ADHD and the control participant. Participant 04's graph has more clear branches that are not obstructed by clusters of nodes, whereas 05 doesn't have any definitive branches. In participant 05's graph, there is a difference presented that is not seen in any other graph produced. At one point during the participant's narrative, they produced a sentence that doesn't link to any other node in the story.

The software has depicted this by having a branch on the side of the graph that doesn't connect to the rest of the graph, suggesting that this sentence had no connection to the rest of the narrative and is redundant in its addition to the linearity of the narrative. Interestingly, this is only seen in this participant's data.

Looking at these two graphs in terms of number of nodes and edges, participant 05 contains 140 nodes and 217 edges, while participant 04's graph contains 81 nodes and 94 edges. A higher volume of edges and nodes suggests a more inefficient narrative.

The table below presents all the graph parameter data that the SGA software produced for both groups of participants. The averages of each parameter have also been calculated and are presented in their own column. The age of participants have also been included in the table to clearly represent findings that could be linked to the ages of the individual participants.

Participant	Age	Nodes	Edges	Density	Diameter	CC (Clustering Coefficient)
02 (ADHD)	18	110	149	0.024	11	0.051
05 (ADHD)	18	140	217	0.015	9	0.050
03 (ADHD)	21	187	225	0.020	10	0.055
Average (ADHD)	**19**	**146**	**197**	**0.020**	**10**	**0.052**
01 (CONTROL)	18	111	161	0.025	10	0.039
04 (CONTROL)	18	81	94	0.029	14	0.026
06 (CONTROL)	25	134	165	0.018	17	0.020
Average (CONTROL)	**20**	**109**	**140**	**0.024**	**14**	**0.028**

(4) – Table presenting all data gathered from the graph parameters

When looking at all the data of both ADHD participants and non-ADHD participants, the data showed that, on average, ADHD participants produced 145 nodes in comparison to 108

nodes from the control group. In terms of edges, the average for the ADHD group was 197 and for the control group that number was 140. Therefore, on average, the ADHD group produced more nodes and edges in their narrative. As previously stated, a higher volume of edges and nodes contributes to less efficient narrative, therefore this data suggests that the ADHD group had less narrative efficiency than the control group.

The density of the graph reflects the linearity of the narrative and is a measure for the efficiency of the narrative (Tannock et al 2018). The greater the density of the graph, the greater the linearity and efficiency of the narrative. From the data in Figure (4) we can see that there is a variety in the densities between the two groups, with some of the controls producing a low score in the density that mirrors the results of the ADHD participants. However, all ADHD participants produced narratives with lower densities than two of the control participants.

Diameter represents the maximum amount of linear information in the narrative and is also a measure of narrative efficiency. In Figure (4), the data shows that the control participants' graphs have a greater diameter than ADHD participants, except participant 01 who had the same diameter as ADHD participants. However, the diameters produced by the control participants do not match those produced in other studies. In the study done by Tannock et al (2018) on older adults using this methodology, the two control participants had diameters of 21 and 30. Interestingly, the only participant in my study that was close to the expected result was the oldest control participant who had a diameter of 17. I will discuss implications of this further in my discussion section.

CC (Average Clustering Coefficient) represents the major repeated nodes in a narrative and due to the book not having any events that repeat, a zero value is expected to be produced. The greater the CC, the more disorganised and convoluted the narrative is (Tannock et al 2018).

From the data in Figure (4), we can see that there are no zero values produced, not even by the control subjects. This is an unexpected result as all control participants in both Tannock et al (2018)'s study and Coelho et al (2021)'s study produced a CC result that was zero. However, the ADHD participants in this study produced a greater CC than the control subjects and therefore still produced a more convoluted and disorganised narrative.

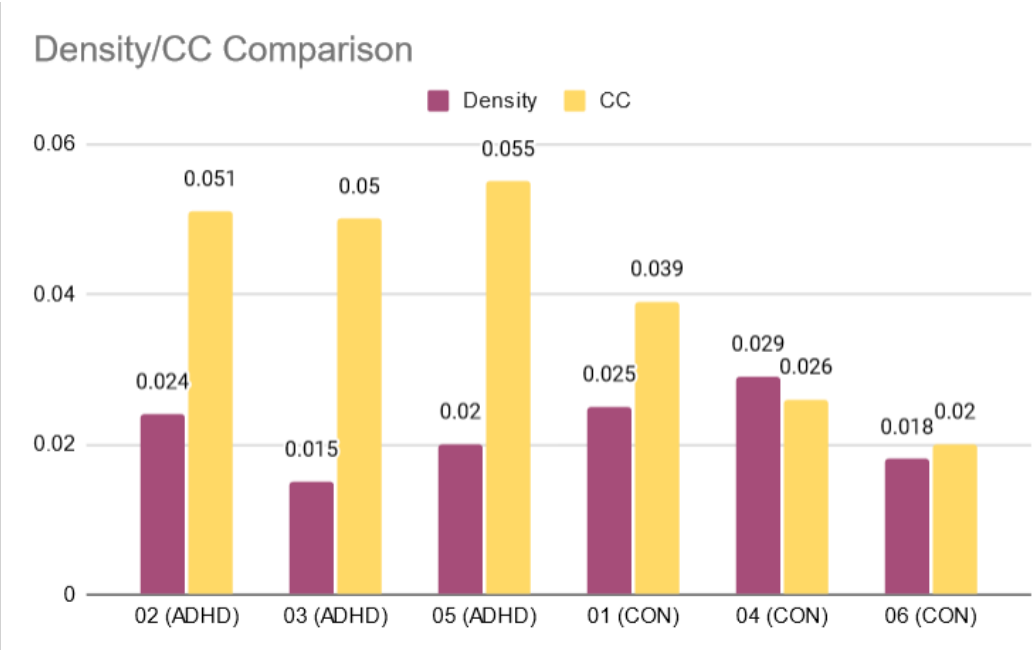
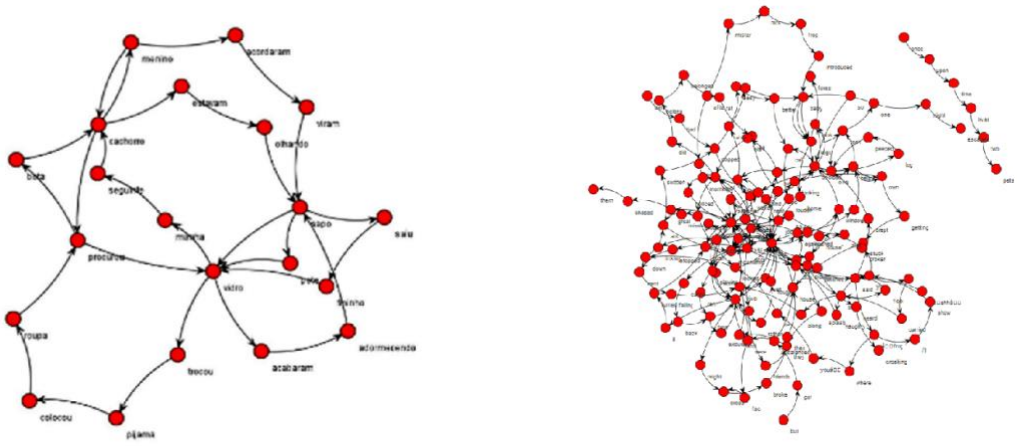


Figure (5) – Bar graph depicting the comparison between density and CC

In Figure (5), we can see the comparison between the control participants and ADHD participants in terms of the density and CC parameters produced by the software. As represented by Participants 04 and 06, control participants tend to have a similar value of both density and CC, suggesting that despite there being some disorganisation, it is not as great as the differences between the density and CC of ADHD participants. Considering that lower density and a greater CC depicts less narrative efficiency and linearity, the comparison shown on the graph demonstrates the level of disorganisation of the ADHD participants' narratives.

In comparison to other studies done on older adults (Tannock et al 2018) and Brazilian-Portuguese speaking adults between the ages of 18 and 40 (Coelho et al 2021), the results for the ADHD participants in my study roughly reflect the findings in other studies. However, the results of my control participants were not what was expected.

The figure below presents a comparison between a graph from the study done by Coelho et al (2021) and a graph from my study. Both participants have ADHD.



Coelho et al (2021)
ADHD participant

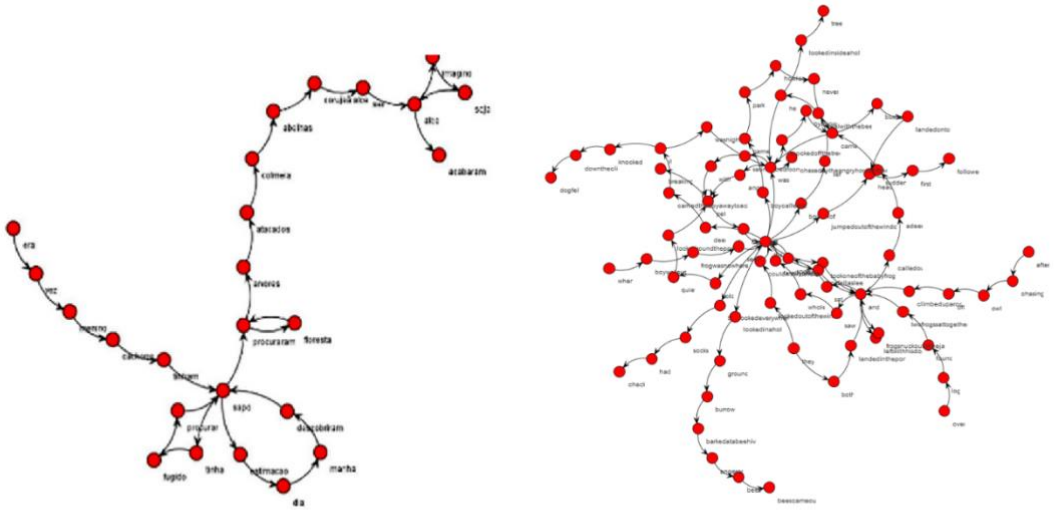
Participant 05 (ADHD)

(6) – The graph on the left was produced during the study done by Coelho et al (2021) when researching the impact of ADHD on narrative production in Brazilian-Portuguese speaking adults. This figure is comparing it to a graph produced by my own study which is on the right-hand side of the figure. Both graphs present data produced by ADHD participants in the study.

While the participant in the study by Coelho et al (2021) has produced far less nodes than participant 05, we can see that there are still some similarities between the loops produced and

that there is no definitive linearity represented in either of these graphs. However, the graph from my study contains a considerably greater volume of node clusters than the other graph.

The figure below is another example taken from Coelho et al (2021)'s study to compare between the results of participant 04. Both are control participants.



Coelho et al (2021)
Control Participant

Participant 04 (CONTROL)

(7) – The graph on the left was produced during the study done by Coelho et al (2021) when researching the impact of ADHD on narrative production in Brazilian-Portuguese speaking adults. This figure is comparing it to a graph produced by my own study which is on the right-hand side of the figure. Both graphs represent data from control participants of the study.

(7) presents the results of control participants of two studies and shows a distinct comparison between them. Participant 04's graph doesn't have any clear line of linearity that is seen from the control participant in the Coelho et al (2021) study. The graph from my study has a much greater number of nodes produced than the graph from the Coelho et al (2021) study and is visually

represented as having far more branches. These results were not expected and will be discussed further in my discussion section.

5.2 Additional Analysis

As referred to in my Methods section, I conducted an additional analysis that focused on the pragmatics of the narrative. This was conducted through calculating the disfluencies in the production of the narratives between the groups to determine whether ADHD participants struggled with deficits in language production which, in turn, affected the fluidity of the narrative. I also calculated the total word counts of each narrative as it's expected that ADHD participants will produce longer narratives than their neurotypical peers. This data is presented in the table below.

Participant	Age	Word Count	Disfluencies
02 (ADHD)	18	516	44
05 (ADHD)	18	661	2
03 (ADHD)	21	500	7
Average (ADHD)	**19**	**559**	**TOTAL: 53**
01 (CONTROL)	18	507	3
04 (CONTROL)	18	311	3
06 (CONTROL)	25	419	5
Average (CONTROL)	**20**	**412**	**TOTAL: 11**

(8) – Word Count/Disfluencies table for participants

The average word count for ADHD participants was 559 words while control participants average was 412. The higher word count as well as the lower density in the data for ADHD participants could be associated with the symptom of excessive talking which not only results in

convoluted narratives but also unnecessary embellishments to their narrative (Tannock et al 2018).

ADHD participants also have a higher total number of disfluencies (53) than the control group (11) which could also be linked to overall language production problems seen in individuals with ADHD. As stated previously in the methods section, all participants were given instructions at the start that they were allowed to read through the book as many times as they wanted before they began the task. All participants opted to go straight into the experiment without looking through the book first, bar participant 03. Interestingly, they were the only participant who pre-planned their narrative and therefore resulted in them having the lowest number of disfluencies out of all participants.

6. Discussion:

6.1 Primary data discussion

With the data gathered from my study, we can begin to answer the initial research question of whether ADHD has an impact on narrative discourse in young adults in university. From the findings, we can observe that university students with ADHD still have issues with narrative production and produce disjointed, unorganised and inefficient narratives. The results mirror those found by other studies that looked at older adults (Tannock et al 2018) and Brazilian-Portuguese speaking adults with ADHD (Coelho et al 2021), with all ADHD participants in every study producing narratives that were not efficient or linear. However, it is interesting to note that the severity differs when compared to the older adults with ADHD (Tannock et al 2018). The participants in the study done by Tannock et al (2018) had lower diameter levels (all participants' graphs returning diameters between 8-5) while the ADHD participants in my study

had diameter levels between 11-9. Similarly, the older adults with ADHD in the Tannock et al (2018) study had a greater measure of CC. One participant had a CC of 0.19 which is much greater than the participant who produced the highest CC in my study which was 0.055. While both sets of participants still produced non-linear narratives that were disorganised and inefficient, there is a considerable difference between the extent of the lack of linearity and disorganisation. It's important to note that the ADHD participants in my study are likely all high functioning as they have managed their ADHD to a good enough degree that they have been able to succeed in their academics despite their symptoms of ADHD. The results of my study could suggest that while young adults with ADHD who attend university still struggle with narrative production, they may be better at managing it than individuals with more severe cases of ADHD. To further investigate this theory, a future study could be done by conducting a comparison between ADHD sample groups to see whether there is a difference in narrative production that is dependent on the severity of an individual's symptoms.

As the participants of my study were solely diagnosed with ADHD and had no other known disorders that could impact their language production, their inefficiency could be a result of executive function deficits commonly associated with ADHD. As discussed in the literature, executive function is involved in the responsibility of working memory and response inhibitions which directly impacts individual's planning, organising and monitoring skills, therefore resulting in problems associated with organised language production (Barkley 1997; Castellanos and Tannock 2002; Parigger 2012; Van Lambalgen et al 2008; Willcutt et al 2005). Further studies should attempt to gather data on executive functioning while participants are carrying out a similar narrative task to determine if there is a concrete correlation.

While the results for the ADHD participants in my study, it was the control participants that produced unexpected results. The control participants in my study don't follow the same pattern

of other control participants in both studies done by Tannock et al (2018) and Coelho et al (2021). Despite not having any known disorders, the control participants still produced disorganised and non-linear narratives unlike the adults in the other two studies. An example of an unexpected result was in the CC parameter. As previously stated, it's expected that the CC should be zero considering that the CC parameter measures for repeated nodes and there are no repeated events in the book. However, all control participants in this study produced results between 0.02 - 0.039. While this is lower than the ADHD participants, it's still an unexpected result and demonstrates a lack of linearity in the control participants narratives.

Interestingly, the participant closest to the expected results of a control participant was participant 06 who was the eldest of the group (25) while the younger participants produced results that were more similar to the ADHD participants. Unlike the control participants, age didn't improve the ADHD participants' ability to produce an efficient and linear narrative. A possible explanation for this lack of organisation and linearity could be associated with the maturation of parts of the brain that are associated with producing, planning, and organising narratives. Neuro-linguists have researched the possible areas of the brain that are associated with narrative production and comprehension. The studies, including the one discussed previously in the literature review by Troaini et al (2008), have produced evidence that supports the idea that frontal regions of the brain, such as inferior frontal regions and dorsal frontal regions, contribute to narrative production and organisational processes including working memory (Mar 2004; Troiani et al 2008).

An investigation was done by Kaczmarek (1984) to research the prefrontal areas of the brain to determine their role in speech production. Patients all had focal lesions of frontal lobes and were matched with a control group with no abnormalities with their brain. For the study, participants were instructed to repeat a story that was told to them by an examiner and one that

they had read themselves. They also had to describe a situation presented in a single picture and in a series of pictures. The final task the participants were given was to tell the examiner something that they know a lot about and an abstract topic. Results of the study indicated that patients with frontal lesions had difficulties in the initiation of a narrative, organisation of linguistic information and difficulty in the formation of ideas. These results strongly supported the idea that the frontal lobes are necessary for narrative production. Specifically, his research has evidence that suggests that the left dorsolateral frontal lobe is involved in the sequential organisation of linguistic information and that the left orbitofrontal lobe is required for the direct development of a narrative. Research on different brain-damaged patients further support this theory, with a reviewed imaging study finding evidence that the dorsolateral regions of the frontal cortex and temporal regions including the temporoparietal junction are involved in producing and comprehending narratives (Mar 2004).

The reason this is important in the discussion of my study is due to the differing age ranges of my participants. With the youngest participant being 18 and the eldest being 25, it is possible that there is a large difference in brain maturation of these frontal lobes, resulting in differences in the results. Studies have suggested that the cognitive control that supports inhibition, working memory, planning and attention – all of which are crucial for the production of an organised and linear narrative - develops as the frontal and parietal cortices mature in young adults (Horowitz-Kraus et al 2017). Research has found that the frontal and temporal lobes reach their developmental plateau later than other regions of the brain (Tamnes et al 2010) with research suggesting that most frontal connections don't fully mature until the age of 24, with important fronto-temporal connections reaching 90% development only at or after 25 years of age (Lebel et al 2008).

With this research in mind and while also considering that narrative speech production elicits activation in several frontal and temporal regions of the brain (Troiani et al 2008), it's possible to consider that perhaps the reason for the lack of organisation and linearity in the control participants is due to their age. This could be a possible explanation for why the eldest control participant has results that most reflect the results of other control participants and why the younger the participants are, the more their results mirror the ADHD participants due to a lack of brain maturation in important regions associated with narrative production and organisation. To build evidence surrounding this possible theory for the unexpected result, a future study could possibly reproduce this methodology using groups of participants of varying ages that don't have any known language disorders or brain abnormalities and monitor brain activity to compare the results of the different ages of participants.

6.2 Additional Data

The results produced from the additional analysis were as expected. ADHD participants elicited, on average, a higher word count than the control participants. While this could be due to the excessive talking symptom of ADHD, it could also be linked to the unnecessary embellishments of narratives that other studies also reported (Coelho et al 2021). Similarly, in terms of overall disfluencies in the narratives produced, ADHD participants produced a higher total number of disfluencies. All ADHD participants produced more disfluencies than the control participants, except for one participant. However, it is important to note that participant 05, who produced the least number of disfluencies, was the only participant in the entire study to have taken the offer to read through the picture book before beginning the experiment. Therefore, they were the only participant who pre-planned their narrative before the recording started. Interestingly, while this potentially improved the fluidity of the participant's narrative, it didn't improve their ability to produce an organised and linear narrative as their graph

parameters were as expected in comparison to the other two ADHD participants. This could support the theory of the extent of executive function skills having an impact on the organisation and monitoring skills of individuals with ADHD as even when given the chance to plan their narrative beforehand, they still struggled with overall linearity and organisation.

The result of this analysis also supports the theory by Engelhardt et al (2011) that was outlined in the literature. ADHD participants in their study also produced more disfluencies in language and produced more words overall in their speech. Therefore, the data I found can act as support for the theory that language production problems persist into adulthood and isn't solely a problem that affects children and adolescents. It is also possible that these disfluencies are linked to the frontal lobe regions of the brain as executive function impairments are often associated with either frontal lobe as the prefrontal cortex is the centre of executive functions (Levin et al 2001; Metin et al 2016). A study was done by Levin et al (2001) in which they studied word fluency in individuals with closed head injuries. These injuries reduced their word fluency, reduced spontaneous speech, and caused a difficulty in discourse formulation. The study found that participants with damage to their left frontal lobes struggled more with word fluency. Levin et al (2001) proposed that the damage to the left frontal lobes could be linked to executive dysfunction and that is what is affecting the word fluency of those participants. As executive dysfunction is theorised to be associated with ADHD (Coelho et al 2021; Kofler et al 2010; Papaeliou et al 2015), this could be a possible explanation as to why ADHD individuals struggled more than the control participants with disfluencies in their speech, which resulted in a less fluid narrative.

7. Conclusion:

Overall, in both analyses, it was found that ADHD participants are impacted in their ability to produce organised and efficient narratives, resulting in narratives with unnecessary embellishments and disfluencies that were not present in the control participants. The results produced by the SGA software were expected from the ADHD participants, with their narratives being disorganised and lacking linear. The surprising result of this study was within the control group as they didn't produce the expected results in the graph parameters produced by the SGA software. All control participants produced narratives that lacked the expected organisation, resulting in less linear narratives than adults of other similar studies. However, they produced the expected results in the additional analysis as they didn't display notable deficits in fluency and weren't prone in producing overly long narratives with excessive embellishment. Therefore, this suggests that their deficits in narrative organisation could be a result of lack of brain maturation in the frontal lobes that are responsible for narrative organisation and production, rather than an overall problem with language production which could be the cause of the ADHD participants' results. Overall, the data of this study and the research discussed, suggests the possibility that all the participants' lack of linearity and organisation is down to deficits in either the maturation of frontal lobes or the executive functions associated within the frontal lobes. It's expected that as the control participants' age, their frontal lobes will mature and their narrative production will improve, while ADHD participants' narrative discourse may always be impacted by deficits in executive function.

With these results, possible implications of this study could involve ideas of diagnostic testing and action in university establishments for better support and understanding for students who struggle to construct narrative pieces. Further research would need to be conducted to see if

ADHD also impacts an individual's ability to write coherent and organised narratives to better support students in their academic writing. In terms of diagnostic testing, psychologists could use factors of word fluency, narrative production and comprehension as factors involved in diagnostic tests. The study also allows further understanding that despite there being a considerable portion of ADHD individuals who struggle with academic underachievement and experience an abundance of academic and educational problems (Daley and Birchwood 2010), there are still students who can achieve academic success.

By identifying incoherent and disorganised narratives as a common trait of ADHD individuals, the data found in this study might also support early detection in young children having ADHD if they have difficulty in producing and comprehending narratives and will therefore support the process of providing medication where necessary to prevent academic underachievement (Jangmo et al 2019). With further research, the results of my study could even support research into further understanding the neurotypical brain and the understanding of the different regions of the brain in their role of narrative production and the impact of brain maturation on narrative production.

The limitation of this study is the small sample size of participants in both groups. It was difficult to recruit ADHD participants as despite verbally agreeing to take part in the study, when given the task of completing the consent form, many ADHD participants were unable to return the form within the time frame of my data collection. While there is enough data to reach a solid conclusion, the study would benefit from a larger pool of participants as it would allow the possibility of conducting statistical analysis and there would be a wider range of ages. A broader range of ages would allow scope into determining whether there was a substantial difference between control participants' results in regard to their age.

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