RESEARCH REPORT



The effects of virtual reality immersion on the content and structure of the narrative discourse of healthy adults

Clarisse Baker | Lucy Bryant | Emma Power |

Faculty of Health, University of Technology Sydney Graduate School of Health, Sydney, NSW, Australia

Correspondence

Lucy Bryant, University of Technology Sydney Graduate School of Health, 100 Broadway Chippendale, NSW 2007. Australia.

Email: Lucy.bryant@uts.edu.au

Funding information

University of Technology Sydney

Abstract

Background: Narrative discourse is central to effective participation in conversations. When discourse is assessed in people with communication disability, structured tasks (e.g., picture descriptions) provide experimental control, while unstructured tasks (e.g., personal narratives) represent more natural communication. Immersive virtual reality (VR) technology may provide a solution by creating standardized experiences for narrative retell, therefore balancing ecological validity and experimental control in discourse assessment. Research is needed to understand how VR immersion affects narrative retell, first for adults with no communication disability, before application with adults with aphasia or related communication disability.

Aims: To assess (1) the effects of VR immersion on the linguistic content and structure of narrative retells in a healthy adult population; and (2) whether VR immersion can influence the way a narrative is retold so that the speaker conveys their own experience, rather than the experience of the characters they are watching.

Methods & Procedures: In this pilot cohort study, 13 healthy adult participants with no reported communication disability watched an animated short film and a comparable immersive VR short film in a randomized order. Participants were asked to retell the events of the story after each condition in as much detail as possible.

Outcomes & Results: Mean length of utterance (in morphemes) was significantly higher in the video condition compared with the VR condition. Significantly more first-person pronouns were used in the VR condition compared with the video condition. No other measures of linguistic content or structure were significantly different between the VR and video conditions.

Conclusions & Implications: Increased morpho-syntactic length and complexity in the video condition may suggest effects of elicitation stimulus on the narrative produced. The larger number of first-person pronouns in the VR condition may reflect that participants experienced a sense of presence in the virtual

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environment, and therefore were able to retell their communication experience rather than narrating the experiences of characters from an external perspective. Given the increasing need for more functional assessment of discourse in people with communication disability, further research is needed to validate these findings.

KEYWORDS

discourse, narrative, retell, virtual reality

WHAT THIS PAPER ADDS

What is already known on this subject

As an ecologically valid tool, discourse analysis is often used to assess daily
communicative exchanges in adults with acquired communication disability.
Clinicians and researchers using narrative discourse assessment must balance the experimental control and diagnostic reference sample capabilities
of structured tasks with the ecological validity and real-life transferability of
unstructured personal narratives.

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What this study adds to existing knowledge

• This study explores the use of immersive VR technologies to create standardized, replicable, immersive experiences as a foundation for narrative discourse assessment. It highlights how the 'sense of presence' in a virtual world can prompt healthy adult speakers to retell a narrative of a personal experience that can be replicated for many different participants. The results suggest that immersive VR narrative assessment for adults with communication disability may balance ecological validity with measurement reliability in discourse assessment.

What are the potential or actual clinical observations of this work?

 Immersion in VR resulted in the production of narratives with morphosyntactic features that aligned with typical narrative generation, rather than retell. Participants used more first-person pronouns, suggesting retelling of personal experience. Though further study is needed, these preliminary findings suggest clinicians can use immersive VR stimuli to generate structured story generations that balance experimental and diagnostic control with ecological validity in narrative discourse assessment for adults with communication disability.

INTRODUCTION

Discourse analysis is frequently used as a functional tool to assess *language in use* in adults with a range of communication disabilities including aphasia (Bryant et al., 2016; Stark et al., 2021), and those caused by traumatic

brain injury (Steel & Togher, 2019) or dementia (Guendouzi & Muller, 2005). The popularity of discourse assessment comes from its ecological validity—its relevance to language use in everyday life (Dietz & Boyle, 2018; Whitworth, 2018). It can be used to assess daily communicative exchanges such as giving instructions, conversing casually

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or sharing past experiences (Linnik et al., 2015). Because of the increased complexity required to combine pragmatic, linguistic and cognitive domains in the construction of connected speech (Linnik et al., 2015), clinicians using discourse analysis may be better able to detect difficulties in syntactic organization, word order, cohesion and coherence that may not be identified using traditional word and sentence level tasks (e.g., Fromm et al., 2017).

When discourse is impaired, there are subsequent impacts on social participation (Azios et al., 2022) and quality of life (Davidson et al., 2003). Recognizing these impacts, people with aphasia often prioritize rehabilitation goals that reflect discourse targets and communication beyond basic needs (Worrall et al., 2011). Clinicians, therefore, need to conduct assessments that provide insight into the language needed to achieve key functional goals. To achieve this, clinical assessments for adults with acquired communication disability must extend beyond the impairment level to include discourse (Power et al., 2015; Togher et al., 2014).

To appropriately assess discourse, clinicians and researchers must consider different genres including narrative (retelling an event), procedure (giving instructions or directions), description (describing attributes in detail), persuasion (argument of facts and opinions) and exposition (factual interpretation about a topic) (Kintz & Kim, 2023). Each genre and accompanying elicitation task may alter the nature and content of language produced by imposing different cognitive and linguistic demands on speakers (Bliss & McCabe, 2006; Kintz & Kim, 2023; Stark, 2019). Narrative discourse is often chosen as the target of language interventions for adults with acquired communication disability due to evidence that the genre acts as a bridge between clinical and everyday communication (Whitworth, 2010). Additionally, the meaningful value of narrative as an avenue through which adults disclose their personal stories and hence establish self-identity emphasizes the importance of storytelling as a functional communication target (Hillman et al., 2018). Narrative discourse involves the retelling of events, either real or fictional, that unfold over time and include a beginning, a middle and an end.

While eliciting narrative discourse, there is an interplay between experimental control and ecological validity. Stimuli used to elicit narrative discourse, such as picture descriptions, can be structured for experimental control to restrict the range of language produced and facilitate standardization (Bliss & McCabe, 2006). Structured tasks are generally based on fictional events, where the participant is asked to read or watch a story and then retell the events (e.g., the Cinderella story; MacWhinney et al., 2010). Core lexicon and main concept lists can be developed using structured tasks to compare performance between and within individuals (Dillow, 2013; MacWhinney et al., 2010;

Richardson et al., 2021). These are time-efficient and informative ways to analyse discourse samples, as the discourse produced by a speaker can be compared with standardized expectations for linguistic and semantic content to identify linguistic deficits and track progress over time (Richardson et al., 2021). The structured Cinderella story core lexicon list developed by Dillow (2013) was based on 158 healthy adults with no known communication disability, where included words were produced by at least 50% of participants. The developed core lexicon list was proven sensitive to differences in narrative production between controls and people with aphasia, indicating it was a reliable tool to assess narrative discourse impairment. Similar methods including thematic and content unit analysis have been developed for several structured narrative tasks, such as the 'Cookie Theft' picture description task (Yorkston & Beukelman, 1980) and 'The Picnic' scene description (Marini et al., 2011), providing normative data for clinicians to assess and monitor language used in fictional narrative discourse. For these reasons, structured formal tasks are often used in research contexts to elicit narrative discourse (Bryant et al., 2016).

However, structured elicitation tasks may not be representative of natural communication in which people discuss personal experiences (Whitworth, 2010). Previous research, while limited, has suggested that structured tasks do not generate samples that are as linguistically or contextually representative of the language production seen in natural communicative contexts (e.g., ability to be understood by the listener, informativeness) (McCullough et al., 2017). McCullough et al. (2017) highlighted the differences between structured fictional narrative elicitation and personal narrative production in 10 people with aphasia. Participants produced narratives in two conditions: during spontaneous conversation and in response to a fictional, structured narrative task. The authors found there were significantly higher levels of informativeness, sentence formulation, topic initiation, and topic maintenance in the unstructured conversational task, where personal narratives were elicited. The authors theorized that the higher informativeness was a result of differences in functional purpose between the two tasks and concluded that unstructured tasks (i.e., personal narratives) produced samples that more accurately depicted a person with aphasia's true functional communicative ability.

Similar research investigating structured and unstructured tasks in children have found further linguistic differences. Structured fictional tasks generally provide more support for semantic retrieval and elicit more syntactically complex utterances in comparison to unstructured personal narratives (Bliss & McCabe, 2006; Westerveld & Gillon, 2010). Westerveld and Gillon (2010) demonstrated the relationship between task structure and semantic retrieval, comparing personal narratives elicited from

conversational prompts, where no further structure was provided, to structured fictional narratives elicited using an audio recording and wordless pictures of the story in 11 children with reading disability, and 11 children with typically developing reading skills. The authors found that fictional narratives elicited using structured methods produced longer narrative samples with a greater range of vocabulary and percentage of complex sentences. The authors suggested that the structured fictional tasks provided a scaffold for story retell, facilitating schema activation and use of complex syntactic structures.

The differences in narrative assessment outcomes demonstrate that structured tasks enable development of normative data and hold resultant diagnostic value, they do not provide a complete representation of true functional language ability and produce linguistically different samples in comparison to more unstructured personal narrative samples. This results in poor ecological validity and real-life transferability. Unstructured tasks eliciting personal narratives may therefore seem optimal while assessing functional language; however, the clinician has less control over the language produced by participants. As clinicians are unfamiliar with personal events present in the lives of those whose narratives they assess, they are restricted in their ability to judge narrative 'correctness' (Dillow, 2013). Further, personal narrative assessment tasks make the development of a uniform content analysis and normative data difficult as language varies considerably regarding topic discussed, vocabulary used, and grammatical complexity produced (Bliss & McCabe, 2006). Therefore, while unstructured tasks elicit more naturally occurring personal narratives, they are difficult to standardize as each personal experience is different. There is a resultant tension between experimental control and ecological validity within narrative assessment.

Recent developments in virtual reality (VR) technology and its preliminary application in the study of communication disability suggest that an equal balance between experimental control and ecological validity may be achievable, thus bridging this gap (Peeters, 2019). VR technologies previously utilized in health research include immersive and non-immersive systems (Bryant et al., 2020). In non-immersive technologies, the user is not a part of the simulated environment, instead interacting with the story in third-person using a computer-generated avatar (e.g., EVA park; Marshall et al., 2018). The role of non-immersive VR in the treatment of discourse and other language impairments in aphasia has been previously investigated by several research groups (Bryant et al., 2020).

Immersive VR systems comparatively situate users in the virtual environment while simultaneously allowing them to interact with it. Current immersive VR systems produce multi-sensory feedback through either head-mounted displays (HMD), or through the use of a computer-automated virtual environment via projection screens (CAVE) to simulate three dimensional real-life environments. The nature of immersive VR technology enables creators to design and control the sensory input the participant receives. Immersive VR systems incorporate motion-detection technology to track participant eve, head, and body movements and change digital surroundings accordingly (Fox et al., 2009), allowing participants to interact with the simulated world. Using immersive VR technology, it is also possible to create feelings of both immersion (i.e., objective degree of likeness to the realworld) and presence (i.e., subjective feeling of presence in the virtual world) (Smith & Mulligan, 2020). Several factors support feelings of immersion and presence in VR simulated environments, including elicitation of genuine responses to stimuli (e.g., emotional, behavioural) and the participant production of personal stories following events in the simulation (Riches et al., 2019). Similarly, immersion in other literature-based narrative experiences can be supported by and reflected in the use of language structures. Personal pronouns in particular have been shown to influence narrative immersion, with first-person pronouns (I, me, we) associated with a greater sense of immersion when compared with third person pronouns (e.g., he, her, they) (Hartung et al., 2016).

Therefore, it is plausible that in the right conditions, immersive VR technology can simulate a more controlled and replicable communication experience where the clinician can predict the language produced. If possible, this technology may be used as a clinical tool to assess narrative discourse in a more functional way for people with communication disability. In achieving this, it may also be possible to expand upon the current understanding of the cognitive and neural processes that inform linguistic and communicative ability under real world circumstances (Peeters, 2019). The concept of utilizing VR technology to standardize a singular experience and assess functional language in aphasia reflects the principles outlined in an exploratory VR opinion study conducted by Garcia et al. (2007). Garcia et al. conducted focus groups with speech pathologists to determine clinician perspectives on future applications of VR within the field of speech pathology. Several themes were identified, including potential applications for linguistic assessment, and supporting functional communication. However, despite emerging evidence for the potential applications and benefits of immersive VR technology, there is currently limited research that explores the applicability of VR technology in the assessment and treatment of people with a communication disability (Bryant et al., 2020). Before such research can take place, it is important to first assess the

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feasibility, safety, and outcomes of VR immersion in adults without communication disability to create control data and inform application of novel techniques.

This study therefore aimed to investigate the possibility of using immersive VR technologies to create standardized, replicable, immersive experiences as a foundation for narrative discourse assessment. This aim is first achieved by establishing control data with adults without communication disability. In doing so, we aimed to investigate the effect of VR immersion on the language produced in narrative retell and to determine whether immersion in VR can simulate a communication experience in participants with no communication disability. The research addressed the following questions:

- 1. How does VR immersion affect the content and structure of the discourse produced in a narrative retell, when compared with a standard video retell in terms of:
 - a. microstructure (i.e., morphosyntactic length and complexity and lexical diversity); and
 - b. macrostructure (i.e., the proportion of information retold)?
- 2. Does VR immersion increase the cognitive demands of a narrative retell when compared with a standard video retell, as measured by linguistic fluency?
- 3. Does VR immersion prompt the retelling of a personal narrative with the speaker in focus (i.e., in the first person, using first-person pronouns)?

We hypothesize that immersive VR systems can create a communication experience from which participants will retell a narrative with themselves in focus (i.e., from a first-person perspective), that can be replicated for many different participants, and thereby meet the need of balancing ecological validity with measurement reliability.

METHOD

This pilot cohort study used a randomized AB design to assess the differences between the narratives produced across two elicitation conditions. The research was approved by the Human Research Ethics Committee of the University of Technology Sydney (ETH21-5892).

Participant recruitment

Participants were recruited using a convenience sampling strategy. A flyer was distributed online via twitter, by email through existing professional networks, and was posted in strategic physical locations on the grounds of the Univer-

sity of Technology Sydney. People who were interested in participating were instructed to contact the researchers via email to express interest. The researchers then contacted potential participants to screen eligibility and organize suitable times for data collection.

Participants were recruited if they met the following inclusion criteria: (a) were aged 16 years or over, (b) were able to provide informed written consent to participate in the study, and (c) had no self-reported health conditions that affected communication, cognition or physical movements. Participants were excluded from the study if they met one or more of the following exclusion criteria: (a) were under 16 years of age, (b) had a condition that would create a personal safety risk when immersed in VR (e.g., chronic ear and eye infections, heavy pregnancy), (c) had a history of epilepsy and/or seizures, or (d) had severe hearing or vision impairments. Inclusion and exclusion criteria were set to ensure the safety of all participants and researchers during VR immersion, and to provide suitable pilot data on the use of VR by typical populations. All participants received a small reimbursement of their travel costs to the research facility. All participants provided written consent to participate. The recruited participants were part of a larger pilot study examining the feasibility of using immersive VR in rehabilitation (Bryant et al., in preparation).

Procedure

Participants who met inclusion were screened before using VR technology for risk of cybersickness using the motion sickness susceptibility questionnaire—short (Golding, 2006) and the University of Technology Sydney Graduate School of Health VR safety protocol. Participants were advised of personal risks associated with the potential for adverse events and cybersickness (including nausea, eye strain, headaches, vertigo; Jones et al., 2004) and were given the option to withdraw from the study. No participants withdrew and all were provided with education on the signs and appropriate response to cybersickness.

All participants were immersed in VR using an Oculus Rift VR device connected to a custom Dell gaming computed in a specially designed laboratory at the University of Technology Sydney. All participants were immersed in a series of five VR experiences (Bryant et al., in preparation) and watched one non-VR video. One VR experience and the non-VR video were used to generate narrative retells. The third of the VR experiences was the VR animated short film Invasion 360 (Baobab Studios Inc., 2020). Immediately after this experience, participants were asked to retell the narrative of what they had watched. Participants also watched a standard Pixar animated short film

Presto (Hollander & Sweetland, 2008). Supplementary File 1 in the additional supporting information provides a link with more information on each narrative experience.

The order in which participants viewed each story condition was randomized, with some participants watching the VR condition first and others watching the non-VR condition first to avoid order effects. Participants were randomly assigned to condition A, where they watched and retold the non-VR video immediately before the first of five VR experiences, or condition B where they watched and retold the non-VR video immediately after the fifth VR experience. Randomization was determined upon entry to the study using an online random sorting tool.

Immediately following each viewing, participants were instructed to retell the narrative with the instruction 'Tell me the story of what you just watched in as much detail as possible, with a beginning, a middle, and an end'. Participants who did not produce stories that included key details were then prompted with a variation of 'Can you tell me more about the events that happened?'. No further instructions were given. All samples were collected by the second author, a certified practicing speech pathologist with knowledge and experience with VR technology and discourse elicitation and analysis.

Each story retell (N = 26) was audio-recorded and then orthographically transcribed by a trained research assistant and the first author, a student speech pathologist. Supplementary File 2 in the additional supporting information contains an example transcript from each narrative condition. Twenty percent of the total samples transcribed were selected at random and checked by a research assistant experienced in transcription to reduce human error. The point-to-point agreement between the two examiners for transcription reliability was 98.2% with a range of 96.67–100%. The samples were then segmented and coded by the first author. Utterances were manually segmented into communication units (C-units) following Systematic Analysis of Language Transcripts (SALT; Miller et al., 2017) software recommendations, where a C-unit consists of a main clause and its subordinating clauses. All repetitions or revisions (referred to 'mazes' in SALT) were placed within parenthesis and morphemes, utterances, and unintelligible components were coded as per SALT coding guidelines. All segmentation and coding were checked by the second author.

Data analysis

Discourse analysis

Narrative retells were analysed using a multilevel language analysis across microstructural and macrostructural domains to describe linguistic and production differences between the VR and non-VR elicitation contexts. Microstructural (syntactic complexity and lexical diversity), macro-structural (content units recalled), and fluency (percentage of mazes) measures were investigated for each narrative. Further, a quantitative perspective measure (number and type of pronouns) was also included with the aim to quantify the level of immersion within each story condition.

Microstructural analysis was conducted by the second author using SALT software (SALT-NZAU 18; Miller et al., 2017) to answer research question 1a. Syntactic length and complexity were assessed using measures of the number of subordinating conjunctions, and the mean length of utterance in morphemes (MLU-m) in participants' narrative samples. Lexical diversity was measured using the moving average type-token ratio (MATTR; Covington & McFall, 2010).

Macrostructural analysis was used to quantify the level of informativeness of each sample, for research question 1b. Reflecting the pilot nature of the study, information content was quantified as the percentage of total content units (CUs) recalled. CUs were manually calculated by the first author and checked for accuracy by the second author. Each participants' narrative samples were separated into individual CUs and collated into a list of CUs identified by all participants. CUs for each narrative were defined as details or events relevant to the story that were identified by at least one participant (see Supplementary File 1 for a list of CUs for each narrative). This procedure was built upon the method of Yorkston and Beukelman (1980) previously used to calculate informativeness in narrative discourse. They defined a CU as 'a grouping of information always expressed as a unit by normal speakers' (p. 30), consisting of a noun, verb or propositional phrase that was mentioned by at least one participant. The CUs identified in the present study therefore represented the complete number of events recalled by at least one participant while retelling the narrative. There were 96 coded CUs for the video condition Presto and 85 for the VR condition Invasion 360 (see Supplementary File 1 in the additional supporting information).

Each narrative was scored against the list of total CUs. A speaker received a score of '1' for each CU produced, and a score of '0' for each CU omitted from their narrative retell. If the recalled CU was comparable to another in terms of content, then it was scored as '1' regardless of specific wording used. The number of CUs for each transcript was summed and calculated as a percentage against the total number of possible CUs in each narrative (i.e., number of CUs produced divided by total number of possible CUs for that narrative × 100). To check reliability, 20% of samples were randomly selected and recoded by the second

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author. Interrater reliability was assessed using Cohen's Kappa (McHugh, 2012). The resulting interrater agreement of 94% represents an almost perfect agreement between the two examiners, indicating high reliability (McHugh, 2012).

Fluency analysis was used to answer question two and investigate the potential impact of elicitation context on the cognitive and linguistic demands of each narrative retell. The number of dysfluencies (including repetitions and revision) were manually coded in each narrative and were calculated using SALT-NZAU 18 (Miller et al., 2017). The proportion of dysfluencies were calculated as a percentage against the number of total words in each sample (i.e., number of dysfluent words divided by total number of words \times 100). Theoretically, an increased number of dysfluencies is thought to reflect processing difficulties associated with the production of language, and contexts with greater cognitive demand (e.g., narrative over conversation) and longer utterances may lead to an increased number of dysfluencies (Thordardottir & Weismer, 2002).

Perspective analysis

In response to research question three, perspective and immersion within the story were conceptualized and analysed through counts of the number and type of personal pronouns (first, second and third person) in each sample. The use of first versus third person pronouns has been previously linked to immersion in studies of literacy and reading (e.g., Hartung et al., 2016). Number and type of pronouns were calculated using SALT-NZAU 18 (Miller et al., 2017). Participants reference of first-person pronouns (e.g., I, me, we) indicated that the subject 'in focus' was the participant and their experiences (i.e., they generated a personal narrative retell). In comparison, participants reference of third person pronouns (e.g., him, her, they) showed that the participant described another's experience (i.e., they generated a standard fictional retell) rather than their own personal experience.

Statistical analyses

Count and percentage outputs from each discourse analysis variable were entered into the Statistical Package for the Social Sciences program (SPSS; IBM Corp., 2020). Each variable was assessed using paired samples tests to assess differences between the video and VR conditions. Data was screened and evaluated for normalcy using frequency histograms and visual inspection. No values were missing from the dataset. As data were not normally distributed, statistical significance was calculated using a

non-parametric related samples Wilcoxon signed rank test. Statistical significance was determined by an alpha level of p < 0.05. No adjustment was made to the alpha level for multiple comparisons due to the preliminary nature of the investigation (Vasilopoulos et al., 2016). The results of the non-parametric statistical analyses, the median (Mdn), interquartile range (IQR), and minimum and maximum values are reported.

RESULTS

Participant characteristics

A total of 13 participants were recruited from 15 expressions of interest (three non-response), including nine females and four males with an age range of 22-49 years (mean = 27; SD = 6.69). All participants were familiar users of tablet technology, but novice users of VR. Participant characteristics are detailed in Table 1. All were eligible to participate and provided informed consent.

Question 1a: Microstructural analysis

Results from the analysis of microstructural discourse variables are in Table 2. MLU-m was significantly higher in the video condition (Mdn = 10.67, IQR = 3.05) compared with the VR condition (Mdn = 9.44, IQR = 2.01), Z = 6.00, p <0.006. Video and VR narrative retells did not significantly differ in terms of the number of subordinating conjunctions or the MATTR. There was noted variation on most measures (Table 2). The number of subordinating conjunctions showed an equal amount of variation in both video (IQR = 7.50) and VR (IQR = 7.50) conditions. The measure with the least variation was the MATTR in both the video (IQR = 0.06) and VR (IQR = 0.05) conditions.

Question 1b: Macrostructural analysis

There was no significant difference in the proportion of CUs produced between the video (Mdn = 22.92) and the VR (Mdn = 36.47) retell conditions, Z = 69.00, p < 0.101(Table 2). Participants showed variation in the proportion of CUs produced in both the video (IQR = 43.75) and the VR (IQR = 48.23) conditions.

Question 2: Fluency analysis

There were no significant differences in the number of mazes between the video (Mdn = 7.70, IQR = 5.55), and

TABLE 1 Participant characteristics

Participant no.	Age (years)	Gender	Language(s) spoken other than English	Vision impairment	Correction worn during collection	Tablet use	Virtual reality use
1	25	F	Cantonese	Short-sighted	None	Often	Rarely
2	24	M	None	None	None	Often	Never
3	25	F	Dutch	Short-sighted	None	Never	Never
4	25	M	None	None	None	Often	Never
5	23	F	None	None	None	Often	Never
6	24	F	None	None	None	Rarely	Never
7	25	M	Cantonese	None	None	Often	Never
8	49	F	None	Unspecified	Glasses	Rarely	Never
9	24	F	None	None	None	Often	Rarely
10	29	F	Indonesian	None	None	Rarely	Never
11	22	F	None	None	None	Never	Never
12	26	M	None	Unspecified	Glasses	Never	Never
13	30	F	None	Astigmatism	Glasses	Often	Never

TABLE 2 Descriptive statistics for discourse measures across virtual reality and video elicited narratives

	Condition									
	$\overline{\text{Video }(n=13)}$				Virtual reality $(n = 13)$					
Measures	Minimum	Maximum	Median	IQR	Minimum	Maximum	Median	IQR	p	\boldsymbol{Z}
MLU-m	7.80	14.00	10.67	3.05	6.41	10.7	9.44	2.01	0.006*	6.00
Sub conj.	2.00	22.00	6.00	7.50	2.00	14.00	5.00	7.50	0.241	16.00
MATTR	0.48	0.62	0.59	0.06	0.52	0.62	0.57	0.05	0.326	22.00
% CUs	9.38	53.13	22.92	43.75	14.12	62.35	36.47	48.23	0.101	69.00
Mazes	3.20	21.90	7.70	5.55	1.60	17.60	7.50	5.80	0.169	21.50
Total pronouns	7.00	81.00	20.00	25.50	8.00	50.00	31.00	21.5	0.249	62.00
1st Person pronouns	0.00	21.00	3.00	3.50	0.00	18.00	9.00	9.50	0.013*	70.50
2nd Person pronouns	0.00	5.00	0.00	1.00	0.00	16.00	0.00	6.50	0.495	18.00
3rd Person pronouns	4.00	55.00	18.00	24.00	3.00	31.00	19.00	8.50	0.814	36.00

Note: %CUs, percentage content units recalled by each participant; IQR, interquartile range; MATTR, moving average type-token ratio; maximum, maximum data value; minimum, minimum data value; MLU-m, mean length of utterance in morphemes; Sub conj., Subordinating conjunctions.

the VR (Mdn = 7.50, IQR = 5.80) conditions, Z = 21.50, p < 0.169 (Table 2).

Question 3: Perspective analysis

There were no significant difference in the total number of personal pronouns between the video (Mdn = 20.00, IQR = 25.50), and the VR (Mdn = 31.00, IQR = 21.5) conditions, Z = 62.00, p < 0.249 (Table 2). Significantly more first-person pronouns were used in the VR condition (Mdn = 9.00, IQR = 9.50) compared with the video condition (Mdn = 3.0, IQR = 3.50), Z = 70.50, p < 0.013). All other measures of perspective (second- and third-person pronouns) were not significantly different between the two conditions.

There was variation between participants in the total number of pronouns (IQR = 25.50) and number of third person pronouns (IQR = 24.00) in the video condition, and in the total number of pronouns in the VR condition (IQR = 21.5).

DISCUSSION

This study investigated the effect of VR immersion on language produced in narrative retell, to determine whether immersion in VR can replicate a realistic communication experience in participants with no communication disability.

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^{*}Statistical significance.

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Question 1: Effects of VR immersion on discourse micro- and macro-structure

Narratives retold following immersion in VR were significantly less morpho-syntactically long and complex as measured by MLU-m, though did not differ in terms of syntactic subordination, lexical diversity, or the proportion of information content produced. This suggests that the video condition elicited narratives with more syntactically complex sentences, but comparable lexical and information content compared with VR narrative retells. While differences in the complexity of discourse elicited in response to different stimuli are well documented (Bliss & McCabe, 2006; Kintz & Kim, 2023; Stark, 2019), both samples analysed in this study were narrative retells. As such, the genre of the sample was likely not an influencing factor. However, the nature and content of elicitation materials used to prompt the narrative retells may have influenced syntactic complexity.

Elicitation methods are known to impact on the complexity of narratives (McCabe et al., 2008; McCullough et al., 2017; Westerveld & Gillon., 2010). Westerveld and Gillon (2010) found that narratives produced when retelling a fictional story from a picture book had greater morphosyntactic complexity and lexical diversity than freely generated narratives told about personal experiences. The differences between the video and VR retells in this study are consistent with these discourse patterns. That is, video retells were less syntactically complex than those told following VR immersion, where participants appeared to be responding more in line with retelling a personal experience. These findings might reflect that immersion in VR influenced participants to generate narratives with greater similarity to recounted personal events, than to retold fictional stories.

Question 2: Cognitive demands of narrative retell

Theoretically, the linguistic differences between personal and fictional narratives relate to working memory capacity (Westerveld & Gillon, 2010). To produce a narrative, the participant must activate a story schema, organize this content in a logical way and utilize language that contains explicit language and complex syntactic structures. The fictional elicitation context provides a scaffold for narrative retell, whereas personal narratives may not provide the same level of structure. The present study, however, negated effects of working memory capacity, as we provided a structured personal experience through VR, where the participant experienced the fictional story and was provided with a schema to follow while retelling the story. As such, no differences were seen in the fluency of retells between the VR and standard retell conditions.

Question 3: Perspective of narrative retell

In addition to changes in syntactic complexity, narrative retells generated in response to VR immersion produced significantly more first-person pronouns compared with the video condition. This may suggest that participants experienced an increased 'feeling of presence' (Jones et al., 2004: 590) in the immersive VR environment, and were therefore generating a narrative of their immersed experience, rather than retelling a fictional story. The grammatical production of first-person pronouns (e.g., I, we, me) indicates the use of first-person perspective in the narrative told, reflects personal subjectivity, and implies explicit reference to oneself (Hinzen & Rossello, 2015). This pattern of self-reference suggests that in response to VR immersion, healthy adults without communication disability produced personal narratives describing their own experiences rather than describing another's experience, as they did in the video retell condition. Garcia et al. (2007) previously suggested that this outcome would support the use of VR to assess language in simulated functional contexts. However, further research is needed to validate the preliminary findings reported in this study and determine if this use of VR to elicit narratives might support language assessment in adults with communication disability.

Considering these findings, immersion in VR may provide a realistic communication experience, balancing ecological validity and experimental control in discourse elicitation tasks (Peeters, 2019). Such a tool would provide a way to elicit a personal story that is representative of functional communication (Whitworth, 2010), while also providing an avenue for structured experimental control over the nature and content of language produced (Bliss & McCabe, 2006). Clinicians and researchers may then have an accessible tool that controls the discourse elicited in the same way as the more commonly used picture descriptions and fairy-tale retells (Bryant et al., 2016), while also allowing individuals to discuss their own perceptions and experiences to generate a self-referential narrative. A controlled elicitation tool such as the VR immersion opens opportunities for researchers to collect normative data to assess and monitor changes in discourse, using strategies previously applied to picture descriptions and fairy tales (Marini et al., 2011; Richardson et al., 2021; Yorkston & Beukelman, 1980).

It is notable that individual variations were observed across discourse measures when comparing video and VR

of VR immersion on the production of narrative discourse. The video and VR conditions used to elicit narratives aphasia (Worrall et al., 2011).

Considering the vital importance of producing personal narratives to people with acquired communication disability (Hillman et al., 2018; Whitworth, 2010), more attention in this area is needed. Future research should focus on validating the results of this study through further study across healthy controls (i.e., adults with no communication disability) and participants with acquired communication disability. This will strengthen our understanding regarding the potential of VR immersion to elicit personal narratives in clinical populations.

Future research should also confirm criterion validity by assessing how accurately use of pronouns reflects immersion in VR. While the relationship between immersion and pronouns is clear in other narrative studies (Hartung et al., 2016), there is no known application of this measure to the

narrative retells, even with the healthy adult sample without communication disability used in this research. Three participants in particular retold the VR narrative using third-person perspective (i.e., pronouns he, she, they) and so did not show the same patterns of language use as the rest of the cohort. If pronouns are representative of immersion (Hartung et al., 2016), this may suggest that some people did not experience a sense of immersion or presence within the VR simulation, but rather experienced it as a viewing experience of which they were not a part (Smith & Mulligan, 2020). The findings suggest that sense of presence and effectiveness of VR in eliciting personal experiences vary between individuals, confirming prior research on 'sense of presence' in VR (Riches et al., 2019). Riches et al. (2019) interviewed 76 healthy participants after immersion in VR, and identified that sense of presence could be affected by emotions about self and others (e.g., anxiety, detachment, recognition of self), thoughts about self and others (e.g., social judgement, paranoia), physiological reactions (e.g., anxiety and cybersickness), behaviour of avatars (e.g., narrative duration and characteristics of interaction), and interactivity within the environment (e.g., movement and familiarity). Further, the authors found that VR simulations created a stronger sense of presence when participants experienced genuine responses (e.g., emotional, behavioural) and presence decreased when participants felt cyber sickness and were aware of apparatus and body movements (Riches et al., 2019). As the present study did not include a qualitative interview post-immersion, factors affecting participant immersion and subjective feelings of presence in the VR simulation are not clear. Future research examining discourse elicitation following VR immersion will need to examine sense of presence using post-immersion interviews to better understand the factors that affected immersion and narrative generation in cases where individuals provide fictional narrative retells than personal narrative generations.

Limitations

This study investigated a small sample size. Results should be interpreted with caution until future research can extend and validate findings. While appropriate for the preliminary nature of this research, the small sample size may have influenced the high variability between participants and the non-normally distributed data set. Nonparametric statistical analysis was used to account for distribution, and a high level of reliability in the discourse measures provide strength to these findings. However, future research will need to replicate this study with more and older participants, and those with a range of acquired

communication disabilities to better understand the effects

in this research were not identically matched in terms of length and complexity, and so varied in the number of content units that participants could produce. This, rather than the genre of narrative elicited, may have influenced the level of syntactic complexity observed in the narratives of participants and masked effects of elicitation condition. However, it may not be clinically possible to match two different stories completely in number of key events and details. Therefore, future research may explore the viability of creating similar narratives specifically for the purpose of assessment, that can be utilized in both VR and video conditions.

Clinical implications and future directions

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Based on the findings of this preliminary study, further research is warranted to determine whether immersive VR environments have potential for clinical use. Findings of the present study need to be replicated and validated to determine whether VR could be used as a structured narrative elicitation tool that balances experimental control and ecological validity. If these findings can be validated, it may be possible to direct narrative discourse assessment for people with acquired communication disability towards more functional outcomes that can be objectively measured over time. Clinicians for example, may use an immersive VR story environment to assess a client's personal narrative production and use this information to guide therapy goals, or repeat the same immersive VR environment to retest a person's progress post-intervention. In this way, the clinician might gain a more functional view of communication, in line with the prioritization of life participation goals commonly identified by people with



study of immersion in VR specifically. Further validation of this measure might be achieved by comparing subjective reports of immersion with quantitative production of first-person pronouns. Understanding the mechanisms of immersion, sense of presence, and personal narrative generation may inform the clinical suitability of using VR to elicit personal narratives in clinical and research contexts.

CONCLUSIONS

This study aimed to investigate the effect of VR immersion on narrative retell and to determine whether immersion in VR can simulate a realistic communication experience in participants with no communication disability. Most linguistic measures showed no significant difference between the two conditions. This finding suggests that video elicitation methods remain a clinically appropriate tool to assess narrative discourse. Participants produced significantly more syntactically complex sentences following the video condition, which may have resulted from genre or content effects. Participants produced more first-person pronouns in the VR condition, potentially reflecting participants' salient perspectives within the VR simulation, in which they felt present and part of the story experience. The findings from this study illustrate that further research is warranted to determine the potential of immersive VR technology in eliciting personal narrative discourse in a controlled and repeatable way, balancing experimental control and ecological reliability. Should future studies validate these findings, VR could aid clinicians in assessing functional narrative ability adults with communication disability and guide therapy targets towards life participation-oriented long-term goals such as telling personal experiences in everyday life.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The research presented here was completed in partial fulfilment of Clarisse Baker's Masters of Speech Pathology degree.

DATA AVAILABILITY STATEMENT

The data collected and reported in this research paper are subject to participant confidentiality, and therefore cannot be shared.

ORCID

Lucy Bryant https://orcid.org/0000-0001-8497-7406

Emma Power https://orcid.org/0000-0002-2638-0406

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