Cognitive-Linguistic Difficulties in COVID-19: A Longitudinal Case Study

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Abstract: This case study examines a 44-year-old woman who contracted SARS-CoV-2 in early 2020 at the beginning of the COVID-19 pandemic in the UK. She was first examined by the author in January 2021. By that stage, it was apparent she had not made a complete recovery from her COVID infection and had gone on to develop the long COVID syndrome. Her predominant symptoms were fatigue and marked "brain fog". As well as causing considerable distress, these symptoms were preventing her from resuming her occupational role as a community nurse working in a district nursing team. On assessment by the author, significant difficulties were evident in immediate and delayed verbal recall, the informativeness of spoken discourse, and verbal fluency. The author and woman communicated regularly between January and July 2021. Although some improvement in her condition was reported during this time, it was not sufficient for her to return to work and resume other daily activities. The author assessed her again at the end of July 2021 and reported a moderate improvement in her earlier cognitive-linguistic performance. This case study examines the onset and progression of this woman's COVID illness, with particular focus on the cognitive-linguistic difficulties that remain her most persistent and troubling symptom.

Keywords: Brain fog, COVID-19, long COVID, SARS-CoV-2, speech-language pathology.

INTRODUCTION

The emergence of SARS-CoV-2 in late 2019 marked the start of a global pandemic that continues unabated to the present day. The toll in human lives has been substantial, with 4,697,099 deaths reported by the World Health Organization by 22 September 2021. Against this large and growing number of deaths is an equally staggering number of people reporting long-term health impacts of COVID-19 disease (the so-called long COVID syndrome). The presence and duration of 29 different symptoms have been studied in 508,707 people in the community in England with self-reported COVID-19 [1]. Investigators reported a weighted population prevalence of persistent symptoms lasting 12 weeks or more of 5.75% for one and 2.22% for three or more symptoms. A significant number of these long COVID sufferers report experiencing cognitive-linguistic symptoms (so-called "brain fog") that for many people have prevented a return to work and the resumption of daily activities. In October 2020, the author began to examine reports of brain fog in people who had not made a complete recovery from COVID-19 infection[1]. The detailed results of this work are reported elsewhere [2,3,4,5]. A 44-year-old woman who participated in this study was first examined by the author in January 2021. She reported significant cognitive-linguistic difficulties even as some of her other long COVID symptoms had started to improve. She was assessed for a second time six months later in July 2021. Her performance across these two points of assessment is examined in this case study, alongside an account of the onset and progression of her COVID illness.

CASE STUDY

Background

Jill (not her real name) is a 44-year-old woman who lives in northwest England in the UK. She is married and has two children, a girl aged 15 years and a boy aged 13 years. Jill qualified as a registered general nurse in 2003 and worked on acute medical wards and in rehabilitation in a hospital setting between 2003 and 2018. She is currently employed as a community nurse working in a district nursing team. This role involves her driving to patients' homes and nursing or residential facilities where she undertakes palliative care, diabetic and catheter care, and wound treatment, among other duties. Jill describes her nursing role as challenging but also highly rewarding: "I absolutely loved my job. I still had a lot more to learn within district nursing, but I loved it. I had to think quick as often I would be presented with an acute situation or a change in a patient's condition at the time of arrival". As well as enjoying her work, Jill reports that she had a healthy work-life balance.

Prior to her COVID illness, Jill reports having "brilliant" health. She is 5 feet 5 inches in height and

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before her illness weighed 145 pounds. Her BMI was 24.1 (normal weight). Since becoming unwell, her weight has increased by 4lbs due to reduced physical activity. In December 2006, Jill was diagnosed with Hashimoto's thyroiditis for which she takes medication (see *Medication*). In 2010, she underwent an appendectomy. Jill has normal hearing and wears contact lenses to correct myopic vision. She uses an EpiPen for the treatment of anaphylaxis related to wasp stings. Jill also has hay fever and is allergic to various animals and fabrics. She has an adverse reaction to Penicillin. Jill does not smoke or vape and consumes a small amount of alcohol – a couple of glasses of wine – at the weekend. She has a well-balanced vegetarian diet and takes daily multivitamins, vegan omega 3-6-9 and vitamin D. Jill has no history of anxiety, depression, or any other mental health issues.

Jill's COVID illness began on 11 March 2020. On this date, she had headaches which she described as a thick, heavy, thumping head. She had a rash on her forearms and a mild tickle in her throat that she felt she wanted to clear. She did not have a persistent cough, which was one of the symptoms of COVID-19 emphasized by the UK Government at the start of the pandemic. Jill recalled feeling very cold and tired for several days before the onset of her headaches on 11 March. Her husband became unwell around the same time, although he only experienced a tickle in his throat and shivers. On 17 March, Jill had a negative PCR test. She was certain that she would test positive given her symptoms and the fact that several of her colleagues had the same symptoms and had tested positive. Jill had a second PCR test on 29 April, and this was also negative. Jill contacted her general practitioner after her first negative PCR test. Her GP believed the result was a false negative. Jill was given a clinical diagnosis of COVID-19 and was signed off work because she still had symptoms. Jill believes she was exposed to the virus through her work. She was working with clients without the use of personal protective equipment (PPE) at the onset of her symptoms. Although PPE was available, it was only to be used with certain patients (e.g., patients who tested positive or had a cough or temperature) and only hospitalized, not community, patients were tested for the virus.

In the absence of a positive PCR test, Jill returned to work on 30 March 2020. She worked for approximately 3.5 weeks but had a significant relapse and stopped working on 29 April 2020. She has not been able to return to work since that date. Jill remained at home during the acute and chronic phases of her COVID illness. Throughout this time, she received support from her general practitioner and regular reviews from an occupational health consultant. Other professionals involved in Jill's care were neurologists, an occupational therapist, and a speech and language therapist (see *Communication*). She also had a telephone consultation lasting 1.5 hours with a Covid support team on 27 November 2020.

Several medical investigations have also been performed on Jill, including a chest X-ray, electrocardiogram (ECG), full blood test, a CT head scan, and two MRI scans of the brain. The CT scan of the head was conducted on 25 May 2020 and revealed descent of the cerebellar tonsils below the foramen magnum by approximately 10.8mm. This was confirmed through an MRI scan of the brain to be an Arnold-Chiari malformation type I without hydrocephalus or change in the cord. A neurologist reassured Jill during a telephone consultation on 10 July 2020 that this was an incidental finding with no relationship to her COVID illness and that no surgical intervention was required. The same MRI scan identified a small, 9mm meningioma in the left frontal region. This lesion was discussed at a neuroradiology multidisciplinary team review conducted on 15 March 2021. It was concluded that a more recent MRI scan had revealed no interval progression in this lesion. A blood test in August 2020 revealed levels of vitamin B12 and ferritin that were at the low end of the normal range. After 10 months of taking supplements, her levels of both compounds had returned to normal. All other medical investigations failed to produce significant findings. By October 2021, Jill had not been vaccinated for SARS-CoV-2 because of concerns that it might induce the reactivation of her COVID-19 symptoms.

Clinical Symptoms

Jill has carefully recorded the onset and progression of her COVID illness. She has documented no fewer than 27 different symptoms. Her first symptoms were headache, fatigue, brain fog and a rash on her arms. Other symptoms included a loss of taste, diarrhoea and abdominal pain, chest pain, neuropathic pain, muscle and joint pains, and pains on the left side of her head. Jill also experienced nerve buzzing/twitching, tinnitus, abnormal lumps that bruise, cough, sore glands, temperatures up to 38.4°C, blood oxygen saturation between 82-90% at times, and a heart rate of 120-130 beats per minute on exertion. Jill also reported heat intolerance in the sun and during a shower which manifests as spiking temperatures and rashes.

Like many people with long COVID, Jill did not rate any single one of her physical symptoms as severe. The respiratory symptoms most often associated with COVID illness were relatively minor in nature, e.g., Jill described her breathing difficulties as "very, very mild". Some symptoms were transient in nature (e.g., the sensation of water droplets on her skin), while other symptoms occurred intermittently over a period of several months. Jill reported raised temperatures and rashes that lasted for 15 months, for example. In the first 12 days of her illness, Jill logged her symptoms in considerable detail, and recorded symptoms on every day except for the fifth day. The continually shifting set of symptoms that makes long COVID a particularly challenging condition to manage is well captured by Jill: "Every day is different. Every hour is different. One minute I feel I will never get better, and the next I feel okay".

Jill reports significant cognitive-linguistic difficulties as part of her COVID illness. These difficulties are confirmed on assessment. On 8 June 2020, a neurologist assessed Jill using the Addenbrooke's Cognitive Examination. She achieved a score of 88/100 and lost points on language. She was unable to say the words 'caterpillar', 'eccentricity', 'unintelligible', and 'statistician'. The neurologist's impression was that she might have a progressive non-fluent aphasia. On 16 December 2020, Jill was assessed again on the Addenbrooke's Cognitive Examination during a home visit conducted by an occupational therapist. She scored 79/100, suggesting some further deterioration in her cognitive functioning. Jill has observed certain factors that trigger a deterioration of her cognitive and language skills. A key trigger appears to be eating. This was directly observed by her occupational health consultant during an online review conducted on 5 May 2021. Jill had eaten lunch just before the review took place. This led to a significant deterioration in her cognitive functioning during the review. Jill's occupational health consultant has seen well over 200 health staff with long COVID since the start of the pandemic. He has been struck by the severity of her cognitive difficulties. At Jill's most recent review conducted on 29 September 2021, her consultant remarked:

> "[Jill] has been perhaps the worst affected that I have come across over the whole of the period when I have been seeing these patients in terms of her cognitive impairment."

The duration and complex nature of Jill's physical and cognitive symptoms place her at risk of mental health difficulties such as anxiety and depression. Also, anxiety and depression are possible neuropsychiatric consequences of COVID disease [6]. When asked if her COVID illness had had an adverse impact on her mental health, Jill responded "[I] don't know how not, but no". Her extended comments reveal a process of psychological adjustment to her illness and a sense of loss for the life she once led and still hopes to resume:

> "I wonder sometimes if I have just learnt to live with this, to adapt, to accommodate the new way I feel. My new way of life is [the] polar opposite to anything I was like before. I never stopped talking, never stopped moving, never stopped thinking, never stopped moaning, never stopped helping others. I was hyper, energetic, lively, quick witted. I had an endless stream of energy which flowed through me from the minute I opened my eyes to the minute I went to sleep. That is now not who I am. I have made many adaptations to my life to accommodate this illness, but one thing has never changed and that is the support and love from my husband and kids. They have been by my side throughout. They have adapted with me and helped me through with endless support and this is why I remain happy, strong, and positive."

Daily Activities

Before her COVID illness, Jill had a high level of physical and social activity. She walked her dog twice a day for between 30 minutes to one hour. She ran three times a week for between 30 minutes to an hour on each run. Often at the weekends, she went hill walking with her family. These walks were between 7 to 10 miles. Jill enjoyed a high level of social interaction with friends and family before her illness. On her days off work, she met friends for lunch, coffee, or occasionally a glass of wine and would often go for a walk with them. She regularly went out for family meals with other families and friends. Jill was the first aider for her son's rugby team. She enjoyed camping with other families and regularly went on holiday with her brother and his family as well as with her friends. She describes herself as "the doer" in her social network. She was the person who supported and helped others through difficult times, and she loved doing so. In Jill's

own words, she was "a busy, assertive, confident, happy, outgoing person who was enjoying life" before she developed COVID-19.

The impact of COVID infection on Jill's physical and social activities has been considerable. Her ability to undertake physical exercise has reduced considerably. Where she was able to undertake regular walks and running before her illness, she can now only walk. By September 2021, Jill was able to walk for 20 minutes in the morning. If she walked beyond an hour, her legs would become weak, and her language would deteriorate. Jill no longer meets friends on a regular basis as talking is "hard work". She reflects on the reduced social interaction that has resulted from her illness and mentions the absence of meals with other families and friends as a particular loss: "This is something I miss, a sociable meal with my husband and children with our friends/family and their children." Before her COVID illness, Jill used social media platforms. She has had to limit her screen time since becoming unwell, although she still does use Twitter to keep herself informed about COVID. Jill no longer drives as she does not feel safe.

Jill's cognitive difficulties have had a significant impact on her daily life. She describes this impact as follows:

> "Crossing the road is hard sometimes, making the decision when to cross. Hanging out the washing, putting washing away. Which bedroom do I need to go to? Whose socks are they? Which pile do I need to put these in? Does that item of clothing belong to my son or daughter? It feels like there is so much thought/concentration/processing/understanding needed for these little things. Stacking things in date order is like a degree and so hard to work out. Putting measuring spoons back together has been impossible to do. I was trying to fit the big ones inside the little ones!"

Medication

Jill takes Levothyroxine 175µg every morning for the treatment of her thyroid condition. She took no medication during the acute phase of her COVID infection. On 12 May 2020, she was prescribed an antibiotic, Doxycycline 100mg once a day, which she took for a week. This was during the period when she experienced a severe relapse in her condition following a return to work. Jill also takes an antihistamine, Fexofenadine hydrochloride 120mg, once a day.

Communication

When Jill first contacted the author, she gave a very clear account of the speech and language difficulties that she was experiencing. Her problems with communication started in May 2020, or at least that is when she became aware of them for the first time. (It was quite common for the COVID participants in the author's study to describe how they only became aware of cognitive-linguistic difficulties as their physical symptoms started to improve, or that they were too physically unwell earlier in their illness to notice these difficulties.) Jill reported a wide range of problems in producing words. Some of these difficulties resembled neologisms and semantic and phonemic paraphasias seen in aphasia. She used wrong words and non-real words. She got stuck on a word and kept repeating it. She was unable to pronounce certain words. Jill used words with the opposite meaning to that which she intended (e.g., saying *answers* when she meant *questions*, or saying *down* when she meant *up*). In conversation she reported "accidentally merging" sounds from different words such as saying "blag" for *bloody bag* and "rail" for *Royal Mail*. Jill reports that she can start talking but then loses where she is in a sentence.

Jill's reading and writing have also been compromised during her COVID illness. She cannot read words that she has known for years. She needs to "blend them like a child" to say them aloud and will pronounce words incorrectly based on their spelling. She "gets stuck" when writing and does not know if a word begins with the letter R or F, for example. Jill remarked that her speech and language difficulties are most pronounced the longer she talks, after eating, when she is tired, and when she has too much screen time. In-person communication is particularly challenging for her. She finds it easier to talk when she is sitting down and lying down if she is on the phone.

Jill was assessed by a speech and language therapist during a virtual consultation on 5 August 2020. The therapist diagnosed significant speech and language processing deficits that reflected a difficulty with nervous system functioning following COVID infection. No specific SLT intervention was recommended, and she was advised she could seek a further SLT consultation if she considered it necessary.

The author met Jill on Skype on 30 January 2021 at 11am UK time. Her husband was present during the session. He helped Jill recall some of her symptoms but otherwise sat quietly in the background. The interaction lasted 1 hour and 15 minutes. She recalled the exact moment she first experienced speech and language problems. She was walking along the river with her son and said to him: "Your daughter's making cakes for you today". Her son replied: "Mum, you mean sister". Jill reported that by June 2020 she could not say a sentence or even produce her husband's name. Just 5 minutes and 30 seconds into the session, she described feeling fatigued. There was a significant deterioration in her speech and language at this point. She started to produce sound errors in words such as when she said, "when I brush" ('brush' for *rush*) and "twitch off" ('twitch' for *switch*). Her speech also became markedly dysfluent: "speaking too, too long, longa, long, long, long effort then, then, then".

Jill completed the 12 tasks used in the author's COVID language study [2]. These tasks examined immediate and delayed verbal recall, sentence generation, picture description, letter and category fluency, confrontation naming, procedural discourse, confrontation naming, and narrative production (see Figure **1** in Appendix). Jill's performance on these tasks is shown below, alongside the mean scores and standard deviations of the 26 healthy participants in the study (see Figure **2** in Appendix):

Jill's performance was below the mean of healthy participants on all 12 tasks. Her strongest performances were in category fluency for vegetables, sandwich-making procedural discourse and confrontation naming, where her scores fell within 1 standard deviation below the mean of healthy participants. In four tasks, Jill scored between 1 and 2 standard deviations below the mean of healthy participants: immediate recall; sentence generation; letter fluency; and letter-writing procedural discourse. Jill's weakest performance, with scores between 2 and 3 standard deviations below the mean of healthy participants, were recorded in the following five tasks: delayed recall; picture description; category fluency for animals; Flowerpot Incident narrative production; and Cinderella narration. Jill's scores relative to the means and standard deviations of healthy participants on the 12 tasks are displayed below. It is worth remarking that Jill's letter and category fluency scores are also significantly below normative data in various published sources [7-9]:

Although Jill displayed considerable struggle across all tasks, her most pronounced difficulties were unsurprisingly in tasks with greatest cognitive demands. The high memory load involved in the delayed recall of the 100-word Sam and Fred story was particularly challenging for Jill. But so too were other forms of cognitive processing. Jill struggled with lexical generation of animal names and the use of executive function in letter fluency. Even when tasks placed few demands on memory, Jill exhibited cognitive-linguistic difficulties. Her spoken discourse was markedly under-informative across all contexts in the tasks. (This was

Table 1: Jill's Scores Relative to Mean and SD Values in Healthy Participants

Task	Jill's scores[§]	Healthy participants Mean (standard deviation)
Sam and Fred (immediate recall)	7/14	9.7 (±1.9)
Sam and Fred (delayed recall)	5/14	9.3 (±2.0)
Cookie theft picture description	5/12	7.7 (±1.2)
Sentence generation	4/6	5.2 (±0.8)
Letter fluency (F-A-S)	32	48.0 (±10.8)
Category fluency (animals)	14	25.8 (±4.7)
Category fluency (vegetables)	14	15.3 (±3.7)
Flowerpot incident narration	8/20	13.8 (±2.9)
Cinderella narration	17.5/50	32.0 (±5.7)
Procedural discourse (sandwich)	6/8	6.6 (±0.9)
Procedural discourse (letter)	4.5/8	6.5 (±1.4)
Confrontation naming	16/20	17.6 (±2.0)

[§]Figures are raw scores.

Table 2: Jill's Performance Relative to Mean and SD Values of Healthy Participants

Up to 1 SD below mean	1 SD to 2 SD below mean	2 SD to 3 SD below mean
Category fluency (vegetables)	Immediate recall	Delayed recall
Procedural discourse (sand.)	Sentence generation	Picture description
Confrontation naming	Procedural discourse (letter)	Category fluency (animals)
	Letter fluency	Flowerpot narration
		Cinderella narration

in marked contrast to her conversational discourse which was informative.) This included contexts where pictorial support was present throughout the task, and the demand on memory was consequently low (Cookie Theft picture description and Flowerpot narration), as well as a context where the demands on memory were moderated by the script of a well-known fictional narrative (e.g., Cinderella narration). The production of informative discourse is a challenging cognitive-linguistic task, involving the integration of visual information with inferences and background knowledge. The demands of discourse production clearly exceeded Jill's cognitive capacity 10.5 months into her COVID illness. For an individual who held a challenging occupational role prior to contracting SARS-CoV-2, these difficulties may reasonably be taken to be a marked departure from her pre-morbid functioning.

It is instructive to examine Jill's narration of the Flowerpot Incident, a storytelling task based on a sequence of six, black-and-white line drawings. The utterances that make up her narrative are well-formed and meaningful. Jill produces a single sound error in her use of 'stops' for *steps*. It is clear from Jill's use of the expression 'I don't understand' that she is struggling to relate information across successive pictures. Also, some information is omitted such as the man and dog are walking along the street and the man doffs his hat to reveal a lump on his head. Other information is mentioned late in the story. The dog is introduced for the first time, for example, when the woman gives it a bone towards the end of the story. Jill also uses pronouns in place of nouns (e.g., *he - the man*) for the first mention of characters in the story, which further reduces the informativeness of her narrative:

Flowerpot Incident narration:

"so someone's chucked a plant pot on his head (1.18) and then he's shouting (2.63) then he goes in (3.29) must be like a flat (.) because he's gone up some stops [steps] (1.15) and then he's hammering on the door (2.74) I don't understand what she's (1.15) see he goes from hammering on the door to then she comes out (1.50) she must be saying sorry and she gives the dog a bone and then (4.00) she he kisses her (1.89) was a bit I don't understand it actually"

Jill's Cinderella narrative also displayed reduced informativeness. Throughout the narrative, key events were omitted that were needed to contextualize parts of the story. We are not told *why* Cinderella came to be living with her stepmother and stepsisters – her mother had died, and her father had remarried. We are also not told *why* the ball was taking place in the palace – the king wanted his son to find a wife and provide an heir to the throne. The episode where the fairy godmother uses a magic spell to turn a pumpkin and the mice into a carriage and horses, respectively, and Cinderella is given a ballgown and glass slippers to wear is omitted entirely. Jill mentioned towards the end of the story that the pumpkin had changed into a carriage. But at this late stage in the narrative, she had almost certainly transposed the words *pumpkin* and *carriage* and had meant to say that the carriage had turned back into a pumpkin. Other events are narrated at the wrong point in the story. The mice do not help Cinderella escape from her room *before* she attends the ball, but rather *after* she attends the ball. The combined effect of these different anomalies is a marked reduction in the informativeness of Jill's Cinderella narrative relative to the performance of healthy participants on this same task:

Cinderella narration:

"she (1.97) she basically was the (1.04) she had the hu [xxx (*unintelligible*)] thee awful stepsisters and she was the one that was made to clean all the time in lock down (1.45) in the cellar (1.75) and then

> (2.15) she made a wish (.) um to her fairy godmother (1.52) and then (7.62) um (4.43) then the mice came let her out and she was able to go (.) to the ball she was dressed up and went to the ball (5.40) and (3.90) oh she had to be home for midnight from the ball or she would change back into her rags um and she lost she was dancing with the prince and she lost track of time and she left she ran off (.) and I think she left her shoe she went to the pumpkin had change into her carriage with the mice and she got back home and then the prince (1.85) was looking for her with the size of the shoe that got left and then (.) they found her because it fit her foot an they got married lived happily ever after"

As these extended extracts illustrate, Jill clearly had sufficient expressive language skills to construct an informative narrative, notwithstanding her intermittent speech sound and fluency difficulties. The author assessed that Jill's reduced informativeness in discourse was instead attributable to underlying cognitive processing problems. The production of an informative narrative requires the use of well-formed, meaningful utterances if any content is to be conveyed at all. But skilled narration also demands a wide range of other abilities. This includes the ability to draw inferences that link events in space and time, to contextualize events for the hearer, to relate events in the order in which they occurred and in a manner that can be readily assimilated into the hearer's mental representation of the story. These important dimensions of narration require high-level cognitive processing. It was judged that it was these aspects of Jill's cognition that were functioning less efficiently since her COVID infection and were causing her reduced informativeness during narrative and picture description. It was concluded that Jill's difficulties were more akin to a cognitive-communication disorder in this regard than a primary language disorder.

Jill and the author remained in contact with each other after this assessment took place in January 2021. Although Jill reported an improvement in her overall condition and a lessening of her cognitive and language symptoms, this had not been sufficient to enable her to return to work. It was decided that it would be helpful to assess Jill a second time, six months after her first evaluation, to establish if the moderate improvements she was reporting in her language skills could be documented in an improvement in her test performance. Because Jill was able to recall the tasks that were used to assess her in January 2021 – tasks like Cinderella narration and letter fluency are highly memorable – a set of matched test materials was devised by the author. These tasks are listed in Figure **1** in the Appendix.

The author met Jill again online on 30 July 2021 at 10am UK time. The session lasted 1 hour and 20 minutes. Her performance on the 12 tasks used during the session is displayed in Table **3**, along with her scores from the assessment conducted in January 2021 for comparison. Although Jill's immediate recall remained largely unchanged since her first assessment, her delayed recall did show some modest improvement. Her letter and category fluency performances were still well below normative scores for healthy adults. Jill was able to produce a total of 26 words beginning with the letters C, F and L. Jill's letter fluency score was between 1 and 2 standard deviations below the mean of age-equivalent healthy adults (see Table **4**) in published sources [10,11]. Jill's category fluency score for fruits fell just within 1 standard deviation below the mean of age-equivalent healthy adults (see Table **5**) [7,12]. Jill produced 10 names of vehicles in 60 seconds. Her category fluency score for vehicles was lower than mean scores for younger and much older healthy adults in published studies [13,14]. These scores clearly suggest that in the 6 months since her first assessment, there had been little spontaneous improvement in Jill's verbal fluency performance.

In marked contrast to Jill's verbal fluency and verbal recall performances, the informativeness of Jill's spoken discourse did display a substantial improvement at her second evaluation in July 2021. While this improvement was relatively minor in the Horseshoe Incident story – a narrative based on a sequence of six, black-and-white line drawings – it was more substantial in the picture description task (the Picnic Scene). The most significant improvement of all was recorded in the task involving narration of the Little Red Riding Hood story. On this task, Jill nearly doubled her informativeness score on the equivalent task (the Cinderella story) undertaken in the first evaluation. A comparison of Jill's Little Red Riding Hood story with her Cinderella narrative reveals some of the gains that she had made (see Table **6**).

During the narration of Little Red Riding Hood, Jill spoke for longer, produced a greater number of words, and produced more essential propositions than she

Table 3: Jill's Test Scores on her First and Second Evaluations

First evaluation		Second evaluation	
Task	**Jill's scores**	**Task**	**Jill's scores**
Sam and Fred (immediate recall)	7/14	Summer fete (immediate recall)	7.5/14
Sam and Fred (delayed recall)	5/14	Summer fete (delayed recall)	7/14
Cookie theft description	5/12	Picnic scene description	8/12
Sentence generation	4/6	Sentence generation	5/6
Letter fluency (F-A-S)	32	Letter fluency (C-F-L)	26
Category fluency (animals)	14	Category fluency (fruits)	12
Category fluency (vegetables)	14	Category fluency (vehicles)	10
Flowerpot incident narration	8/20	Horseshoe incident narration	9.5/20
Cinderella narration	17.5/50	Little red riding hood narration	32/50
Procedural discourse (sandwich)	6/8	Procedural discourse (laundry)	7/8
Procedural discourse (letter)	4.5/8	Procedural discourse (coffee)	6/8
Confrontation naming	16/20	Confrontation naming	16/20

Table 4: Scores of Healthy Participants on C-F-L Letter Fluency

Carone *et al*. (2005)	**Zakzanis *et al*. (2000)**
37 healthy subjects	35 healthy subjects
Age: 42.3 years (±9.4)	Age: 43.9 years (±20.1)
Education: 15.0 years (±2.0)	Education: 12.6 years (±2.2)
Letter score: 42.2 words (±10.2)	Letter score: 39.77 words (±9.04)

Table 5: Scores of Healthy Participants on Category Fluency for Fruits and Vehicles

Fruit names	**Fruit names**
Acevedo *et al*. (2000) *Age:* 50-59 years: 16.0 (±4.1) *Education:* 13-16 years: 13.3 (±3.9) *Gender:* Female: 13.8 (±3.6)	Badcock *et al*. (2011) 69 healthy subjects Age: 40.2 years (±13.2) Education: 13.4 years (±2.4) Fruits: 15.6 names (±3.8)
Vehicle names	**Vehicle names**
Clark *et al*. (2014) 25 healthy subjects Age: 70.1 years (±6.9) Education: 16.2 years (±2.5) Vehicles: 12.4 names (±2.9)	Kiang and Kutas (2006) 34 healthy subjects Age: 20.8 years (±3.6) Vehicles: 14.5 names (±3.6)

Table 6: A comparison of Jill's Cinderella and Red Riding Hood Narratives

Cinderella		Little Red Riding Hood	
Total number of words	167	Total number of words	299
Total duration of narrative (secs)	105	Total duration of narrative (secs)	240
Number of essential propositions	17.5	Number of essential propositions	32
Number of missing propositions	32.5	Number of missing propositions	18
Events in wrong order in narrative	5	Events in wrong order in narrative	2
Number of fillers per minute	1.71	Number of fillers per minute	2.0
Number of words per minute	95.4	Number of words per minute	74.8
Duration of pauses per minute (secs)	18.9	Duration of pauses per minute (secs)	16.8

had done during the telling of the Cinderella story at her first evaluation. These findings are consistent with the markedly increased informativeness of Jill's Red Riding Hood story relative to her Cinderella story. Jill also omitted fewer propositions and related fewer events in the wrong order during the Red Riding Hood story than in her Cinderella narrative. It is noteworthy that Jill also produced significantly fewer words per minute in her narration of Little Red Riding Hood than in her narration of Cinderella. Jill's reduced rate of lexical delivery suggested greater cognitive planning during narrative production in her second evaluation compared to her first evaluation. This increased planning enabled her to establish the essential information that needed to be conveyed and the order in which that information should be presented to the hearer. This could account for the increase in the amount of accurate information that Jill conveyed through her narrative. To the extent that greater cognitive planning may underlie gains in informativeness at Jill's second evaluation, some improvement in her general cognition may also account for her greater ability to monitor her output and correct errors in her narrative, to relate events through causal and temporal inferences, and to use mental states of characters in the Red Riding Hood story. None of these discourse features were present in Jill's Cinderella narrative from her first evaluation:

Self-Monitoring and Error Correction:

"she wu, went in then realised (2.72) um that it was the wolf no (2.89) no she didn't realise it was the wolf she (2.03) she said she'd made a cake"

Causal and Temporal Inferences:

"Little Red Riding Hood got to the house knocked on the door (1.80) um (2.77) the wolf told her to go in" (causal inference: the wolf told her to come in *because* he heard the knock)

"he ran off ahead (2.83) and then she (1.58) she got to grandma's house (.) and (2.84) the wolf had already got to her house" (temporal inference: the wolf arrived at grandma's house *before* Red Riding Hood because he ran ahead)

Mental States of Characters:

"she **decided** to pick some flowers"

"she **realised** it was the wolf"

"she still **thought** it was grandma"

Another noteworthy difference between Jill's Cinderella and Red Riding Hood narratives is the type of conjunctions used to link the clauses of her narratives. Conjunctions are revealing for the type of conceptual relations they express. The conjunction 'and' expresses a simple additive relation between clauses. Conjunctions like 'so', 'if' and 'although' express more complex concepts of consequence, conditionality, and concession. In her Cinderella narrative, Jill used the conjunction 'and' (or 'and then') on 14 occasions. This was almost to the exclusion of other types of conjunctions, with conjunctions other than 'and' accounting for just 12% of Jill's conjunction use. This pattern was in marked contrast to her use of conjunctions in her Red Riding Hood narrative where conjunctions other than 'and' accounted for 32% of conjunction use. The use of a wider range of more complex conjunctions at Jill's second evaluation contributes to the impression of greater narrative competence at this evaluation and suggests that gains in her cognitive performance may also extend to the conceptual relations that she uses to link clauses.

CONCLUSION

The case of this 44-year-old community nurse confirms other published reports of cognitive deficits following COVID infection [15] and examines the impact of these deficits on language. At Jill's first evaluation some 10.5 months after the onset of her COVID symptoms, her performance on all 12 language tasks placed her below the mean scores of healthy participants. On 5 of 12 tasks, Jill's scores fell between 2 and 3 standard deviations below the mean. Areas of significant difficulty were delayed verbal recall, category fluency for animals, and discourse production across contexts with varying cognitive demands: a single scene (Cookie Theft); a sequence of six pictures (Flowerpot Incident); and a well-known fictional narrative (Cinderella).

Jill's second evaluation took place six months after her first evaluation. This was 16.5 months after the onset of Jill's COVID symptoms. Although Jill's delayed recall showed only a modest improvement and her letter and category fluency performances were still well below mean scores for age-equivalent healthy participants, there was a significant improvement in the informativeness of all three of her spoken discourses. This improvement was most marked in her telling of the Little Red Riding Hood story, where gains were observed in not just the informativeness of her discourse, but also in several other discourse features. These features included the drawing of temporal and causal inferences, the attribution of mental states to the characters in the story, and Jill's ability to monitor her spoken output and correct errors. Jill also used a wider range of conjunctions in her narration, allowing her to express more complex conceptual relations between clauses in her story. The overall impression was that Jill was producing a much richer type of discourse, in which she used a greater amount of conceptually complex and informative language than she had done at her first evaluation. This improvement in test performance corresponded to Jill's self-reported cognitive gains over time and could plausibly be taken to reflect some spontaneous improvement in her general cognition with further recovery from her COVID illness.

That cognitive-linguistic difficulties should be reported as part of the long COVID syndrome is not entirely unexpected. It was apparent to Chinese doctors who treated early cases of COVID-19 infection in Wuhan that the SARS-CoV-2 virus affects many organs and systems in the body other than the lungs and respiration [16]. This includes the nervous system. Neurological symptoms (e.g., headache) and complications (e.g., cerebral hemorrhage) are recognized clinical features of patients with COVID-19 infection [17]. Also, the SARS-CoV-2 virus has been detected in neural tissue on postmortem examination [18], although central nervous system (CNS) involvement caused by direct neuroinvasion is believed to be rare relative to CNS sequelae related to systemic hyper-inflammation [19]. Whatever physiological mechanism underlies the long COVID syndrome, Jill's case demonstrates that it can have an impact on cognitive-linguistic functioning long after initial infection with SARS-CoV-2, and to an extent that prevents the resumption of normal occupational and social activities. With such large numbers of people experiencing the long COVID syndrome, this finding has significant implications for the long-term health and economic support of these individuals.

A question of some interest to speech-language pathologists is where language problems in the long COVID syndrome fit into a nosology of language disorders. Jill does not display the marked structural language difficulties or auditory verbal comprehension problems of adults with aphasia. Her difficulties are not a *primary* language disorder of this type. Jill's language problems appear to be *secondary* to her cognitive deficits. To this extent, they are more akin to a cognitive-communication disorder of the kind observed in adults with traumatic brain injury, right-hemisphere damage, and neurodegeneration. It is noteworthy that Jill's most marked language impairment during testing – her reduced informativeness – is a well-recognized feature of discourse in adults with neurodegeneration, even in the absence of dementia [20-24]. Adults who sustain traumatic brain injury and right-hemisphere damage have also been reported to exhibit reduced informativeness in discourse [25,26]. As we saw above, informativeness in discourse is not the product of any single cognitive or linguistic process, but involves multiple, interacting components, including language planning, inferencing, and mental state reasoning. The cognitive limitations that ensued from Jill's COVID infection appeared to restrict her ability to deploy flexibly these cognitive-linguistic resources and, in so doing, limited her ability to construct informative discourse, even when she possessed sufficient expressive language skills for this purpose. Finally, it is worth remarking that it would be incautious to characterize these difficulties as more subtle or minor in nature than the cognitive-communication problems of

these other clinical populations when their impact has been to prevent the return to work for over 18 months of a once busy health professional and to limit all other aspects of her social functioning.

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DECLARATION OF INTEREST

The author has no conflict of interest to report.

APPENDIX

First evaluation (January 2021)	Second evaluation (July 2021)
Immediate recall – Sam and Fred	Immediate recall – Summer fete
Delayed recall – Sam and Fred	Delayed recall – Summer fete
Picture description – Cookie theft [27]	Picture description – Picnic scene [28]
Sentence generation	Sentence generation
Letter fluency (F-A-S)	Letter fluency (C-F-L)
Category fluency – animals	Category fluency – fruits
Category fluency – vegetables	Category fluency – vehicles
Flowerpot Incident narration	Horseshoe Incident narration
Cinderella narration	Little Red Riding Hood narration
Procedural discourse – sandwich	Procedural discourse – laundry
Procedural discourse – letter	Procedural discourse – coffee
Confrontation naming	Confrontation naming

Figure 1: Tasks used in Jill's evaluations.

Study group	Number	Age (mean)	Age (range)	Gender (M/F)	Education (years)
Healthy participants	26	48.2 years	18-64 years	10 M/ 16 F	7 under 17 years 19 over 17 years

Figure 2: Characteristics of healthy participants.

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