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Case Report

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Case Reports in the Integration of Technology with Cognitive Rehabilitation for Individuals with Memory Concerns and Their Care Partners

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ABSTRACT

Objective: Technology can be combined with psychological interventions to support older adults with memory concerns. Using a bi-phasic design, cognitive rehabilitation (CR) was integrated with off-the-shelf technology and delivered to two people with cognitive impairment, and one care partner.

Method: Pre- and post-intervention assessments were completed for all participants. Individuals with memory problems received pre- and post-intervention remote neuropsychological assessment (i.e., Rey auditory verbal learning test; mental alternations test; animal fluency), and the hospital anxiety and depression scale (HADS). The care partner completed the HADS, Zarit burden interview, and neuropsychiatric inventory questionnaire. Change metrics incorporated reliable change indices where possible. Goals were tracked using the Canadian occupation performance measure; these data were analyzed through visual inspection. A research journal (used to document intervention process) was analyzed thematically.

Results: Results cautiously suggested our integration was feasible and acceptable across several technologies and varying goals. Across participants, significant changes in goal progress suggested the integration of technology with CR successfully facilitated goal performance and satisfaction. The research journal underscored the importance of a visual component, intervention flexibility, and a strong therapeutic alliance in integrating technology and CR.

Conclusions: CR and technology present a promising avenue for supporting people living with cognitive impairment. Further exploration of technology and CR with a range of etiologies and target goals is warranted.

Keywords: Cognitive rehabilitation; Aging; Case reports; Everyday functioning; Quality of life; Caregiver issues

INTRODUCTION

Populations around the globe are aging into older adulthood (World Health Organization, 2020). With an aging population comes an increasing prevalence of age-related cognitive impairment and dementia (Alzheimer's Disease International, 2021; Corrada et al., 2010), despite declining incidence (Wu et al., 2017). As the prevalence of dementias rises, there is need for interventions to minimize the impact of the disease. Cognitive rehabilitation (CR) is a promising but understudied (Huntley et al., 2015) non-pharmacological intervention that has been demonstrated to help individuals with mild cognitive impairment (MCI), early-stage dementia due to Alzheimer's disease (AD) and vascular dementia (VaD) create (Burton et al., 2016) and attain personally important functional goals (e.g., Bahar–Fuchs et al., 2013; Clare et al., 2019; Clare & Woods, 2003; Kudlicka et al., 2023). CR can be adapted to different modalities (e.g., videoconferencing; Burton & O'Connell, 2018), with others discussing how technology may be used to augment CR (e.g., Frank Lopresti et al., 2004; Seelye et al., 2012). Further, CR can be used to train older adults who may or may not be living with impairment in technology use (Imbeault et al., 2016; O'Connell et al., 2003; O'Connell et al., 2021a). Literature (e.g., Astell et al., 2019; Seelye et al., 2012) and the experiences of care partners (R. Beleno, personal communication, May 1, 2020; S.

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Green and N. Stewart personal communication, November 1, 2021) have indicated that technology can be leveraged in the caring for people living with dementia, including the potential for remote monitoring (Coradeschi et al., 2013; Snyder et al., 2020), supporting cognitive functioning (Irazoki et al., 2020) and fostering independence (Lorenz et al., 2019). As such, we sought to explore the intersection of CR and technology to increase the quality of life for individuals living with cognitive impairment and their families.

Clare and colleagues (e.g., Clare et al., 2010; Clare et al., 2019) developed the dominant approach for CR for individuals with early-stage dementia due to AD (or mixed AD and VaD), emphasizing functional goals (Clare, 2008). The process entails assessment (Clare, 2008), followed by a collaborative discussion of the person's goals (Clare et al., 2011). Goals frequently include everyday memory problems, practical skills, and activities and concentration. These types of goals have yielded functional benefits for participants across studies (e.g., Bird, 2001; Clare et al., 2003; Clare et al., 2010; Clare et al., 2019; Kim, 2015; Thivierge et al., 2014) and Cochrane reviews (see Bahar-Fuchs et al., 2013; Kudlicka et al., 2023). Goals selected aimed to maximize current function rather than attempting to restore lost abilities (Clare & Woods, 2004). Much of the time, these goals are addressed through weekly 1-hr sessions using empirically supported methods such as spaced retrieval (Camp & Stevens, 1990), errorless learning (Clare & Jones, 2008; de Werd et al., 2013), cueing and fading (Glisky et al., 1986), and memory aids (Clare, 2008). Although CR has been recognized as important (Bahar-Fuchs et al., 2013; Clare & Woods, 2001 & 2003; Kudlicka et al., 2023; Thivierge et al., 2014), more research is needed to evaluate CR for individuals with early-stage dementia.

Care partners of persons living with dementia are also important for implementation of CR (Bahar-Fuchs et al., 2013; Kasper et al., 2015; Neely et al., 2009; Quayhagen et al., 2000). Additionally, several studies have suggested that care partners can benefit from CR (Burton & O'Connell, 2018; Germain et al., 2018; Moebs et al., 2017). For instance, one care partner Burton and O'Connell's (2018) small-scale randomized control trial reported increased quality of life due to CR and described how other family care partners spontaneously engaged in the CR strategies, which helped with meaningful engagement with the person living with dementia. As well, other authors have reported attitudinal shifts around caregiving, increased coping strategies (Moebs et al., 2017), as well as lessened subjective and objective experiences of care partner burden (Germain et al., 2018) after participating in CR.

CR has the potential to be adapted, integrated, and expanded to benefit people living with dementia and their care partners (e.g., Seelye et al., 2012; Elbogen et al., 2019). As an example, Burton and O'Connell (2018) demonstrated that CR could be delivered over telehealth videoconferencing in a manner that was both feasible and acceptable to participants. In the realm of assistive technology, some have suggested that smart technologies may have a place in CR (e.g., scheduled cues; Seelye et al., 2012). When considering technology for use in CR, literature from traumatic brain injury rehabilitation suggests four main features: support in the execution of complex daily tasks, automatic error detection, home-based performance, and accessibility (Cogollor et al., 2018). The authors suggested that these features maximize the chance for an efficient and personalized CR program. Though exciting, it has been urged that the functional emphasis of CR must not be lost in pursuit of novelty (Meiland et al., 2017). Maintaining a functional emphasis becomes especially important when working with older adults, who must be able to see the functional benefit of technology (Bharucha et al., 2009).

Investigations into the integration of technology for CR methods have been documented previously (Boake, 2003; Kurlychek, 1983; Talassi et al., 2007; Wilson, 2008), including in the management of dementia (e.g., Dewar et al., 2016; Elbogen et al., 2019). As an example, De Oliveria Assis et al. (2010) reported a case study where CR was integrated with technology (i.e., computer games, a mechanical calendar, an activity board, and a routine organizer). The case described B.S., a 73-year-old male diagnosed with probable AD wishing to address his memory, language, calculation, and spatial–temporal orientation, as well as functional abilities. He received individual CR sessions twice a week, one at home and one in an outpatient clinic; errorless learning was prioritized. During home sessions, the calendar and routine organizer were used to stimulate spatial and temporal orientation and improvements in daily living activities. Notably, B.S.'s family members were involved in the intervention goals and were trained to use the equipment to assist at home. Clinic-based sessions began with reality orientation using the calendar and software exercises. Subsequently, games and exercises were carried out using the computer program and activity board; exercises were selected based on goals as well as B.S.'s occupational history. Through this work, improvements in temporal orientation and verbal fluency, as well as qualitative reports of improved activities of daily living were noted (de Oliveira Assis et al., 2010).

Another group described a series of case studies where three individuals with AD were taught to use an app and integrate its functions into their daily lives (Imbeault et al., 2016). The app (Imbeault et al., 2011) was designed to help individuals with AD compensate for their memory problems in day-to-day activities (e.g., remembering appointments and medication). All participants successfully learned an app and incorporated its functions (e.g., appointments or a notepad) into their daily lives. In these cases, technology appeared useful on a long-term basis, despite the progression of AD. For one participant there was evidence of 24 months of use of the external cognitive aid (Imbeault et al., 2016). It is also worth noting that one care partner in this investigation reported decreased feelings of burden following the introduction of an app-based organizer.

Care partners of people living with dementia can also benefit from the integration of technology into caregiving (Astell et al., 2019). For instance, the use of technology has been reported to decrease experiences of care partner burden (Topo, 2009). A potential example is the use of technology for remote monitoring of people with dementia (Coradeschi et al., 2013; Snyder et al., 2020), which has been reported to increase the potential for a care partner to relax in the home (S. Green and N. Stewart personal communication, November 1, 2021; Snyder et al., 2020). Relatedly, technology has been reported to help foster the independence of people living with dementia (Lorenz et al., 2019), which may decrease the frequency and intensity of care partner involvement. Additionally, in rural settings, technology has helped provide access to health and support services, as well as education and information about dementia (O'Connell et al., 2014). Though this evidence is promising, a concern noted in the use of technology for caregiving is the trade-off between "effort and relief" (Holthe et al., 2018, p 759). Holthe and colleagues described that the success of a technology for caregiving was contingent on care partner engagement, time, and willingness.

Considering the earlier evidence, case studies appear uniquely positioned to demonstrate the benefits of CR for both a person with memory impairment and a care partner through a flexible and individualized approach. As such, our study focused on three case reports using off-the shelf technology coupled with CR. To date, there has been little attention to the use of off-the-shelf technology with CR in dementia contexts, though some have suggested the benefits of smart environments (e.g., tracking of behaviors related to MCI; see Chikhaoui et al., 2018) and descriptions smart environments for other populations (e.g., CR in traumatic brain injury; see Jasiewicz et al., 2011).

It is especially important to understand the process by which technology can be integrated in supporting people living with dementia and their care partners as we emerge from the COVID-19 pandemic, as evidence has suggested that this world event has changed the perceived usefulness of technology in the eyes of some older adults (e.g., Grewal et al., 2024; Haase et al., 2021; O'Connell et al., 2021a). Given that techniques often included in CR (e.g., spaced retrieval) have been applied in a tele-rehabilitation format (Burton & O'Connell, 2018) it is reasonable to expect the therapy to be amenable to flexibility in modality and implementation, presenting a unique opportunity to probe how best to practically introduce technology into a person's world. Presently, we investigated the feasibility, acceptability, and impacts of delivering CR integrated with various off-the-shelf technologies to individuals with memory concerns and their care partners to gain insight into how technology and caregiving may interact to increase quality of life.

MATERIALS AND METHODS

Experimental Design

This study details three cases conducted under a bi-phasic design (Boakye et al., 2022; Tate & Perdices, 2015). Though a multiple baseline design (e.g., Burton & O'Connell, 2018) was initially planned, our participants each articulated one goal at intervention outset, so the design was changed to maintain the spirit of CR (Clare, 2008). Each participant was observed repeatedly during the baseline and treatment phases. The repeated observations over the baseline and treatment phases met the criteria for a bi-phasic design (Kazdin, 2011; Tate & Perdices, 2015). Importantly, we selected minimum three-week intervals based on single-case experimental design guidelines (Smith, 2012). These guidelines indicate three as the minimum number of data points to establish acceptable baseline and the minimum number of data points needed in each phase (Smith, 2012).

Recruitment

Ethical approval for this case series was granted by the University of Saskatchewan Behavioural Research Ethics Board (approval #1413). Participants were recruited through community-based organizations, doctors' offices, and a hospital-based geriatric assessment program. Due to troubles with enrolment in past CR studies in our setting (Burton et al., 2018 and the COVID-19 pandemic, inclusion criteria were intentionally broad. Individuals with subjective cognitive decline and no diagnosis, MCI, early-stage dementia due to AD, or mixed AD and VaD were invited to contact us if interested in the study and were consequently eligible for participation. Participants with or without a care partner were invited, including the possibility that a care partner was the primary participant. There were no exclusion criteria beyond these factors. Diagnoses were self-reported, but all self-reported diagnoses were examined with a clinical interview, neuropsychological testing, and questionnaires administered in the assessment phase (see subsequently). All individuals were encouraged to participate with a family member or friend, but having a care partner participate was not mandatory. Informed consent procedures consisted of formal documentation using a consent form, along with iterative discussions between KG and each participant, as consent is an ongoing process (Wiles et al., 2007).

Measures

Two sets of measures were used, namely pre-post and weekly measures. First, a set of measures were administered to participants at the initial assessment and after the intervention was delivered. Second, weekly observational measures and measures of goal performance and satisfaction were collected. The measures selected were informed by the CR programs of Clare et al. (2010, 2019) and previous studies based on this work (e.g., Burton et al., 2018).

Initial assessment and post-treatment measures

All participants completed the following pre- and post-intervention: an interview (i.e., a flexible clinical interview, and a semi structured exit interview) and self-report measures of mental health. Neuropsychological testing was conducted for participants with memory difficulties, Support persons completed measures of mental health (self and participant), and care partner burden. All pre-post measures were selected based on a predetermined set of measures being used in an ongoing wing of clinical research aimed at studying the barriers and facilitators to use of videoconferencing technology to deliver post-diagnostic dementia care remotely (Rural and Remote Memory Clinic—interventions [RRMCi]). Neuropsychological measures given in the RRMCi were selected from the Canadian longitudinal study on aging's (CLSA) remote neuropsychological battery (O'Connell et al., 2021a; Tuokko et al., 2017) that has normative data for remote delivery (O'Connell et al., 2021b). Measures were also selected from the RRMC's neuropsychological battery if the participant required in-person testing. Each of the measures and their psychometric properties are briefly described subsequently. The neuropsychological battery was constructed for each participant as appropriate to facilitate hypothesis testing around cognitive functioning and subsequent intervention

Table 1. Overview of the neuropsychological assessment batteries for the two participants with memory difficulties. Batteries were constructed based on clinical hypotheses and participant factors (e.g., setting of the assessment)

Assessment Domain	Ms. K	Mr. Q
Screening	MMSE	MMSE/t-MMSE
Premorbid estimate	-	ACS premorbid
Attention/working memory	-	WAIS-IV
		Digit span forward
		Digit span backward
Processing speed	-	DKEFS
		Number sequencing
		Letter sequencing
		Color naming
		Word reading
Language	AFT	DKEFS
		Letter fluency
		Category fluency
		AFT
		BNT (15-item)
		Token test
		Point and repeat
Visuospatial skills	RBANS Line Orientation	WAIS-IV
		Block design
Learning and memory	BVMT-R	BVMT-R
		CVLT-3-SF
		WMS-IV logical memory
		REY-I and REY-II
Executive functioning	MAT	DKEFS
		Letter-number switching
		Category switching
		Inhibition
		Inhibition-switching
		MAT
Mood/anxiety	HADS	HADS

Note: MMSE = mini mental state examination; t-MMSE = telephone administered mini mental state examination; ACS premorbid = advanced clinical systems estimate of premorbid functioning; WAIS-IV = Wechsler adult intelligence scale, fourth edition; WMS-IV = Wechsler memory scale, fourth edition; CVLT-3-SF = California verbal learning test, third edition, Short form; BVMT-R = brief visuospatial memory test—revised; D-KEFS = Delis–Kaplan executive function system; BNT = Boston naming test; HADS = hospital anxiety and depression scale; REY = modified Rey auditory verbal learning test; AFT = animal fluency test; MAT = mental alternations test; RBANS = repeatable battery for the assessment of neuropsychological status.

planning (see Table 1 for a summary of each neuropsychological battery).

Modified mini mental state examination and telephone modified mini mental state examination

The mini mental state examination (MMSE; Folstein et al., 1975) is a widely used brief instrument for screening cognition, taking about 5–10 min to administer. Covering a range of domains including orientation, registration, attention and calculation, recall, and language, the MMSE allows a snapshot of an individual's cognitive status. It has a range of 0–30 and is pathognomonic, such that decrements in scores are very clinically meaningful. The remotely administered telephone MMSE (t-MMSE: Newkirk et al., 2004) was also administered. It has been shown to correlate strongly to the traditional version (Newkirk et al., 2004). Further, it has been suggested as a reliable and valid remote method to estimate cognitive status in dementia (Newkirk et al., 2004; Wilson et al., 2010).

Brief visuospatial memory test-revised

The brief visuospatial memory test-revised (BVMT-R; Benedict, 1997) was used to assess visuospatial episodic memory. There are three learning trials, in which a stimulus page containing six geometric shapes was presented for 10 s. The examinee was then asked to draw as many as they could remember in the correct place on a response page (i.e., immediate recall); this procedure is completed three times. A delayed recall trial is administered after 25 min. Finally, a recognition trial is administered where the respondent was asked to identify which of 12 shapes were included among the originals. Investigations of the psychometric properties of the BVMT-R point to adequate reliability and validity (Benedict, 1997; Benedict et al., 1996; Kane & Yochim, 2014). Further, it has demonstrated utility in detection of memory deficits (e.g., Strauss et al., 2006).

Repeatable battery for the assessment of neuropsychological status

The repeatable battery for the assessment of neuropsychological status (RBANS; Randolph et al., 1998) provides a brief evaluation of adult cognitive functioning across 12 subtests (Strauss et al., 2006). Of these 12, we used the line orientation subtest. Line orientation requires the examinee to match two variably oriented target lines to a multiple-choice array of 13 lines arranged at equal intervals along a 180-degree axis. The test consists of 20 items (each with two "target" lines), with a score range of 0–20, and is balanced in the number of target lines presented on the left and right sides of the display. The RBANS has been suggested to have good utility for detecting neurodegenerative cognitive profiles (Karantzoulis et al., 2013), as well as adequate test–retest reliability (Dong et al., 2013).

Modified Rey auditory verbal learning test

The original Rey auditory verbal learning test (RAVLT; Rey, 1964) asks participants to remember a list of 15 words over a series of learning trials. The CLSA version, termed the REY, was modified in two ways: (i) it was administered by telephone, using a recording to ensure standardized timing of the list; and (ii) it consisted of a single exposure trial with immediate recall (REY-I) and a 5-min delay with free recall (REY-II; Tuokko et al., 2017). The parent RAVLT has indexed good test–retest reliability (Lezak et al., 2004) and has been shown to be highly sensitive to cognitive decline (e.g., Estévez-González et al., 2003; Tierney et al., 2005).

Animal fluency task

In the animal fluency task (AFT; Goodglass & Kaplan, 1983) participants are asked to name as many animals as possible in 60 s. A lenient scoring algorithm was used where scoring was consistent with rules for semantic fluency in the Delis–Kaplan Executive Function System (Delis et al., 2001a; O'Connell et al., 2021b) where credit can be given for each distinct animal named. AFT is highly sensitive to normal cognitive decline and can dissociate normal aging from early-stage dementia (Crossley et al., 1997; Hall et al., 2011). AFT has been suggested to have adequate psychometric properties (Delis et al., 2001b), sufficient for inclusion in the CLSA (e.g., reliability, validity, and responsiveness to change; Tuokko et al., 2017).

Mental alternation test

The mental alternation test (MAT; Teng, 1994) is a verbal analog of the trail making test (Reitan, 1958), where participants must verbally alternate letters and numbers in ascending order (Teng, 1994). The score is the number of consecutive correct responses in 30 s. The MAT has been shown to be highly sensitive and specific for detecting cognitive impairment (Billick et al., 2001; Jones et al., 1993). As well, Tuokko et al. (2017) detail that the MAT is derived from the trail making test, which is highly sensitive to progressive neurodegeneration (e.g., dementia; see Lezak et al., 2004), so it is anticipated that the same would be true of the MAT.

Hospital anxiety and depression scale

The hospital anxiety and depression scale (HADS; Zigmond & Snaith, 1983) is a freely available scale (for research) that has been shown to be responsive to anxiety and depression (Bjelland et al., 2002; Creighton & Kissane, 2019; Zigmond & Snaith, 1983). It has generally satisfactory psychometric properties (e.g., Bjelland et al., 2002). Both of its subscales (i.e., depression and anxiety) were used here. The HADS has been noted to be acceptable and feasible within a dementia population, with factor analytic guidance pointing towards separate depression and anxiety factors (Stott et al., 2017). Further, recent investigation of the HADS in a sample of care partners suggested it has robust psychometrics with good internal consistency and convergent validity (Vatter et al., 2020). Review evidence has also suggested the HADS to have adequate reliability and validity in medical patients (Herrmann, 1997).

Neuropsychiatric inventory questionnaire

Completed if a care partner was present, the Neuropsychiatric Inventory Questionnaire (NPI-Q; Kaufer et al., 2000) is a flexible and relatively brief screening instrument for neuropsychiatric symptoms in neurocognitive disorders such as dementia. It allows a snapshot of the severity of various symptoms, while simultaneously evaluating the amount of distress the symptom is causing the care partner. Completing the twelve NPI-Q questions required about 10 min. Evidence suggests that the NPI-Q correlates with its parent, the Neuropsychiatric Interview (e.g., Kaufer et al., 2000; Wong et al., 2014), for which validity evidence has recently been reviewed (see Saari et al., 2020). Further, factor analytic evidence supports its use in discerning noncognitive symptoms of dementia (Johnson et al., 2012). Additionally, minimal clinically important difference scores have been suggested for a dementia sample (Mao et al., 2015).

Zarit burden interview

Completed by care partners, the Zarit burden interview (ZBI; Bédard et al., 2001) is a self-report measure of care partner burden. This short form instrument has adequate internal consistency, and there is evidence for its validity (Bédard et al., 2001; Gratão et al., 2019; O'Rourke & Tuokko, 2003) as well as good test–retest reliability (Seng et al., 2010).

Weekly measures

During weekly sessions (i.e., in baseline and treatment phases), participants completed the Canadian occupational performance measure (COPM; Law et al., 2005). At outset, the COPM involves conducting a semi-structured interview where clients identify problems from a range of domains, allowing them to be the experts (Enemark Larsen et al., 2018). Clients rate the importance of each activity from 1 to 10 and then problems (i.e., foci of therapy) are identified (Vyslysel et al., 2021). Presently, this interview phase was combined with collaborative goal setting for CR (Clare et al., 2011). Administration guidelines for the COPM dictate that for each problem clients subsequently rate their current performance and their satisfaction with their performance from 1 ("not able to do it" or "not satisfied at all") to 10 ("able to do it very well" or "extremely satisfied"; Carswell et al., 2004; Law et al., 2005). Performance and satisfaction ratings for CR targets were completed weekly. Importantly, the COPM is responsive to change (e.g., Thyer et al., 2018), with clinical significance regarded to be anything greater than or equal to a change in two points (Law et al., 2005). The measure has demonstrated adequate test–retest reliability (0.84–0.92), with accompanying evidence for its content, criterion, and construct validity (Law et al., 2005).

Technologies

Various off-the-shelf technologies were selected as potential candidates for integration with CR. Given their potential for flexibility and their many features (e.g., alarms, passive monitoring, scheduling) smart-home devices were chosen to

Table 2. Cognitive rehabilitation procedure guided by Clare (2008)

Phase	Description
Assessment	All participants participated in an assessment consisting of pre-treatment questionnaires neuropsychological testing and an interview. Assessments were carried out over one or two sessions, based on availability of the participants.
Baseline	Following initial assessment, goals for cognitive rehabilitation were set collaboratively. Baseline performance and satisfaction was measured using the COPM for all goals during three baseline sessions.
Intervention	Each participant's goal was addressed in cognitive rehabilitation in the fourth week, (i.e., following the baseline phase) allowing for the minimal number of data points required (Smith, 2012). Technology was installed for participants in their homes, and sessions occurred either in-person or by remote methods as preferred by the participants. Remotely delivered sessions were delivered using a platform that the participant was most comfortable with (i.e., Zoom), consistent with proposed guidelines for remote dementia research (O'Connell et al., 2021).

be offered to participants. We selected the Google Nest and Nest Hub, as well as the Amazon Echo Show devices. We opted to have several systems available in case the participant or any involved family/care partners have experience or preferences, because autonomy is important in CR (Seelye et al., 2012). Also, leveraging prior learning is critical when training someone how to use new technology (O'Connell et al., 2003). Further, these devices have a reasonable likelihood of fitting into each participant's lifestyle and environment, a feature noted as significant in assistive technology adoption (Forlizzi et al., 2004). As well, other devices such as smartphones or bluetooth speakers were leveraged for therapy if appropriate. This is described at the level of each participant subsequently, and importantly, technologies were identified and chosen based individual preferences and need.

Intervention

CR followed the procedures outlined by Clare (2008) in her manual *Neuropsychological rehabilitation and people with dementia.* This approach emphasizes individualized, person-centered goal setting. All interviews, assessments, and interventions were completed by a senior clinical psychology doctoral student (KG) and supervised by a neuropsychologist (MEO). An overview of this procedure is available in Table 2. Goals for rehabilitation were participant driven, in keeping with Clare's (2008) guidance. As discussed previously, goals were quantified using the COPM (Law et al., 2005).

Research Journal

A research journal was kept throughout this study documenting each case from planning to completion, as well as information around recruitment (Birks et al., 2008). Entries were made in the journal after planning meetings (e.g., to discuss potential features of a piece of technology); each assessment, baseline, or intervention session; and after the intervention was completed (i.e., exit interview). Journal entries documented session (or meeting) content, reflections on the experience of delivering the intervention, and emphasized any adaptations that were made to make CR amenable to integration with off-the shelf technology. Exemplar task lists used in these case studies can be found in Appendix 1.

Data Analysis

Analysis of participants' quantitative data

Quantitative data was analyzed using a combination of visual inspection and statistics. Statistics were employed in determining changes across measures at the pre/post intervention level (i.e., neuropsychological battery and questionnaires). Visual inspection focused on the baseline versus intervention phases of each case study. Visual inspection is the primary method of data evaluation in single-case research (Busk & Marascuilo, 2015; Kazdin, 2011; Lane & Gast, 2013), and has been employed in previous investigations into CR (e.g., Burton & O'Connell, 2018). Though statistical tools are available for case study designs (see (e.g., Park et al., 1990) they are not widely used (Kazdin, 2011); rather Kazdin (2011) described change that is visibly evident as clinically important. Using visual inspection permitted examination of changes in magnitude of the data as well as changes across intervention phases (Kazdin, 2011). Using Kazdin's (2011, 2019) well-cited approach, we were interested in two characteristics of single-case data magnitudes: changes in means across phases and changes in level across phases. A change in means refers to a change in the average of a measure in one phase to another. A change in level refers to shift, jump, or discontinuity in the data from the end of one phase to the beginning of another. Accompanying these are two rate-of-change characteristics: changes in trend and changes in latency (Kazdin, 2011). A change in trend as defined by Kazdin (2011) is a change in the slope of the data from one phase to the next. Importantly, Kazdin (2011) articulated that a change from no trend (i.e., horizontal line) during baseline to a trend (i.e., increase or decrease in outcome measure) during the intervention phase would constitute a change in trend. A change in latency, according to Kazdin (2011) refers to the time that passes from when the phase changes (i.e., the onset of the intervention) until there is a change in the data.

Using visual inspection to evaluate effects has been shown to be reliable in the presence of strong results (Kazdin, 2011; Matyas & Greenwood, 1990). This is typically taken to mean easily discernable changes from one phase to another (Kratochwill et al., 2013; Lundervold & Belwood, 2000). As such, weak effects may not be reliably detected using this method, leading researchers to probe interventions from which they expect to see clinically significant effects (Kazdin, 2011).

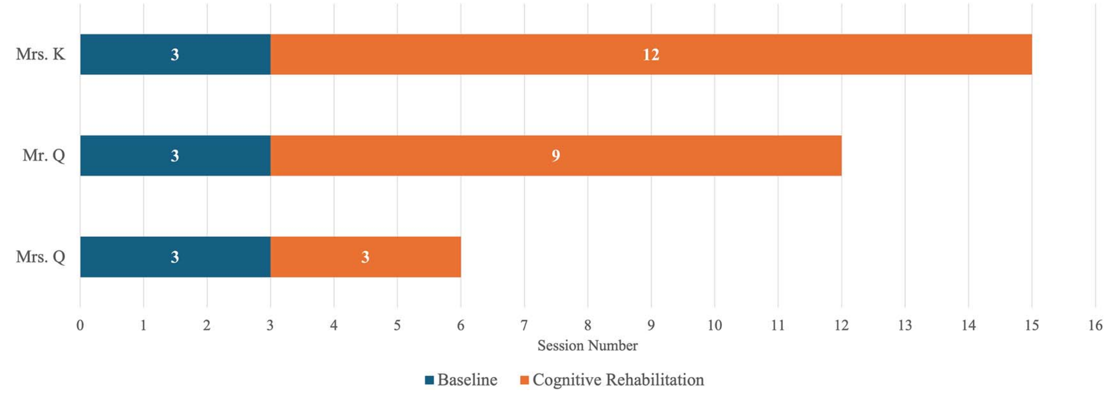

Fig. 1. Visualization of sessions for each case study. Alt text for Fig. 1: a bar graph plotting the number of sessions for each participant.

Kazdin (2011) suggested this to be a strength of the approach in that probing for results easily found by inspection may minimize potential Type 1 errors. In the current study, we were interested in determining whether there was a significant change in performance from the baseline to intervention phase, and changes in level and trend (Kazdin, 2011) were both of interest.

Analysis of qualitative data from the research journal

The journal documenting the experience of integrating CR with off-the-shelf technologies was analyzed thematically. Journal entries were organized into a descriptive summary following the qualitative description method outlined by Sandelowski (2000, 2010). Subsequently, thematic analysis (Braun & Clarke, 2012, 2021) was undertaken. The analysis was informed by theory, as opposed to a purely inductive approach. Coded responses related to ways in which the intervention's integration with technology can be evaluated (i.e., is it feasible; Bowen et al., 2009). These included areas such as acceptability, implementation, practicality, adaptation, and integration (Bowen et al., 2009). This descriptive method was low inference, intended to generate a comprehensive summary of events in everyday terms (Sandelowski, 2000).

RESULTS

The subsequent sections outline a brief description of intervention recruitment factors and three complete cases, including cognitive functioning, goals and intervention planning, intervention progress, and findings. A visualization of each case's progression is available in Fig. 1. Following case descriptions, thematic findings from the research journal are described. All initials have been changed to preserve confidentiality.

Comments on Recruitment

Insights into unsuccessful recruitment

During the recruitment phase, we engaged with two interested care partners who were interested in learning more about and perhaps participating in the study. Unfortunately, both individuals declined our invitations. One care partner stated they were reluctant to participate because the person receiving care had advanced memory impairment and they were worried that CR would therefore likely require a large time investment. Further, the care partner had concerns that her loved one could not fully understand and participate in the research. Another possible care partner was a busy full time healthcare worker, fitting our initial meeting in her lunch break. Unfortunately, we did not hear back, so the reasons for reluctance to participate were uncertain, but it was possibly to the busyness of the care partner and living apart from their care recipient.

Insights into successful recruitment

Several factors seemed to influence successful recruitment. First, all participants expressed a desire for some help with a present problem. The seeking of a solution which could fit into their life circumstance appeared to be a common factor. Additionally, all participants expressed a want to contribute to improving the lives of people with cognitive impairment. With respect to recruitment methods, participants felt that face-to-face recruitment was more effective than advertisements like posters. One participant noted face-to-face approaches (e.g., through knowledge translation talks) were preferable, as "... a poster may stimulate my interest, but with the talk I could ask questions about the requirements right then." Finally, all participants noted that having the technology supplied to them was a major facilitator to participation. In addition to cost concerns, participants expressed that prior to the intervention they were unsure of the technology's benefit, so they would have been hesitant to spend money on devices.

Case 1: Ms. K

Participant history

Ms. K was an 88-year-old right-handed woman with 14 years of education living in an assisted living facility, who hoped to gain help communicating with others. Despite using hearing aids, she was experiencing profound hearing loss which was interfering with her satisfaction in daily life. When obtaining her history, she related experiencing a significant stroke approximately two years prior. As a result, she reported losing the ability to walk independently, decreased bilateral fine motor skills, decreased memory function, as well as loss of hearing. Since the stroke, she had regained some fine motor skills but was still exhibiting bilateral weakness. At the time of intervention, she could walk with a walker but spent most of her time in a wheelchair. It was difficult to ascertain a timeline for Ms. K's hearing loss, so it was assumed that there was likely a combination of cortical

Table 3. Initial assessment and post cognitive rehabilitation assessment measures for Ms. K

Test	Change Statistic (RCI[a]/MCID[b])	Pre-intervention Score	Post-Intervention Score
HADS (raw)			
Anxiety	MCID = 1.4[c]	3/21	3/21
Depression	MCID = 1.6[c]	7/21	3/21*
BVMT-R†			
Total recall (z-score)	No change score reported due to unreliability of the test score.	−2.21	−2.68
Delayed recall (z-score)		−2.17	−1.83
Recognition hits (raw)		6/6	6/6
Recognition false alarms (raw)		2/6	6/6
AFT (z score)	RCI = −1.94[d]	−0.962	−1.92*
MAT (z score)	RCI = 0.225[d]	−1.61	−0.74
MMSE (raw)	MCID = 1.4[e]	22/30	25/30*
RBANS line orientation (raw)	No change score reported. Administration was non-standardized for testing functional limits and clinical conceptualization.	8/20	-

Note: HADS = hospital anxiety and depression scale; BVMT-R = brief visuospatial memory test—revised; AFT = animal fluency test; MAT = mental alternations test; MMSE = mini mental state examination; RBANS = repeatable battery for the assessment of neuropsychological status. Selection of normative data considered the test, clinical issues, and available demographic information. †Mrs. K's age was beyond the typical norms for the BVMT-R. To score this test, we relied on published norms from Benedict et al. (1996); normed recognition scores were not available. Post-test was included for research purposes, but due to underlying visuospatial deficits, served little clinical value. *Significant change in test score [a]Standard error of the difference (SE_D) is the *SD* of the expected test–retest difference score if no change has occurred; accounts for standard error in measurement (SEM) at both time points; $SE_D = \sqrt{2 * (SEM)^2}$. $SEM = SD\sqrt{1 - \text{reliablity}}$. Reliable change indices (RCI; Strauss et al., 2006) incorporate SE_D and expected improvement in performance due to practice effects or expected changes due to standard error in prediction and regression to the mean in addition to practice effects, depending on the RCI formula. The RCI's reported here are in z-score units. [b]MCID—minimum clinically important difference. [c] Puhan et al., 2008 detail changes in HADS scores that were important based on external measures, which is a suggested method for determining MCID. [d]RCI values for AFT and MAT were based on the Canadian longitudinal study on aging comprehensive cohort for in-person assessment. RCIs were generated by Dr. Megan O'Connell (O'Connell et al., 2022). [e] Watt et al. (2021) reported MCID values for the MMSE. Their derived values converge with previously published MCID literature on the MMSE.

deafness and both sensorineural and conductive hearing loss. Ms. K elaborated on difficulties with her memory, recalling her difficulties to be most prominent immediately following the stroke and improving slightly over time. In particular, she noted her short-term memory was worse than her long-term memory; she gave an example of recalling the physical layout of a place she had been many years ago but struggling to remember more recent events. Interestingly, she maintained the ability to read, talking frequently about how it was one of her favorite things to do.

An initial issue when first meeting with Ms. K was her hearing loss impeding conversation, an experience that she related was pervasive in her life. This was worsened by masking mandates during COVID-19. In response, we introduced a medical mask with a clear insert to allow Ms. K to read lips. The new masks were transformative for her; she looked visibly happier and seemed more able to understand KG. In hopes of broadening this benefit to her daily life, Ms. K was provided with two large boxes of these masks to hand out to her visitors. In addition, while working together in session, slow, articulated speech at a high volume assisted in Ms. K's ability to understand.

Neuropsychological functioning

In preparation for the intervention, in-person neuropsychological testing was conducted. The battery consisted of the HADS, BVMT-R, MAT, AFT, and the MMSE (see Table 3). The BVMT-R was used instead of a verbal learning task, because Ms. K's difficulty hearing presented a testing confound.

Ms. K indexed some challenges with measures of executive functioning. She was able to stay on task when listing animals; however, during the MAT she exhibited set loss; she reverted to the alphabet only and stopped listing corresponding numbers. Interestingly, it became apparent during of testing that Ms. K had difficulty with tasks involving visuospatial skills and fine motor control. On one trial of the BVMT-R, she expressed verbally knowing the shapes she should be drawing, elaborating that she was unable to discern their spatial location or draw the figures. She also had marked challenges copying a figure on the MMSE. As a result of this additional confound, we were unable to get a picture of Ms. K's memory.

From these observations, we attempted to discern whether Ms. K's difficulties on the BVMT-R were visuospatial or motor in nature. We used the line orientation subtest from the RBANS to address the source of her difficulties, which Ms. K found quite challenging. On many items she exceeded the time limit, and even when testing the limits (Milberg et al., 2009) by allowing as much time as she needed, she scored poorly (i.e., 8/20). Thus, we concluded the difficulties seen in testing were probably visuospatial in nature, likely secondary to her stroke. These findings were critical for intervention planning, because we became aware that neither visual aids nor pictures should be used within task lists. Further, we identified a need to minimize visuospatial planning or orientation when using or interacting with technology. This case underscored the importance of neuropsychological testing prior to engaging in CR (Clare, 2008). It also highlighted that a clinician cannot gain a solid sense of cognitive strengths and weaknesses just by talking with a patient.

Identification of goals and technology

Ms. K's main goal for CR was to increase her level of social connection in daily life. She also expressed interest in learning how technology could help make her daily life easier. Technology selection consisted of research into possibilities; troubleshooting candidates for selection; and the leveraging of Ms. K's existing knowledge and available technology (O'Connell et al., 2003; see

Table 4. Technology investigated for use with Ms. K

Technology	Source	Reason Selected
iPhone 11 and Siri	https://www.apple.com/by/iphone-11/specs/	–Device already owned by Ms. K –Device familiar to Ms. K –Siri allowed interaction with the device without motor confounds, or getting lost within multiple menu systems
Pocket talker	https://williamsav.com/product/pkt-d1-eh/	–Widely used device in the context of hearing loss –Simple to use –Can be used passively in daily life to improve communication
Technology	Source	Reason Rejected
Telewriter	https://www.sasktel.com/store/product-detail/Personal/Home-Phone/Phones-and-accessories/Telewriter-(TTY)/_/N-275c/_/R-Telewriter__0028TTY_0029	–No land line available in Ms. K's room
iPhone teletypewriter (TTY)	https://support.apple.com/en-ca/HT207033	–Functionally similar to texting –Not intuitive to use
Cell phone captioning services	https://www.healthyhearing.com/help/assistive-listening-devices/captioned-phones	–Only available in the USA; regulated through the Federal Communications Commission
Live captioning glasses	https://xrai.glass/ or https://cog.gatech.edu/support.html	–Only in prototype stage –Only available for Android
Closed captioning for iPhone	https://support.apple.com/en-ca/guide/iphone/iphe0990f7bb/ios	–Still in beta testing stages
Wearable mobile cell phone sound amplifier 72 dB	https://www.amazon.ca/A-GREA-Cell-Phone-Amplifier/dp/B075H759DZ	–Not loud enough –Buttons not intuitive during troubleshooting

Table 4). The initial integration of Ms. K's goal and technology used her iPhone; we aimed to help her make and receive phone calls for social connection. This was something previously inaccessible due to hearing loss, and she related being excited to explore it. As detailed subsequently, Ms. K lost her phone between sessions six and seven, so the technology was shifted to include a pocket talker; however, the goal remained the same.

Number and nature of sessions

Ms. K completed the intake procedure, three baseline sessions, 12 sessions of CR (9 weekly, followed by 3 every two weeks for generalization), follow-up neuropsychological testing and questionnaires, and an exit interview. Sessions took place in her room at an assisted-living facility. Often sessions lasted 70–90 min, longer than typical for CR or psychotherapy. The reasoning for this arose from our conceptualization of Ms. K's presenting problems. In particular, she noted that her sensory impairment left her feeling socially isolated. KG noticed this in session, because Ms. K was often very grateful for visits, and was keen to socialize. Therefore, as a part of the intervention, it was deemed therapeutic to extend session lengths to accommodate the social need of Ms. K. What follows is a description of sessions working towards increasing social engagement and interaction.

Session dynamics and therapeutic alliance

In working with Ms. K, attendance to the therapeutic alliance during sessions was paramount. As mentioned earlier, our sessions were of increased length to accommodate social need, and so time was spent settling into the session with small talk around family and friends. Ms. K noted valuing the social time during the intervention, as it allowed her to feel more like an equal participant in the process. As well, the intervention was delivered such that the dyad were two people working together to solve an external problem. She was happy that the work was approachable and collaborative rather than prescriptive, relating that this made all the difference for her. As well, Ms. K advised that the therapist's approach of humility and curiosity helped minimize frustration and fuel collaborative problem solving.

Baseline phase

The baseline phase (i.e., sessions 1–3) established current ability and satisfaction regarding Ms. K's goal of using technology to facilitate socialization. In particular, the focus was on using her cell phone to make and receive calls. Discussions included who she might call, as well as what issues she was having with the procedure currently. Ms. K related that she had not carried out a phone call in years and would not pick up the phone because (i) she could rarely hear the ringer and (ii) she could not hear the voice on the other end. Ms. K was willing to demonstrate this in session, having the therapist leave the room and initiate a phone call. She was unable to reliably determine whether the phone was ringing nor how to answer it, and on a trial when she did pick up the phone, Ms. K was unable to hear the therapist on the other end. This data allowed the generation of preliminary task lists for Ms. K to engage in phone calls. During clinical supervision, Ms. K's neuropsychological weakness in visuospatial ability was discussed. To accommodate this weakness, integrating the iPhones virtual voice-activated assistant, Siri, into task lists was suggested to avoid manual navigation of menus. This was brought to Ms. K given that Siri and other chatbots have been suggested as a potential avenue for support (Ruggiano et al., 2021).

Additionally, baseline sessions allowed Ms. K to become comfortable with the COPM procedure and establish rapport. She had difficulty during initial sessions assigning a numerical value to her subjective feelings of performance and satisfaction. As the procedure was repeated, she became more accustomed to the COPM. Each session Ms. K would mention "doing the numbers" as a jocular way of signaling this part of the collaborative work.

Intervention phase

Sessions 4–6. Sessions four through six focused on refining task lists and teaching Ms. K how to use her iPhone to make and receive phone calls using Siri. The first issue was determining whether an off-the-shelf technology amplifier from Amazon would assist Ms. K in hearing (see technology selection table). Unfortunately, it was too quiet, and the buttons were too small for Ms. K. Next, we investigated whether the iPhones speakerphone function would be loud enough for Ms. K to hear. After trialing various positions, we found that holding the phone up to her ear while on speakerphone was just loud enough for her to hear a short exchange over the phone. The subsequent focus was going over the task list with Ms. K and refining problem areas.

A notable problem area was setting up the speakerphone function. By default, the iPhone required the user to select and change the audio output from the traditional setting to speakerphone. This step was confusing for Ms. K, because it required her to navigate menus whilst using the phone, so the speakerphone function was set as the new default. The task list was adjusted to match this new information. An additional issue was Ms. K tapping on the speakerphone icon to hear better, not recalling that the adjustment had been made to eliminate this step. The task list was altered again to include a bolded statement indicating that speakerphone was already on and that she did not need to press any additional buttons.

Once the task list had been finalized, CR focused on errorless learning. This entailed slow and repeated practice with the task list until Ms. K felt familiar with the procedure of making and receiving phone calls. As her confidence increased, practice became more independent, and spaced retrieval was introduced. Ms. K showed steady progress, appearing engaged, asking for assistance when needed. Despite the speakerphone being just loud enough for Ms. K, clinical supervision discussions led to the possibility of pairing the speakerphone with a pocket talker to amplify sound and permit more fluid conversation.

Sessions 7–9. Unfortunately, Ms. K's iPhone was lost between sessions six and seven during an outing. The nature of CR shifted, still centered on Ms. K's goal of improved social communication. Instead of the iPhone, a pocket talker (see Table 4) was introduced as communication technology. The device was explored collaboratively, which consisted of finding the ideal volume setting; demonstrating turning it on and off; and practicing holding the device to minimize obstruction the microphone. When Ms. K used the pocket talker for the first time, normal masks were able to be used, and speech returned to a more conversational volume. She was ecstatic, seeing new possibilities for social interaction around the care home. A task list was collaboratively generated for pocket talker use and training.

In session, Ms. K recounted discussing iPhone replacement with her daughter, ultimately deciding it was not worthwhile. As such, the means of reaching Ms. K's goal were formally refocused on teaching Ms. K to use the pocket talker to have conversations with others. This highlighted the flexibility of CR while keeping Ms. K's goal of increasing social contact centered. CR methods remained similar, focusing on errorless learning and spaced retrieval. During learning sessions, many collaborative changes were made to the task list. This iterative process was only possible due to previous rapport building and Ms. K's buy-in. Changes included: altering an instruction to put the pocket talker around her neck to include the word "lanyard"; changing the word "volume" to "dial on the right" because she could not see the volume demarcations on the pocket talker; altering a step indicating that she turn the volume up to a given number to a more general instruction to stop when she could adequately hear the other person; and adding an additional line to the final step indicating that a red light would help signal that the pocket talker had been turned off.

Ms. K related that after several sessions of learning she felt confident enough to try using the pocket talker with others in her facility. Further, she gave consent to discuss our work with the care home director, and the use of the pocket talker was added to Ms. K's care plan. This addition was designed to facilitate practice and independence with the device (i.e., staff were aware she had it and would help her practice).

Sessions 10–12. Sessions 10–12 were aimed at promoting generalization of the pocket talker across Ms. K's life contexts. Ms. K indicated using the pocket talker around the home in many conversations. She also repeatedly demonstrated her ability to put on the pocket talker independently at the beginning of each session. She related that she had encountered some issues hearing people while using the device but excitedly recounted discovering it was due to the other person's distance from the pocket talker's microphone. Ms. K was very proud of this piece of independent learning and problem solving.

Ms. K continued to use the pocket talker independently around the care home. She noted that it had done wonders for her one-on-one conversations, citing that she had much more fluidity in conversing with others. Further, Ms. K described dealing with a previously described limitation of the pocket talker—distance from the microphone—during a bingo session. Initially, she found she was not able to hear the person calling the numbers while using the pocket talker. However, she was able to turn to the person next to her and ask them for assistance, which was possible due to the pocket talker's proximity to this individual. She related that this level of socialization would not have been possible before integrating the technology into her life.

Emergent subgoals

Throughout working with Ms. K, two subgoals emerged. These were not treated as formal intervention targets with a baseline but rather used as an avenue for her to interact with technology and integrate it into her daily life. COPM data were still tracked and are available in Fig. 2.

Changing screen brightness

Early on, a subgoal was identified related to increasing Ms. K's familiarization with technology. She noted that she had difficulty seeing the display on her phone, leading to a discussion

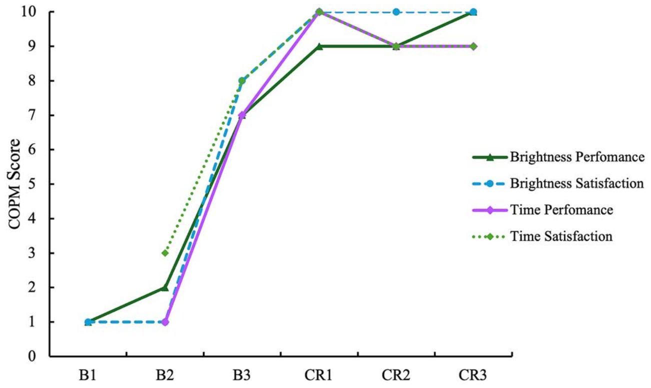

Fig. 2. Canadian occupational performance measure (COPM) scores for Ms. K's subgoals which spontaneously emerged in sessions: using Siri to tell the time and change the brightness on her phone. B = baseline; CR = cognitive rehabilitation session. Note that the X axis labels reflect the timeline of the intervention as it pertained to Ms. K's formal goal and do not reflect any formal baseline measurement for these subgoals. As such, these data were not included in the analysis of Ms. Q's COPM data due to this lack of baseline. Alt text for Fig. 2: a line graph plotting Canadian occupational performance measure scores for Ms. K's subgoals across baseline and intervention phases. Performance and satisfaction scores improved over time.

that brightness was something changeable. Ms. K indicated that she wanted to learn to change the brightness of her phone, so this was used as a subgoal while collecting baseline measurements. Initially, task lists focused on navigating menus and verbal descriptions of steps. 11However, Ms. K was frequently challenged with this approach expressed frustration. Returning to the neuropsychological profile, the idea of using the iPhone's Siri technology was put forth as a way around Ms. K's visuospatial issues. KG then brought this to Ms. K who was thrilled at this new development. Subsequent task lists then focused on using and activating Siri, notably simplifying the procedure.

The first time Ms. K approached a Siri-based task list for changing brightness, she spontaneously and silently read the list in sequence, saying the instructed words leading to success. Ms. K was extremely happy, citing how simple the process was. During this same session, she spontaneously practiced several times while KG held the task list in front of her to read. She did not need to be oriented to the task list. During subsequent sessions, repeated practices were used, along with cueing and fading and spaced retrieval to facilitate uptake of this skill. Ms. K reported practicing between sessions, and her success was reflected in the COPM scores (Fig. 2).

Telling time with iPhone

Ms. K also expressed that she liked using her phone to tell the time but was experiencing difficulties. Specifically, she was using the clock application and getting lost in the various menus. Siri's ability to tell the local time was demonstrated, and Ms. K expressed an immediate desire to learn. It was collaboratively decided that this would be a small target skill during baseline for her main goal and in between training of other skills. Much like the previous subgoal, the task list focused on verbal activation of Siri for telling the time.

When Ms. K approached a Siri-based task list for telling the time, she spontaneously and silently read the list in sequence, speaking to Siri as instructed. This was successful upon first trial, and Ms. K was elated. She was using her phone frequently for telling the time, but related feeling she had more control over the process while using Siri. She excitedly practiced multiple times during the initial session with this task list and seemed overjoyed with the functionality of Siri. She tried once without the task list and stumbled, having some difficulty with using the correct voice command. She was able to consult the task list and was successful on the next attempt. Near the end of the session, Ms. K remarked that she is excited to learn to communicate with Siri, citing that it was "like learning a new language or learning to talk with a new person." During subsequent sessions, repeated practices were used, along with cueing and fading and spaced retrieval with to facilitate learning. Ms. K reported significant extra-session practice with Siri for this purpose, with success reflected in her COPM scores (Fig. 2).

Findings from quantitative data

When examining Ms. K's COPM data through visual inspection (Kazdin, 2011), several patterns can be seen (see Fig. 3). First, the change in COPM score across phases exceeded the minimal threshold for clinical significance (i.e., 2 points; Law et al., 2005). There was also a significant change in means across baseline and intervention phases for Ms. K's ratings of her performance and satisfaction with respect to her goal of social interaction. Further, there was a stark change in level, which is a jump in performance and satisfaction with the onset of the intervention; this change was more pronounced for satisfaction ratings than for performance ratings. There was also a change in trend (i.e., slope; Kazdin, 2011) from the baseline to intervention phases, with performance being more linear than satisfaction. The satisfaction rating pattern was likely related to Ms. K being able to complete a task previously inaccessible to her (e.g., receiving a phone call), resulting in large jumps in satisfaction followed by some regression. In contrast, the performance ratings likely reflected incremental skill building. Finally, there was little latency between the onset of intervention and changes in COPM data, suggesting that CR contributed to indexed changes in self-rated goal progress.

Ms. K also indexed some significant changes between pre- and post-intervention measurements (see Table 3). Her performance on AFT declined significantly, as defined by exceeding the threshold for change delineated by a reliable chance index. Further, her MMSE score significantly declined, and her HADS depression score also significantly declined (i.e., fewer symptoms endorsed), as determined by the change exceeding the thresholds of available respective minimally clinically important difference values.

Perceived impact of intervention

Ms. K described several psychological benefits of participating in CR. First, she often voiced her frustrations about how others perceived her level of functioning following her stroke. She noticed that they seemed to underestimate her and infer lower

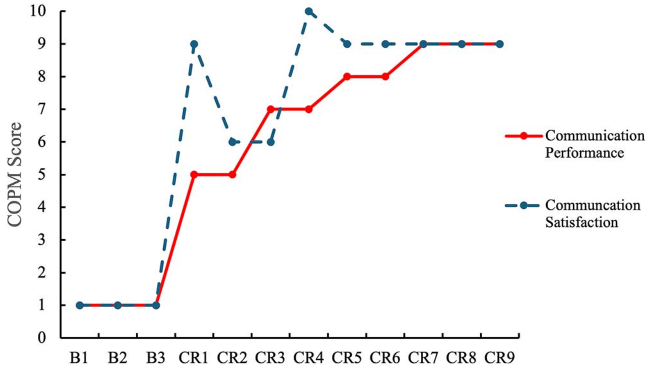

Fig. 3. Canadian occupational performance measure (COPM) scores for Ms. K's goal of increasing social connection through communication with others. B = baseline; CR = cognitive rehabilitation session. Alt text for Fig. 3: A line graph plotting Canadian occupational performance measure scores for Ms. K's main goal across baseline and intervention phases. Performance and satisfaction scores improved significantly during treatment.

functioning from her lack of hearing. However, since working with and learning technology she found that others' perceptions of her were changing which helped her socialize and participate more within the care home. Relatedly, Ms. K reported that her experiences of successful learning had increased her self-esteem and feelings of self-efficacy: "I see that I have a future" she related, in reference to continual learning and social engagement.

Case 2: Mr. Q

Participant history

Mr. Q was a 73-year-old male with 18 years of education who was diagnosed with AD. He lived with his wife (Mrs. Q) in a house in a rural community. He became interested in CR work because of his visit to the RRMC (Morgan et al., 2009), where he participated in a diagnostic interview, neuropsychological testing, and a visit with the clinic neurologist. When inquiring about Mr. Q's difficulties, he related his chief concern to be memory problems, such as forgetting names. He described a slow trajectory of decline over the past two years, with a more accelerated loss of memory more recently. Further, Mr. Q described having challenges with reading, relating that he often had trouble focusing and found himself skipping over lines of text.

Neuropsychological functioning

Neuropsychological testing included remotely delivered neuropsychological tests, as well as more comprehensive in-person testing from the memory clinic visit (see Table 5). Both sets of scores were used to inform case conceptualization and intervention planning, with Mr. Q's consent.

Mr. Q was estimated to have average premorbid functioning, based on developmental, educational, and occupational history. Further, he had difficulty with memory tasks across verbal and visual domains, consistent with his reports of memory problems. He also had challenges establishing mental set for complex tasks of executive functioning which he failed to complete. Mr. Q had notable apraxia (i.e., could not put his boots on, tie his shoes, or use utensils), and exhibited great difficulty with visuoconstruction, drawing, and writing. The combination of visuospatial problems and memory difficulties was suggestive of parietal dysfunction; it is probable he had issues making sense of his visual world. Further probing using a line-orientation task revealed that Mr. Q's difficulties were at the level of perception, as well as the higher-order construction. During the interview, Mr. Q was frequently tangential, and testing data triangulated problems with executive functioning. This included rigidity and inflexibility, as well as challenges with multitasking. Further, he demonstrated manual dexterity and coordination problems. Due to Mr. Q's neuropsychological profile, it was postulated that he required technology that could be interacted with verbally, because his difficulties would prevent him from effectively navigating menus or systems reliant on visual information.

Identification of goals and technology

When discussing aims for CR, Mr. Q related that he had a thirst for knowledge and learning, specifically reading and history. As a result of his ongoing difficulties, Mr. Q discussed his challenges with reading and expressed an interest in exploring ways to keep his mind engaged.

Mr. Q's goal was to be able to engage with audiobooks to circumvent his reading challenges. He was particularly interested in using verbal commands to prevent frustration in navigating technology-based menus. Mrs. Q was supportive and agreed to be a part of the planning and intervention stages. As a part of her participation, Mrs. Q set a goal to learn the technology for audiobooks alongside her husband, acting as a support. Technology selection consisted of research into possibilities, troubleshooting candidates for selection, and the leveraging of Mr. Q's existing knowledge, and available technology (O'Connell et al., 2003; see Table 6). Discussions about technology occurred during the baseline phase. Ultimately, technology selections included the Audible application and several Amazon Echo Devices, as well as existing technology such as an iPhone 10 and a speaker.

Number and nature of sessions

Mr. Q completed the neuropsychological testing, pre-intervention questionnaires and interview, three sessions of baseline, and nine sessions of CR. At the conclusion of the intervention, he completed an exit interview, along with post-intervention neuropsychological testing and questionnaires. Mrs. Q also participated in pre- and post- intervention interviews and completed questionnaires at both time points. Sessions took place virtually over Zoom, lasting approximately 60 min. Sessions typically began by addressing glitches or troubleshooting concerns that arose the week prior, then proceeding with CR methods. COPM measurement occurred every session to track goal progress for Mr. and Mrs. Q respectively.

Session dynamics and therapeutic alliance

As sessions were attended by both Mr. Q and Mrs. Q, it was important to track the interpersonal dynamics. At outset, Mr. Q was more reserved, with Mrs. Q taking the lead around concerns, questions, or recounting the previous week. In response, KG intentionally shifted focus to include Mr. Q, seeking his perspective, and searching for his insights. Mr. Q was less verbose than Mrs. Q, and at times had difficulty with word finding. KG modelled patience with Mr. Q, allowing him space to find the words,

Table 5. Initial assessment and post cognitive rehabilitation assessment measures for Mr. and Mrs. Q

Mr. Q ***Measures administered as a part of the diagnostic memory clinic service.***

Test	**Change Statistic (RCI[a]/MCID[b])**	**Pre-Intervention Score**	**Post-Intervention Score**
MMSE (raw)	-	19/30	-
ACS premorbid (standard score)	-	110	-
WAIS-IV			
Block design (scaled score)	-	Discontinued	-
Digit span forward (scaled score)	-	9	-
Digit span backwards (scaled score)	-	8	-
WMS-IV			
Logical memory I (scaled score)	-	3	-
Logical memory II (scaled score)	-	3	-
CVLT-3-SF			
Trials 1–4 (index score)	-	47	-
Short delay free recall (scaled score)	-	1	-
Long delay free recall (scaled score)	-	1	-
Long delay cued recall (scaled score)	-	1	-
BVMT-R			
Total recall (*T*-score)	-	<1	-
Delayed recall (*T*-score)	-	<1	-
Recognition hits (raw)	-	4	-
Recognition false positives (raw)	-	3	-
D-KEFS			-
Number sequencing (scaled score)	-	1	-
Letter sequencing (scaled score)	-	1	-
Letter-number switching (scaled score)	-	Discontinued	-
Letter fluency (scaled score)	-	6	-
Category fluency	-	Discontinued	
Category switching	-	Discontinued	
Color naming (scaled score)	-	1	-
Word reading (scaled score)	-	1	-
Inhibition	-	Discontinued	
Inhibition-switching	-	Discontinued	
BNT (15 item)	-	Discontinued	
Point and repeat			
Total point (raw)	-	9	
Total repeat (raw)	-	10	
Token Test	-	Discontinued	
Measures administered as a part of cognitive rehabilitation.			
Test	Change Statistic (RCI[a]/MCID[b])	Pre-Intervention Score	Post-Intervention Score
t-MMSE (raw)[c]	-	-	12/26 Prorated = 13.8/30
HADS (raw)			
Anxiety	MCID = 1.4[d]	4/21	3/21
Depression	MCID = 1.6[d]	4/21	6/21*
REY-I (scaled score)	RCI = −1.86[e]	2.61	2.69*
REY-II (scaled score)	RCI = −1.23[e]	6.77	5.52
AFT (scaled score)	RCI = − 0.55[e]	3.55	5.10
MAT (scaled score)	RCI = − 0.88[e]	3.05	3.49
Mrs. Q			
HADS (raw)			
Anxiety	MCID = 1.4[d]	2/21	6/21*
Depression	MCID = 1.6[d]	2/21	1/21
NPI-Q (raw)			
Severity	MCID = 2.77[f]	3/36	4/36
Distress	MCID = 3.10[f]	1/60	2/60
ZBI (raw)	RCI = 0.71[g]	24/88	29/88

Note: MMSE = mini mental state examination; t-MMSE = telephone administered mini mental state examination; ACS premorbid = advanced clinical systems estimate of premorbid functioning; WAIS-IV = Wechsler adult intelligence scale, fourth edition; WMS-IV = Wechsler memory scale, fourth edition; CVLT-3-SF = California verbal learning test, third edition, short form; BVMT-R = brief visuospatial memory test—revised; D-KEFS = Delis–Kaplan executive function system; BNT = Boston naming test; HADS = hospital anxiety and depression scale; REY-I = modified Rey auditory verbal learning test immediate; REY-II = modified Rey auditory verbal learning test delayed; AFT = animal fluency test; MAT = mental alternations test; NPI-Q = neuropsychiatric inventory questionnaire; ZBI = Zarit burden interview. Tests were discontinued based on standardized discontinue rules. If these were not available tests were discontinued based on clear difficulty with easy items. Selection of normative data considered the test, clinical issues, and available demographic information. *Significant change in test score. [a]Standard error of the difference (SE_D) is the *SD* of the expected test–retest difference score if no change has occurred; accounts for standard error in measurement (SEM) at both time points; $SE_D = \sqrt{2 * (SEM)^2}$. $SEM = SD\sqrt{1 - \text{reliability}}$. Reliable change indices (RCIs; Strauss et al., 2006) incorporate SE_D and expected improvement in performance due to practice effects or expected changes due to standard error in prediction and regression to the mean in addition to practice effects, depending on the RCI formula. The RCIs reported here are in *z*-score units. The resultant value can be thought of as a type of *z*-score that can be interpreted with reference to upper or lower tails of a normal probability distribution. [b]MCID–Minimum Clinically Important Difference. [c]Due to CR being remotely delivered, we were unable to administer an in-person MMSE to Mr. Q after the intervention. No change score is reported, considering evidence that in-person and remotely delivered neuropsychological tests are not equivalent (Smith et al., 2023). [d] Puhan et al. (2008) detailed changes in HADS scores that were important based on external measures, which is a suggested method for determining MCID. [e]RCI values for REY-I, REY-II, AFT, and MAT were based on the Canadian Longitudinal Study on Aging Tracking Cohort. RCIs were generated by Dr. Megan O'Connell (O'Connell et al., 2022) and are presented in *z*-score units. [f] Mao et al. (2015) described MCIDs for the NPI-Q subscales through two methods. The distribution-based estimates are reported here. [g]Internal consistency reliability = 0.90 and *SD* = 15.64 (Bedard et al., 2001). Using this information, a SE_D can be calculated: $SEM = SD\sqrt{1 - 0.9} = 4.94$.

$SE_D = \sqrt{2 * \left(4.95\right)^2} = 7.00$. The RCI can be calculated in z-score units using the following formula from Jacobson and Truax (1991): $RCI = (S_2 - S_1)/SE_D$. The resultant value can be thought of as a type of *z*-score that can be interpreted with reference to upper or lower tails of a normal probability distribution. Therefore, RCI scores falling outside a range of −1.96 to 1.96 would be expected to occur less than 5% of the time due to measurement error alone (Strauss et al., 2006).

Table 6. Technology investigated for use with Mr. and Mrs. Q

Technology	Source	Reason Selected
iPhone 10	https://support.apple.com/kb/sp770?locale = en_US	–Device already owned by Mr. Q and his wife –Device familiar to Mr. Q and his wife
Doss soundbox	https://www.dossaudio.com/products/soundbox	–Device already owned by Mr. Q and his wife –Device familiar to Mr. Q and his wife, as they use it for music. They suggested pairing it with the iPhone for audiobooks
Audible streaming service	https://www.audible.ca	–Most dominant audiobook streaming service, so support and guide videos were plentiful online –Large catalogue of books (an important feature for Mr. Q) –Easily integrated with iPhone and Amazon Echo/Alexa
Amazon echo devices	https://www.amazon.ca/Echo-Show-8-2nd-Gen/dp/B084DCJKSL https://www.amazon.ca/Echo-Show-5-2nd-gen/dp/B08J8FFJ8H https://www.amazon.ca/echo-dot-with-clock-4th-gen/dp/B07XJ8C8F7/ref=sr_1_7?crid=DXRC98B80WKB&keywords = echo+dot&qid = 1680030564&s = amazondevices&sprefix = echo+dot+%2Camazon-devices%2C118&sr = 1–7	–Easily integrated with Audible as Amazon owns Audible –Alexa voice commands could be integrated with audible to allow hands-free interaction
Technology	Source	Reason Rejected
Google home	https://home.google.com/welcome/	–Less easily integrated with audible ecosystem
Amazon prime eBooks	https://www.amazon.ca/kindle-dbs/fd/nonprime-pr/	–More limited book selection than Audible for Mr. Q's interests –eBooks were read by a computerized voice, which was not interesting to Mr. Q
Libby app for audiobooks	https://www.overdrive.com/apps/libby	–Limited book selection –Confusing interface for Mr. Q –Only a limited number of copies of each book were available for listening due to the service using the library system. Interested listeners needed to join a queue and wait for their turn. This was not acceptable or feasible for Mr. Q.
Amazon echo spot	https://www.amazon.co.uk/gp/help/customer/display.html?nodeId=G9WAHHEQR29Q7RE9 (No North American link available due to discontinuation)	–Discontinued –Would not be eligible for continued software updates

and this led to Mrs. Q jumping in with less frequency. Over time, Mr. Q gained more of a voice, often beginning sessions by saying "I have some questions." These questions would act as signposts for the session's structure. As Mr. Q's engagement increased, the sessions became increasingly fluid. The rapport was shared among the couple and KG, allowing each person space to contribute, while also giving space for everyone to be heard. This alliance was maintained into the case of Mrs. Q, reported later.

Baseline phase

The baseline phase consisted of three sessions focused on collecting information on current audiobook access and use, as well as areas for improvement or areas in which their current use of technology was not working. The COPM was introduced for progress monitoring, and the Qs became quickly familiar with the scale. The Qs described currently using a free app that leverages the library system (see Table 6) to access audiobooks, but there were several issues: the user interface was not intuitive; each book had a limited number of virtual copies which prevented access to desirable titles; and there were no easily discernable instructions for how to navigate the system. This led into discussions of available options for accessing on-demand audiobooks in a manner mindful of Mr. Q's neuropsychological challenges. To minimize visuospatial challenges, the Amazon Echo and Alexa ecosystem was collaboratively chosen to engage with audiobooks through Audible (Table 6).

As baseline concluded, some preparatory work was completed to maximize intervention sessions. It was requested that Mrs. Q gather passwords for their Apple and Amazon accounts between sessions to streamline setup. An Audible account was created with the Qs using their computer and iPhone. Mrs. Q's organizational ability was instrumental in expediting these initial but critical steps. The Qs were able to download the Audible app and sign in with their Amazon credentials which automatically created an Audible account linked to their Amazon account. Both Mr. and Mrs. Q were keen on the process and spontaneously started exploring the app asking questions (e.g., "can we sample a book before deciding to use a credit") that prompted collaborative exploration. This attitude of exploration was a major intervention facilitator, making sessions feel lively and generative throughout the case's entirety.

Intervention phase

Part 1: Learning audible on iPhone (sessions 4–8)

This phase of intervention involved instructing Mr. and Mrs. Q on using Audible's iPhone application. Mr. Q found the iPhone challenging to maneuver, so Mrs. Q often assisted him with the fine motor skills required to navigate Audible's iPhone application. However, Mr. Q's goal remained centered, benefitting from this flexible collaboration.

Between the final baseline session and the first intervention session, Mr. Q recounted spontaneously exploring the Audible app with the help of Mrs. Q, purchasing his first book. Mr. Q excitedly discussed the book he had selected and related a story from one chapter vividly. Mrs. Q remarked she was impressed with how much he remembered, and the level of detail Mr. Q relayed; she was happy to see Mr. Q so engaged.

Despite this initial success, Mr. Q was unsure whether he would be able to repeat the procedure. Several preliminary task lists were created for buying and accessing a book. These were collaboratively examined by both Mr. and Mrs. Q and were deemed to be sufficient. The task lists were then used in session to ensure they were functionally appropriate. Task list rehearsal involved an errorless learning approach. The couple was thrilled, stating the task lists were "exactly what they needed as reference material" for their practice outside of session. The task lists for this skill and all subsequent skills were provided over email. The Qs would experiment with the task list and report on any adjustments required; these were rare and minimal (e.g., adjustment of wording), because task lists were collaboratively refined in sessions.

In addition, Mr. Q brought many exploratory questions to sessions, prompting collaborative learning and exploration. For instance, Mr. Q was interested in whether bookmarks were possible within Audible's ecosystem. This question was a result of several instances where Mr. Q was listening to his audiobook and his hand accidentally hit a button causing him to lose his place. Mr. Q and Mrs. Q were coached through the procedure. Mrs. Q followed guided instruction using the Zoom camera to assist in visual instruction (e.g., demonstrating where icons were on the screen). This eased the teaching process, because it was challenging to articulate the exact position of a given feature on the screen; it was much easier to demonstrate. After the guided instructions, it was decided that a task list be created for the procedure if they decide to explore the feature further. This example underscores the more consultative and flexible nature of CR with Mr. Q. Other questions included how to buy more Audible credits, how to adjust the volume of the audiobook, and how to cancel the service if desired in the future. Task lists were created for these queries as deemed collaboratively appropriate.

As Mr. Q finished his first audiobook, both Mr. Q and Mrs. Q related the task lists were clear and helpful as reference materials—they appreciated the explicit nature of the instructions, as well as visual aids (i.e., screenshots). Mr. Q then expressed an interest in adding prospective books to a "wish list" for future purchasing. KG was initially unfamiliar with this feature, so the opportunity was taken to learn and create a task list together through shared curiosity and visual demonstration. Additionally, a catalogue of books included with Audible's membership termed the "Plus catalogue" was discovered. These books existed outside Audible's token economy, allowing unlimited title downloads within the catalogue. Mr. Q was thrilled with this discovery, and an additional task list for accessing this catalogue was created.

The next session centered on task list clarification. Mr. Q and Mrs. Q were having difficulty with the steps on how to access the Audible Plus catalogue; this was the most complex task to date. Time was taken for guided instruction leveraging the task list using errorless learning and spaced retrieval techniques. These techniques were combined with a supportive teaching approach (O'Connell et al., 2021a) as mistakes were corrected and explained. The visual demonstration of the steps was critical to the learning process, lending additional clarity. Multiple trials were completed leveraging errorless learning and spaced retrieval. Trials were spaced with small talk (e.g., Mr. Q recalling excerpts from his audiobooks), exploration of Audible's searching and sorting functions, and how to delete an audiobook from their library. Exploration of these other features promoted immersion in the Audible application, and task lists were created at Mr. Q's request.

As the session concluded, the accessing of Audible's Plus catalogue was practiced one more time. The couple worked collaboratively, talking to each other navigate the process (e.g., "we are a team"). Mr. Q indicated he found it "hard work to make progress" but said that he was "invested in it so the work was worth it." Mrs. Q echoed this sentiment and requested some styluses to help with fine motor and touch screen navigation, which were subsequently provided. This was an insightful request given Mr. Q's fine motor challenges, and the difficulty in teaching touch-sensitive technology.

Although Mr. Q continued to practice accessing Audible with his wife's support, he wished to revisit several skills from previous weeks. Mr. Q wanted more assistance with deleting a book from his library and how to make and use a bookmark using the Audible app. Though Mr. Q was articulating the questions, Mrs. Q was the one primarily involved in guided instruction; Mr. Q keenly observed and asked for clarity. Verbal instructions leveraging the task list phrasing, visual demonstration (e.g., pointing to the phone screen through the Zoom camera), and errorless learning were used to guide the couple through each of their questions. Spaced retrieval was also used, by taking breaks for conversation between trials. As with previous sessions, the visual component to the teaching was critical because there were differences in button location between therapist and client. Additionally, several quality-of-life changes were made to the task list procedure, including ensuring all task lists were numbered, and that each task list was printed on a single-sided piece of paper to minimize confusion.

Mr. and Mrs. Q continued to practice with the Audible ecosystem, selecting and enjoying various books. Further, Mr. Q described that in the process of making his next choice, he found two different versions, with different narrators and different reviews. He was able, with support, to trial each book and determine which choice suited him better. This was a notable accomplishment, and time was taken reinforce his learning and growth. Mr. Q's progression was also evidence for a match between technology, goals, and technique; he was able to leverage technology effectively to do something personally meaningful. As this phase ended, time was spent reviewing previous skills at the request of Mr. Q (e.g., sorting by review rating). During this review, Mr. Q wanted to try following task lists along with Mrs. Q; he read aloud to familiarize himself. During this process, Mrs. Q did something remarkable: she engaged in errorless learning practices independently with Mr. Q. As Mr. Q was reading, he skipped a step—likely due to his visuospatial challenges—and Mrs. Q stopped him gently, redirecting him to the correct instruction, and allowed the task to proceed without errors.

Part 2: Combining audible with Amazon Echo and Alexa (sessions 9–12)

KG visited the Qs in their home to install technology and engage in shared learning. The Qs requested KG join them for lunch and coffee, which helped strengthen rapport and build comfort, because this was the first in-person meeting. The sharing of a meal was meaningful to the Q's and helped put everyone in a collaborative frame of mind. Technology installed included two Amazon Echo Show 8 s, one Amazon Echo Show 5, and one Amazon Echo Dot. Styluses were also provided, to help the Qs interact with their touch screen devices. Technology setup first involved a house tour, allowing for collaborative discussion of where the devices could be placed. The Qs placed three devices in the locations Mr. Q most often read books. The final device was placed in their study, where they attended virtual intervention sessions. Devices were set up and customized with the Qs (e.g., unique voice profiles were set up to assist with voice recognition), and the Audible ecosystem was linked with the Alexa system, permitting voice-command access to purchased audiobooks. Voice commands were used to access and manipulate audiobooks (e.g., play or pause audio), until the Qs became more comfortable with the system's capabilities. The Qs spontaneously requested task lists for all these skills. These lists were collaboratively generated and provided shortly after technology installation to allow between-session practice.

During this meeting further evidence for technology's potential to increase the Qs' quality of life emerged. For example, Mrs. Q remarked "Oh isn't that clock nice, we can see it from the bed," in reference to the Amazon Dot. She expressed an interest in seeing how the Dot could be used for a timer and for an alarm; the use of these features were demonstrated, and she was very interested in learning informally. In response, task lists were created for making a timer and setting alarms using voice commands.

Following technology installation, sessions resumed virtually. The Qs reported a staggering amount of success between sessions. First and foremost, Mr. Q described being able to play/pause his audiobooks verbally using the Alexa system, as well as change the chapter. He related that he was still learning, practicing the commands so he would not "screw it up if [he] [got] anxious." He also described using the timer function on the Echo Dot to allow him to take a timed nap.

Mr. Q described that the process of learning and practicing voice commands was smooth, for the most part. He noted that when he got frustrated, he was able to consult Mrs. Q for help. The couple described a process where Mrs. Q would help orient him to the task lists, and if that failed then she would help him with the steps to operate the system. It seemed that the Qs intuitively adopted a hierarchy of cues (Seelye et al., 2012; Middleton & Schwartz, 2012). A common error was Mr. Q forgetting that books needed to be loaded onto the iPhone prior to using the Alexa's voice commands. Mrs. Q reported that she felt confident in correcting him and navigating the various smart technologies to support her husband.

Mrs. Q continued to immerse herself in the Alexa system, supporting Mr. Q. With respect to supporting Mr. Q, Mrs. Q indicated she has been very pleased with her ability to follow the task lists and guide Mr. Q to "*lightbulb moments.*" For example, Mr. Q asked in session how to find humorous books on Audible. KG oriented the Qs to the "searching" task list, which prompted Mrs. Q to say: "let's try the same thing we did when we searched for biographies on our own. Let's hit the magnifying glass and search for humor." Mrs. Q also described independently generating cues for Mr. Q to interact with the smart home technology. For instance, she created cue cards with the word "Alexa" printed on them to prompt Mr. Q with the verbal response required to activate the system. Both Mr. and Mrs. Q recounted that this cueing system greatly reduced Mr. Q's failures in interacting with the Amazon devices.

Spontaneously, Mrs. Q related using the Echo devices for alarms, timers, music, appointment reminders, and her grocery lists. She reported finding the on-screen and audio prompts helpful as a substitute for write things down (e.g., "I can see on the screen that I have an appointment on Friday . . . I can see that I have three things in my shopping list."). She also reported appreciating the provided styluses, because they made touchscreen interaction easier. Further, Mrs. Q was becoming increasingly independent when troubleshooting problems with the Echo devices. For example, Mr. Q was becoming frustrated that multiple Echo systems picked up their voice commands. She solved the issue by moving the devices to different sections of various rooms to minimize sound interference.

As the intervention concluded, Mr. Q was able to independently search for, select, and purchase the book from the Audible app. Subsequently, he tried to listen to the book over the Echo system but encountered difficulty. Notably, the book he selected was not a unique title (i.e., other books shared the name) so the system could not determine which book Mr. Q was asking for. This issue prompted him to consult the task lists for help and ultimately ask Mrs. Q for assistance in getting the book to play. The couple reported that this was ultimately successful. Overall, both Mr. and Mrs. Q noted feeling satisfied and confident in their newfound skills; they felt they could do what they needed to and independently troubleshoot when required.

Findings from quantitative data

Mr. Q. Visual inspection (Kazdin, 2011) revealed several notable patterns with respect to Mr. Q's ratings of audiobook performance and satisfaction (Fig. 4). First, the change in COPM score

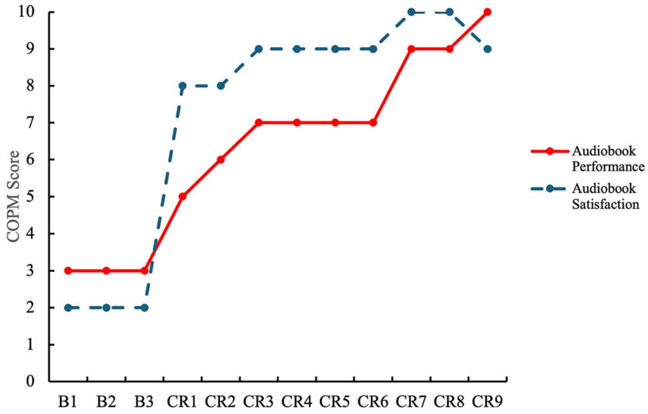

Fig. 4. Canadian occupational performance measure (COPM) scores for Mr. Q's use of audiobooks. B = baseline; CR = cognitive rehabilitation session. Alt text for Fig. 4: a line graph plotting Canadian occupational performance measure scores for Mr. Q's main goal across baseline and intervention phases. Performance and satisfaction scores improved significantly during treatment.

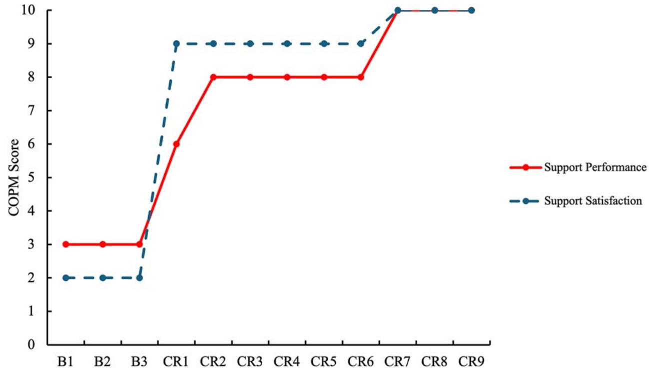

Fig. 5. Canadian occupational performance measure (COPM) scores for Mrs. Q with respect to her goal of supporting Mr. Q's adoption of audiobooks. B = baseline; CR = cognitive rehabilitation session. Alt text for Fig. 5: a line graph plotting Canadian occupational performance measure scores for Mrs. Q's goal across baseline and intervention phases. Performance and satisfaction scores improved significantly during treatment.

across phases exceeded the minimal threshold for clinical significance (i.e., 2 points; Law et al., 2005). With respect to magnitude, there was a noticeable change in mean COPM scores between the pre-intervention and intervention phases; this was true for both audiobook performance and satisfaction. Further, there were changes in level between baseline and intervention phases. Interestingly, the change in level was more pronounced for ratings of satisfaction than for ratings of performance. In terms of rate of change, there were changes in trend (i.e., slope; Kazdin, 2011) between phases. The slope of the performance ratings was steeper than the satisfaction ratings. It seemed that during intervention, Mr. Q's satisfaction elevated quickly and remained elevated while new skills were more incrementally learned towards accomplishing his goal. Finally, there was no latency between the onset of intervention and changes in COPM data, suggesting that CR contributed to indexed changes in goal progress.

Many of Mr. Q's scores on pre-post intervention measures did not significantly change (Table 5). One exception was a significant increase in the HADS depression subscale, as defined by change exceeding a minimally clinically important difference threshold. When queried further, Mr. Q reported this change to be due to dementia related sequelae (e.g., fear/worry of future decline). As well, Mr. Q's normative score on a measure of immediate memory (REY-I) increased significantly from pre- to post-intervention by a change score exceeding the threshold defined by a reliable change index (Table 5).

Mrs. Q. There were also changes in Mrs. Q's ratings of performance and satisfaction in her ability to support Mr. Q's audiobook use (Fig. 5) that can be seen on inspection (Kazdin, 2011). With respect to magnitude, there was a noticeable change in mean COPM scores between the pre-intervention and intervention phases; this was true for both performance and satisfaction ratings. This change exceeded the minimal threshold for clinical significance (i.e., 2 points; Law et al., 2005). Further, there were changes in level between baseline and intervention phases. Again, the change in level was more pronounced for ratings of satisfaction than for ratings of performance. Regarding rate of change, there were changes in trend (i.e., slope; Kazdin, 2011) between phases for both performance and satisfaction ratings. However, the slopes during the intervention phases were quite shallow, consistent with Mrs. Q's behavior during the intervention. She was able to quickly master technology related skills to support Mr. Q and indexed stability in those gains over time. Finally, there was no latency between the onset of intervention and changes in COPM data, suggesting that CR contributed to changes in goal progress.

Perceived impact of intervention

There were notable impacts of the intervention on both Mr. and Mrs. Q. Mr. Q related that he now views technology as another avenue for support, to be added to his current network (e.g., family and friends). Mrs. Q described that the intervention increased her level of compassion for Mr. Q because she could see how dementia was affecting him. She felt she learned to be more patient as they approached this new technology: "By working together it's helped us be more compatible in this situation . . . he is still the same person just with some troubles." Mrs. Q also noticed a shift away from frustration and towards collaborative problem solving. Mr. Q echoed this sentiment, stating "the dementia has brought us closer, but so has this work." Mrs. Q also noted a change in how she approached technological problems. At the outset of the intervention, she recalled being apprehensive about making mistakes or dealing with issues. Post-intervention, she noticed approaching emergent problems with humor and curiosity.

Unexpectedly, Mrs. Q related that CR strategies had begun to generalize into other areas of their lives. She mentioned that Mr. Q was having difficulty operating their television remote, and she independently created her own task list for the procedure. The task list allowed Mr. Q to practice while Mrs. Q corrected any errors. She described the effectiveness of this procedure, having noticed Mr. Q's increased proficiency with the remote.

Though there was no formal follow-up with this case, Mr. Q and his wife provided the therapist with updates after the intervention was concluded. Updates occurred at intervals of several months and conveyed that he was keenly listening to and engaging with audiobooks. His engagement continued even after he moved into an assisted living facility, and he was listening to books until close to his passing approximately eight months after the end of our work.

Case 3: Mrs. Q

Pre-intervention information

Mrs. Q was a 75-year-old retiree, spending her time volunteering with various community organizations. She was the primary care partner for her husband Mr. Q (described previously). Mrs. Q participated in the pre- and post-intervention interview with Mr. Q, so this portion of the intake was not repeated. The scores from questionnaires (i.e., the HADS, ZBI, and NPI-Q) collected during her husband's pre-intervention procedure were used as Mrs. Q's pre-intervention scores (Table 5).

As result of working alongside her husband, Mrs. Q became interested in learning the "drop-in" function for their new Amazon Echos. This feature would allow an instant conversation between Amazon devices or between a mobile phone and Amazon device. She felt learning this skill might be useful for her to remotely monitor Mr. Q while in the house or outside it. While in the house, it would save her having to walk up and down stairs if he was on another floor. It was collaboratively decided that CR would be used to teach Mrs. Q this feature via Zoom-based sessions. Ultimately, the aim was to increase the available tools for caregiving tools to allow for flexibility in her life over time. Additionally, this case would permit further insight into how off-the-shelf technology could be leveraged for caregiving. Sessions occurred weekly, lasting 60 min via Zoom.

Baseline phase

Baseline measurements for Mrs. Q's goal of learning the drop-in feature began while the intervention with Mr. Q was being completed; this comprised two of the baseline sessions. The third baseline session consisted of a brief check-in to see how the Qs were managing with their Amazon devices and to gather a final COPM baseline measurement for the drop-in feature. Mrs. Q was keen to learn this skill but noted requiring some initial support, because she did not know where to begin. Mrs. Q had become comfortable with the Amazon ecosystem through her participation in Mr. Q's rehabilitation, so she appeared eager to explore the new functionality.

Intervention phase

Mrs. Q completed 3 sessions of CR, conducted remotely. Mr. Q also attended the sessions. He was curious to learn alongside his wife and wanted to know the functions she might be using the Amazon devices for, especially if they involved him. Due to the shorter nature of this case, a brief session-by-session summary is presented.

Session 1. The first session began with an overview of the drop-in functions of the Amazon ecosystem. Before teaching Mrs. Q, some preparatory work was completed to ensure ease of interaction within the Alexa app. Mrs. Q was guided in the creation of "rooms" for her echo devices. This way, each device was in its own section on the app, creating less confusion when choosing a device with which to interact. The steps required to drop-in from an iPhone to an Echo were demonstrated while Mrs. Q and Mrs. Q watched.

The first learning trial consisted of working through the task list verbally. KG would read each step aloud, and Mrs. Q would interact with her iPhone. There was some confusion initially because the iPhone had not been set up to allow the drop-in feature, so the instructions were paused for collaborative troubleshooting. Once the settings had been adequately changed, the trial was restarted to promote errorless learning. Mrs. Q seemed hesitant interacting with the app in a new way, but her curiosity prevailed leading to a successful trial.

A second trial was initiated using a device in a different room. Mr. Q volunteered to go stand by the device and be a part of the trial. Mrs. Q followed the task list and successfully dropped in on Mr. Q through an Echo show. They were able to speak to and see each other, which seemed to please them both. Mrs. Q wanted to explore the range of the camera, so she instructed Mr. Q to move around the room until he was out of sight.

A final trial was completed using an Amazon Echo in a third room. Mrs. Q completed this trial mostly independently, only asking one clarifying question about the task list; she was successful once corrected. During this trial a technical problem was encountered. Despite the camera on the Echo Show being turned on, the video connection was not functioning properly. Solutions included rebooting the system or resetting it back to factory settings. Despite the lack of video, the audio functioned as intended. Mrs. Q indicated she felt ready to independently practice with Mr. Q, relating she felt comfortable contacting Amazon support to help with the glitch.

Session 2. Mr. and Mrs. Q reported successful use of the drop-in feature between sessions. Mrs. Q mentioned experimenting by dropping-in to their various devices around the house using voice commands. She described sending Mr. Q into a given room (e.g., sunroom), and using voice commands outlined in the task list to initiate a drop-in. Once active, she instructed Mr. Q to move around the room so she could get a sense of the camera range and become more comfortable with the system. Mrs. Q indicated this all worked well, leading to a discovery about their living room device. She described that in its current position, the camera was too low, so they were going to find something to prop underneath it to maximize their view of the living room. When asked what prompted this exploration of the devices and optimizing camera angles, Mrs. Q related: "we just thought we'd try it" suggesting the couple was becoming increasingly confident independently exploring the Amazon ecosystem.

Mr. Q also provided his thoughts on the drop-in feature. He reported that he was not sure what it would be used for and was finding himself less engaged in this learning as a result. This insight prompted a discussion of the drop-in's functionality, especially if there was a situation where Mr. Q was not able to access his phone to be contacted (e.g., it is in another room, it was out of battery, he could not locate it). This collaborative exploration of the drop-in's use cases was helpful for the couple. Mrs. Q mentioned that she could see this being useful in the future: "we aren't quite at that stage yet, but it's good to know as he progresses."

Reflecting more broadly on her CR, Mrs. Q related that she felt more comfortable with technology because of the pandemic. She noted that the increased interaction with technology out of necessity (e.g., to see her son) decreased her fear about trying new things. Further, she described that she would not have been likely to pursue the Alexa/Amazon devices on her own, without them being introduced to her. She felt having someone introduce the technology and teach her individually was critical for her uptake.

Session 3. Mrs. Q indicated having continued experimenting with the drop-in feature between sessions, encountering no problems. Further, she described successfully dropping in on Mr. Q from outside the home. When recounting the experience, she reflected that she could now clearly see the use for this feature to check in on Mr. Q. Mrs. Q noted that if she was going to use drop-in, she would want to test the camera angles of each Echo device to ensure they were in appropriate positions to be able to see Mr. Q. When asked how she was feeling about her mastery of the skill, Mrs. Q said she was feeling comfortable with the systems and felt adequately prepared to handle glitches and troubleshooting.

During this final session, the Qs were also interested in learning to add their own photos to the Alexa system. Their inquiry arose from a now-obsolete photo frame they had been using to store digital photos; it could no longer be updated so they were seeking an alternative. In response, KG guided them in moving the photos from their computer onto the iPhone, and onto the Echo devices via the app. Mrs. Q was able to successfully add three target photos to two devices and requested a task list be made for the procedure if she or Mr. Q wished to further customize the devices. In addition, Mrs. Q shared the following several days after the final session, illustrating her success with the Echo systems:

"I was at the [community event] today and wondering about how Mr. Q was doing—just before noon and my turn to go home—so I was telling my co-worker about Alexa and showed her how I could drop in and it worked great. He just happened to go into the sunroom as I was dropping in so we could catch up . . . "

Findings from quantitative data

Visual inspection (Kazdin, 2011) revealed several notable patterns with respect to Mrs. Q's ratings of performance and satisfaction regarding the drop-in feature (Fig. 6). First, the change in COPM score across phases exceeded the minimal threshold for clinical significance (i.e., 2 points; Law et al., 2005). With respect to magnitude, there was a noticeable change in mean COPM scores between the pre-intervention and intervention phases; this was true for both audiobook performance and satisfaction. There were also changes in level between baseline and intervention phases. The change in level was approximately equal for the ratings of satisfaction and performance. Regarding rate of change, there were changes in trend (i.e., slope; Kazdin, 2011) between phases. The slope of the performance ratings appeared similar to the slope of satisfaction ratings. It seemed that during intervention, Mrs. Q's performance and satisfaction rose roughly in tandem. Finally, there was no latency between the onset of intervention and changes in COPM data, suggesting that CR contributed to indexed changes in goal progress. Most of Mrs. Q's scores did not significantly change between pre-intervention and post-intervention measurement. The sole exception was a statistically significant increase in the HADS Anxiety subscale as the change exceeded the defined minimally clinically important difference threshold (Table 5).

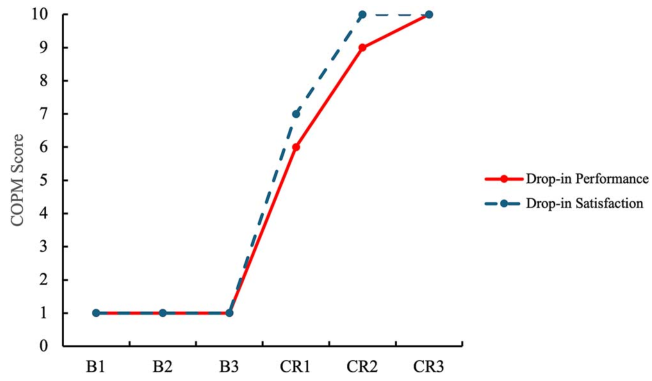

Fig. 6. Canadian occupational performance measure (COPM) scores for Mrs. Q with respect to her goal of learning the Alexa's drop-in feature as a tool for caregiving. B = baseline; CR = cognitive rehabilitation session. Alt text for Fig. 6: a line graph plotting Canadian occupational performance measure scores for Mrs. Q's goal across baseline and intervention phases. Performance and satisfaction scores improved significantly during treatment.

Findings from the research journal

The research journal was used to reflect on the process of integrating technology and CR. The thematic analysis of its contents was intended to summarize the experience delivering CR and is best conceptualized as an individual experience at a particular time. It may be helpful to others considering merging existing technologies with cognitive interventions. Generated codes were organized into two major themes: "therapeutic alliance," and "feasibility" as defined by Bowen et al. (2009). Text pertaining to how the therapist (KG) felt working with the participant, comments the participant made regarding comfort or how they felt in the session aggregated under the "therapeutic alliance" theme. Text pertaining to intervention feasibility as defined by Bowen et al. (2009) aggregated into two subthemes beneath the feasibility umbrella, namely "acceptability and implementation" and "practicality." "Acceptability and implementation" refer to a method's suitability or participant satisfaction, as well as whether the method was employed successfully (Bowen et al., 2009). "Practicality" refers to whether something can be accomplished using existing means, resources, and circumstances (Bowen et al., 2009).

Therapeutic alliance

With each participant, research journal entries reflected the importance of a collaborative therapeutic alliance (e.g., Teyber & Teyber, 2016) to delivering CR. Collaboration was critical for success, both for facilitating participant buy-in and energizing the therapist. Shared curiosity and therapist humility shone through as key to this collaboration. Journal entries underscored feelings of engagement from participants (e.g., "I liked your humble approach, I feel like we are learning together, problem solving together."), as well as a profound sense of motivation from the therapist (e.g., "They come to session with poignant questions about how to maximize Audible in their lives, I really feel like I am making an impact here.").

The interpersonal aspect of the therapeutic alliance also emerged as an important component of integrating technology with CR. Forming an alliance based on human connection allowed participants to feel secure in asking for help and safety in pushing themselves beyond their comfort zones. A strong alliance facilitated an individualized supportive approach, where barriers to approaching technology (e.g., fear) were lowered. This was exemplified in the following excerpts.

From participants:

> "It was better than expected, not bookish but human and humourous. It was two humans relating for a goal."

> "We are entering now into something we have never done before, it's exciting until it doesn't work. We couldn't do it without you."

From the therapist:

> "It seemed that by modelling a supportive approach, the barrier to engaging and exploring the technology was lowered sufficiently to promote autonomous curiosity in this new space."

Feasibility

Across all participants, research journal entries suggested the integration of technology and CR to be a feasible enterprise. Interestingly, entries from the perspectives of participant and therapist centered on similar aspects of feasibility: "Acceptability and Implementation", and "Practicality" (Bowen et al., 2009).

Acceptability and implementation

A first theme arising from the research journal mapped onto Bowen et al.'s (2009) conceptions of acceptability and implementation. Overwhelmingly, integrating technology and CR was described as a positive addition to participants' lives, while also facilitating goal accomplishment. Though goals were unique and technology was tailored to each participant, the effect of integrating technology and CR was powerful and meaningful.

From participants:

> "This device makes all the difference . . . it is a good tool for enhancing hearing. Hearing is the key to my socialization."

> "I never dreamt [Mr. Q] would be in a position to want to get an audiobook by himself."

> " . . . a lot of things were taken away by this dementia, but this is a tool to get some of it back."

From therapist:

> "She described how people would underestimate her function because of her stroke, but when she uses the pocket talker it helps other's perceptions of her. This change in others perception has, according to her, improved her social interactions and self-esteem . . . "

Additionally, the importance of the visual element of teaching a person technology emerged as a key factor in implementation. Interestingly, it was important irrespective of in-person or remote delivery; there were instances where visual demonstration was required to reach those "oh I got it now" moments. The following excerpts serve as excellent exemplars:

> " . . . the visual component to the teaching was critical, as there were differences in button location due to KG and the Q's having different iPhones."

> " . . . my favorite way was through the eyes. I learned best from watching and demonstration."

Further, the flexible and individualized nature of CR was important to bringing meaningful changes through acceptable intervention. The tailored approach was considered critical from both the therapist and participant perspectives:

> " . . . we were able to bring things to you and you addressed them right there or if you didn't know you would go figure it out and help us get where we needed to go."

> "Throughout CR with Mr. Q and Mrs. Q, several things left impacts on me. First, was the inherent flexibility of CR as an intervention. When contrasting this case with the case of Ms. K, it was striking how different the intervention looked. Work with Mr. Q was much more consultative, as his functional level and presence of a care partner greatly facilitated extra-session massed practice and exploration of the technology. To me, this was a powerful illustration of the flexibility of CR as an approach to help people meet their goals, no matter where they are at."

Practicality

Another theme from the research journal fits with practicality (Bowen et al., 2009). More specifically journal entries revealed that CR's integration with technology was doable using existing means, resources, and circumstances (Bowen et al., 2009). Participants were able to leverage existing technology and existing knowledge about technology (e.g., smartphones in their possession; O'Connell et al., 2003) in combination with an adaptable framework to create a technology-enriched environment that served them. Further, it appeared that the intervention left a positive impact, allowing participants to pursue unique goals with flexibility. The following journal excerpt exemplifies this notion:

> "Mr. Q had several questions that had arisen over the past week about Audible on his iPhone. First, he wished to know if the sound could be made louder; KG guided both parties

on how to adjust the volume using buttons on the side of the iPhone. During this process, Mr. Q had the idea to use a Bluetooth speaker that his son had bought for him; he wondered if it could be used for books, as well as the music he was already using it for. The device had already been paired with the iPhone, so KG guided Mr. Q to use the same steps he would use to play music, but instead play audio from Audible. This worked well and solved the volume issue, while opening a new avenue for Mr. Q to enjoy his audiobooks."

DISCUSSION

This study described the process of integrating off-the-shelf technologies with CR for people with memory impairment and their care partners. Results cautiously suggested this integration was both feasible and acceptable, with a variety of technologies and features being employed for a range of goals. Further, the integration of technology with CR permitted increases in goal performance and satisfaction, as evidenced by significant COPM changes across all participants. The addition of technology seemed to open new avenues for increased quality of life. The research journal provided insights into components leading to successful integration of technology with CR. These included the importance of a visual component, intervention flexibility, and a strong therapeutic alliance. The research journal also suggested that integrating CR and technology is practical, helping create environments that served to increase daily quality of life. Finally, these cases contribute to literature suggesting goal-oriented CR (Clare, 2008) is a promising non-pharmacological intervention for older adults with memory concerns (e.g., Burton & O'Connell, 2018; Clare et al., 2011; Clare et al., 2019; Kudlicka et al., 2023).

Results suggested that the integration of technology and CR was beneficial for people living with cognitive impairment and their care partners. First, across all participants, goal progress exceeded the clinically significant threshold of two points on the COPM (Law et al., 2005), and technology-enriched environments were created that served to increase satisfaction in daily life. These gains in functional and satisfaction are consistent with other literature on the impact of CR on goal attainment (Bird, 2001; Clare et al., 2003; Clare et al., 2010; Clare et al., 2019; de Oliveira Assis et al., 2010; Kim, 2015; Thivierge et al., 2014). As an additional consideration, there was little if any latency in the increase in COPM scores (i.e., the time that passes from intervention onset until there is a change in the data; Kazdin, 2011), which could suggest the potential for expedient and meaningful functional gains for individuals considering this type of intervention. Therefore, we tentatively suggest technology can be integrated while maintaining the core principles (i.e., the philosophical assumptions and propositional model of the intervention; Bernal, 2008; Ford & Urban, 1998) of CR.

Engaging in CR appeared to render benefits outside of target goals. For example, two participants (Mr. & Mrs. Q) reported feeling the bond between them was strengthened, including a shift in attitudes towards collaborative problem solving. As evidence for this, Mrs. Q spontaneously integrated CR strategies into other areas of life to assist Mr. Q (e.g., making a task list for the TV remote). These gains outside of target goal attainment align with previous studies detailing how the involvement of a care partner can enhance CR (e.g., Bahar-Fuchs et al., 2013; Kasper et al., 2015; Quayhagen et al., 2000; Woods, 2001) and improve coping strategies (Moebs et al., 2017). As well, the spill-over effect of CR strategies has been reported previously by Burton and O'Connell (2018). They noted one case where family care partners spontaneously engaged in the strategies, increasing meaningful engagement of a person living with dementia. Other psychological changes described presently included increased self-esteem and feelings of self-efficacy (particularly Ms. K). Feelings of low self-esteem and self-efficacy are common in people with memory impairments (e.g., Lopez et al., 2005; Robert et al., 2006) and have been described as important targets for CR (e.g., Mateer & Sohlberg, 2003).

These cases further highlighted the importance of the therapeutic alliance for CR, because it is a psychological intervention at its core (Baier et al., 2020; Teyber & Teyber, 2016). CR's flexibility relies on the alliance (e.g., Cicerone et al., 2000), because changes are frequently required to accommodate individual neuropsychological profiles and preferences (Clare & Woods, 2001; Morgan-Trimmer et al., 2021). Unfortunately, as Burton and O'Connell (2018) pointed out, commentary on the importance of the alliance in CR has not been as robust as discussions of technique. This balance is interesting, because our participants noted the importance of the alliance, and feeling humanity through the intervention. In contrast, they placed little emphasis on specific technique. This dichotomy serves as a reminder to not emphasize technical fidelity (e.g., errorless learning; Cicerone et al., 2011) at the expense of developing an alliance (Bird, 2001; Burton & O'Connell, 2018). Further, the research journal did not reveal any differences in alliance strength between virtual and in-person delivery. This observation was similar to other studies on virtual CR (Burton & O'Connell, 2018) that also lacked formal assessment of the alliance. However, other work on virtual psychological intervention (Anderson et al., 2012; Freeman et al., 2013; Kiropoulos et al., 2008; O'Connell et al., 2014) has suggested equivalence of in-person and remote alliance strength.

Carrying out this intervention revealed possible barriers to the integration of technology with CR. Firstly, all participants noted in their exit interviews that having the technology provided to them facilitated participation. When asked to elaborate, participants detailed being unsure of whether the financial investment would be worth the benefit, consistent with other literature on cost as a barrier for technology uptake (e.g., Kruse et al., 2020; Lee & Coughlin, 2015). A second barrier to technology integration encountered in this study was low perceived usefulness (e.g., Porter & Donthu, 2006). For example, Ms. K and her family decided it was not worthwhile to replace her lost iPhone, likely not viewing the device as sufficiently useful. This development changed the course of the intervention and prevented the exploration of the technology's potential benefit. Perceived usefulness has been described many times as a key issue in technology adoption (e.g., Al-Maroof et al., 2020; Lee & Coughlin, 2015; Porter & Donthu, 2006; Sugandini et al., 2018), suggesting that clinicians and researchers should direct explicit attention to explaining or demonstrating the uses and benefit of technologies to participants and clients.

This study also illuminated several facilitators for successful integration of technology and CR. First, all participants benefitted greatly from visual components of the intervention. Whether intervention was virtual or in-person, demonstrations and the learning process were facilitated by the ability to visually track client interaction with technology. Similarly, O'Connell et al. (2021) found that remote intervention without visual connection was inherently challenging, citing an incident where the therapist was unaware an older adult's tablet was being turned off by the stand in which it was resting. Further, we found that an individualized and supportive approach could help lower barriers to technology use such as apprehension and lack of knowledge. For each participant, the presence of nonjudgmental support lowered well-known psychological barriers to adoption of new technology including perceived lack of benefit, lack of technical support, experience, and confidence (Lee & Coughlin, 2015; Ma et al., 2016; Reddy et al., 2013; Wagner et al., 2010). Our findings are also consistent with previous literature espousing supports as helpful to older adults learning new technologies (Delello & McWhorter, 2017; O'Connell et al., 2021a; Tsai et al., 2017; Vaportzis et al., 2018) and with models of technology adoption such as the technology acceptance model (TAM; Marangunić & Granić, 2015; O'Connell et al., 2021; Porter & Donthu, 2006). The TAM posits an important barrier for uptake is perceived ease of use (Porter & Donthu, 2006), which a support person can influence through available technical support (Lee & Coughlin, 2015), facilitating experience (e.g., "playing around"; Tsai et al., 2017) and increasing confidence (Lee & Coughlin, 2015; Tsai et al., 2017).

Relatedly, these results challenge extant stigma around older adult's ability to learn and use technology. Engagement with technology in later life has been associated with a variety of ageist stereotypes and biases, portraying older people as incapable, technophobic, stubborn, and unwilling to keep up (Neves & Amaro, 2012). Further, it has been demonstrated that older adults can internalize these ageist beliefs which can act as an invisible barrier to technology use (Köttl et al., 2021). The present findings suggest that older adults with and without memory impairment can learn and use technology to increase the quality of their daily lives, especially when support is available (Lee & Coughlin, 2015), as was the case here.

Though there were some changes in cognitive and emotional measures suggestive of the benefit of CR (Bahar-Fuchs et al., 2013; Kudlicka, 2023) and a few suggestive of progressive decline, many of the pre-post measures did not index statistically significant change. The relative lack of statistically significant changes in pre- and post-intervention measures may point to an additional benefit of the present integration of CR with technology. For the participants with memory impairment, it is possible that the lack of statistical change in cognitive measures reflected a slowing of cognitive decline (Nelson & Tabet, 2015). The possibility of delaying or slowing decline with psychosocial intervention has been suggested in previous reviews (McLaren et al., 2013; Rostamzadeh et al., 2022). Additionally, there were few changes in the pre- and post-intervention measures for the care partner (Mrs. Q), which could suggest a stabilization in factors such as care partner burden. Indeed, several studies have shown that interventions not only slow functional decline in people with impairment, but they may also improve quality of life (as seen here) and decrease care partner burden (Callahan et al., 2006; Gitlin et al., 2003; Gitlin et al., 2008; Graff et al., 2007).

Limitations and future directions

This study had several limitations. First, the bi-phasic study design did not have a formal control condition, and there were a small number of replications (Tate et al., 2008; Vilardaga et al., 2019). In the pre-post assessment of several domains (i.e., cognition, mood, care partner burden, psychiatric symptoms), it is possible that outside events or processes contributed to change patterns (Kazdin, 1981). However, in the case of goal attainment, we continually assessed throughout baseline and intervention to minimize validity threats (Kazdin, 1981). Additionally, visual inspection methods (e.g., Kazdin, 2011) have the advantage of highlighting strong effects that are more likely to be functionally relevant and meaningful to individuals participating in rehabilitation. Unfortunately, subtle trends can be missed (Todman & Dugard, 2001), and visual inspection is unreliable when effects are not large. Therefore, statistical methods of analyzing single-case data have been increasingly suggested and integrated (Alresheed et al., 2013; Edgington, 1984; Matyas & Greenwood, 1990).

An additional limitation was the dual exposure of Mrs. Q to CR methods by virtue of participation in both the case of Mr. Q and her own CR. Importantly though, our inclusion of Mrs. Q was to investigate whether the technology could be leveraged to support caregiving, rather than her ability to be trained via CR methods. Further, we did not conduct follow-ups with our participants, outside of the informal updates received from Mr. and Mrs. Q which presents a limitation for conclusions on the maintenance of the gains discussed here. Lastly, it was possible that an element of self-selection bias influenced these findings. There was an element of self-selection bias (Larzelere et al., 2004). Specifically, those that participated were highly motivated and engaged, similar to other studies on CR (e.g., Burton & O'Connell, 2018). Relatedly, it is possible that Mr. and Mrs. Q had a higher baseline comfort level with technology by virtue of being rural and needing to interact with technology to access healthcare (a reality for many rural individuals; Baylak, 2020).

Future investigations could move towards more advanced single case experiments (Tate & Perdices, 2015) with appropriate statistical methods (Matyas & Greenwood, 1990). The current findings may act as a springboard for further exploration of the integration of technology and CR. By demonstrating initial evidence that integration is possible and acceptable, future investigators could continue to gather information central to rehabilitation. This could include sampling more cases with a wide range of target goals to gain insight into what types of cases or goals lend themselves to a technology-enriched approach to CR (Wilson, 1987).

Conclusions

Non-pharmacological interventions are needed to support the function of older adults struggling with memory concerns, as well as their care partners. This study described the integration off-the-shelf technologies with CR to support as one avenue of support. Results cautiously suggest this integration was successful, with a variety of technologies and features being employed to facilitate goal progress in several areas of functioning. Goal performance and satisfaction changed significantly across all participants, suggesting technology can be added to CR while maintaining its core principles. The research journal provided insights into integration of technology such as the importance of a visual component, intervention flexibility, and a strong therapeutic alliance. The research journal also suggested that integrating CR and technology was practical, helping create environments that served to increase daily quality of life. This multifaceted analysis adds to evidence suggesting goal-oriented CR is a promising non-pharmacological intervention for older adults with subjective memory impairment, MCI, and dementia (e.g., Clare et al., 2011; Clare et al., 2019). Future investigations should continue to explore other technologies with a range of goals, while considering alternate case study designs and analytic strategies.

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CONFLICT OF INTEREST

None declared.

AUTHOR CONTRIBUTIONS

Karl S. Grewal (Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing—original draft, Writing—review editing), Eric S. Grewal (Visualization, Writing—review & editing), Allison Cammer (Conceptualization, Methodology, Writing—review & editing), Lachlan A. McWilliams (Conceptualization, Writing—review & editing), Raymond J. Spiteri (Conceptualization, Writing—review & editing), and Megan E. O'Connell (Conceptualization, Formal analysis, Supervision, Writing—original draft, Writing—review & editing)

APPENDIX 1: EXEMPLAR TASK LISTS

Below is an example task list from work with Ms. K. It should be noted that the larger text size and black/white contrast on the printed page allowed Ms. K to read the tasks lists with ease.

Using Your Pocket Talker

1. Put the lanyard around your neck.
2. Put the headphones on your ears. If you cannot get them on ask for help.
3. Turn ON the pocket talker on by turning the wheel on the right up **towards** the microphone.

A Red Light Will Turn On Near the Microphone

4. Stop turning the wheel when you can hear the person you are talking to.
5. Point the microphone at the person you would like to talk with.

When You Are Done Using the Pocket Talker

1. Turn the pocket talker off by turning the knob on the right **away** from the microphone.
2. Keep turning until you see the red light turn off.
3. Remove the headphones from your ears.
4. Remove the lanyard from your neck.

Below is an example task list from work with Mr. Q and Mrs. Q. Again, it should be noted that the larger text size and black/white contrast on the printed page facilitated ease of reading for the couple.

Adding a Collection of Books to Your Library

Adding a collection is useful to "save" a premade collection of books you can return to later to use a credit on. The example we used in session was "Featured Canadian Creators".

1. Bring up the Audible app on your iPhone.
2. Go to the "**Discover**" section of the Audible app.
3. Scroll down until you see "**Editors Picks**".
4. Tap the word "**Editors Picks**" to see the various collections available.
5. Scroll through the collections until you find one you like.
6. Tap on the collection you are interested in.
7. You can now see all the books in this collection.
8. You can tap on each book to read more about it or sample it.
9. If you like the collection, tap the orange "**Save to Collections**" button.

To see your collections:

10. Tap "**Library**" at the bottom of the screen.
11. Where you see "**All, Audiobooks, Podcasts**" use your finger to scroll left.
12. "**Collections**" will appear.
13. Tap "**Collections**" and then you can see all your collections.

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Case Report