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Research Paper

Evaluation of a computer-assisted cognitive remediation program for young people with psychosis: A pilot study

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ABSTRACT

Background: People with psychosis have a range of neuropsychological impairments that impact their functional abilities and rehabilitation outcomes. We designed a Computer-Assisted Cognitive Remediation (CACR) program to help young people with psychosis to restore their cognitive function. The program combines the drill-and-practice approach and the strategic approach to remediation, with sixteen sessions of computerized cognitive training, two sessions of psychoeducation, and four session of coaching on applying cognitive skills to daily life.
Method: This was a randomized, single-blind, controlled study in which the outcomes of the CACR program were compared with outcomes of a treatment-as-usual (TAU) control group. Pre-intervention and post-intervention measures were compared.
Results: When compared with the control group, the intervention group had significant increases in their MCCB neurocognitive composite scores, and specifically in the areas of verbal learning and speed of processing at posttest. They also had significant increases in their secondary outcome measures of mental well-being and perceived occupational competence. There were no significant differences in functional status between the two groups at post-test.
Conclusions: The CACR program was effective in improving overall cognitive function and in the specific domains of verbal learning, speed of processing, and effect sizes were small. Participants also experienced positive changes in mental well-being and perceived competence.

1. Introduction

Cognitive impairment is common among young persons with psychosis. When compared with healthy controls, persons with first-episode psychosis, especially schizophrenia and depressive psychosis, have shown a wide range of cognitive impairments with moderate to high effect sizes (Zanelli et al., 2010). Among young people with first-episode psychosis, pronounced deficits have been found in almost all aspects of cognition, including attention/vigilance, verbal and visual learning, cognitive processing speed, reasoning, and problem-solving (Bachman et al., 2012; McCleery et al., 2014). A recent meta-analysis of 56 studies on Chinese patients with first-episode schizophrenia reported a similar profile of significant cognitive deficits in six cognitive domains of the MATRICS Consensus Cognitive Battery (MCCB). A neuroimaging study by Barch and Ceaser (2012) suggested that cognitive deficits in context processing, working memory, and episodic memory (collectively called proactive control) were linked to impairments in the brain's dorsolateral prefrontal cortex, an area that is the core to executive functioning. Based on a review of neuroimaging studies, Green and Harvey (2014) postulated that people with schizophrenia have difficulty in activating their frontal lobes as effectively and as reliably as healthy controls do. The need to develop interventions that address cognitive impairments in people with schizophrenia is clear.

Since the 1990s, efforts have been ongoing to address cognitive impairment in people with schizophrenia (Green, 1993). Cognitive remediation for schizophrenia is currently defined as a type of behavioral intervention that aims to improve cognitive processes (e.g., attention, memory, executive function, social cognition, and metacognition). Such therapeutic changes need to be generalized to everyday living and functional outcomes and must be maintained over time (Barlati et al., 2013).

Several key rationales exist for providing cognitive remediation for young people with schizophrenia. First, many studies have shown that whereas antipsychotic medications reduce symptoms over time,

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cognitive impairment remains relatively unchanged during the same period (Green and Harvey, 2014; Juuhl-Langseth et al., 2014). Both negative and positive symptoms have demonstrated either little relationship or nonspecific relationships with cognitive impairment (Green and Walker, 1985; Hughes et al., 2003; Müller et al., 2004). Thus, symptom management and cognitive remediation follow fairly independent recovery courses (Bark et al., 2003). Second, cognitive impairment is widely regarded as a major barrier to rehabilitation. Many studies have shown that successful remediation of cognitive impairment is predictive of more favorable functional outcomes, such as employment, social participation, and integration into the community (Green et al., 2004; McCleery et al., 2014; Nuechterlein et al., 2014; Tabarés-Seisdedos et al., 2008; University of North Carolina at Greensboro., M.S, 2017; Vinogradov et al., 2012). Third, there is increasing evidence suggesting that intensive and repetitive learning in cognitive remediation could bring about cognitive improvement through changing cortical plasticity (Genevsky et al., 2010).

The development of cognitive remediation has diversified significantly over the years, and many reviews and meta-analyses have provided critical evaluations of the approach, objectives, strategies, and effectiveness of cognitive remediation for people with schizophrenia. Cognitive remediation programs for individuals with schizophrenia are quite varied in design, and their effect size (from both computer-assisted and other programs) for young people with schizophrenia ranges from small to medium. Wykes et al.'s (2011) and Paquin et al.'s (2014) meta-analyses estimated that the effect size of cognitive remediation was 0.45 (95% CI = 0.31–0.59), with a range of effect sizes from 0.25 to 0.65 for different cognitive domains. Grynszpan et al.'s (2011) review of Computer-Assisted Cognitive Remediation (CACR) in schizophrenia estimated a mean effect size of 0.38 (95% CI = 0.20 to 0.55) for general cognition (covering verbal memory, working memory, attention/vigilance and speed of processing). Revell et al. (2015) found that the effect size of cognitive remediation for people with early schizophrenia was 0.15, which is smaller than that in people with chronic schizophrenia.

This study aims to develop and evaluate an optimal CACR program for young people with schizophrenia. The design of the CACR program is based on current research evidence. First, the program use computerized training programs that promote the motivation of participants (Contreras et al., 2016a; Garrido et al., 2013). CACR programs use game like designs and multimedia activities, which is a stimulating form of learning (Grynszpan et al., 2011; Rass et al., 2012). Computerized cognitive skills training could easily be standardized to provide a prolonged and repetitive practice. Such training requires less supervision, and options for upgrading or downgrading activities are often available. The use of computer-assisted training is also expected to be potentially cost-saving for service operation.

Second, this CACR program combined the drill-and-practice approach and strategic training approaches as they could have a greater impact than when they are applied alone (Barlati et al., 2012, 2013; Kurtz et al., 2007; Wykes et al., 2011) (Kurtz et al., 2007). Third, this CACR program is implemented alongside regular rehabilitation programs like independent living skills training, vocational rehabilitation, or community adjustment programs, which is known to reinforce the effectiveness of CACR (Au et al., 2014; Wykes et al., 2011). The study could be structured as comparing the CACR plus regular rehabilitation programs (Treatment-as-Usual; TAU) with the TAU. Fourth, this study attempted to evaluate the impact of CACR programs on functional outcomes, e.g. employment, academic functioning, or role performance (Au et al., 2014; Medalia and Saperstein, 2013), and coaching strategies could be used to guide clients to apply their skill learning in daily activities.

2. Method

This was a randomized, single-blind, controlled study of a standardized CACR program compared with a treatment-as-usual group (control group). The hypotheses of the study were that participants of the experimental group would have significant greater positive changes than the control group in the outcome measures, including: 1) Cognitive functioning: speed of processing, attention/vigilance, working memory, verbal learning, visual learning, and reasoning and problem-solving, 2) Mental well-being, 3) Perceived competence in occupational functioning, 4) Engagement in occupational roles like worker, student, trainee, or homemaking.

2.1. Subjects

Young people aged 15 to 28, who were diagnosed to have psychosis and schizophrenia by a psychiatrist and who were referred to occupational therapy service, were invited to join the study. Clients with an unstable mental state or intellectual disabilities were excluded. We briefed the clients on the purpose and procedures of study, and those who agreed to join were requested to sign a consent form. The subjects' demographic data, including gender, age, educational level, and previous occupation, were obtained from their case records. We used the Positive and Negative Symptoms Scale (PANSS) to monitor changes in mental state of participants over the study period, and those will significant changes in symptomatology could be recommended to withdraw from the study.

From meta-analyses and reviews, there are wide variations in the effect size of computer-assisted cognitive remediation on cognitive functioning domains. The effect sizes reported could range from low to medium (d = 0.25 to 0.65) for different cognitive domains (Barlati et al., 2013; Galletly and Rigby, 2013; Garrido et al., 2013; Genevsky et al., 2010; Wykes et al., 2011). The repeated-measures design used in this study had two groups (an experimental group and a control group), and there were two repeated measures over time. We used the sample-size software GPower 3.1 to estimate the required sample size for the experiment. Assuming a low effect size of d = 0.35, with α equal to 0.05, two repeated measures, and having six MCCB subscale, a sample size of 55 per group should be adequate to achieve a power of 0.80. This pilot study only have resources to recruit and implement the program for 40 participants. It would not meet the power requirements and should be considered a pilot study for computer-assisted cognitive remediation in Hong Kong.

2.2. Intervention program

Our standardized cognitive remediation program included two sessions of psychoeducational talk, sixteen sessions of a computerized cognitive training program, and four bridging sessions. Our CACR program was designed for young people who were day or out-patients of a major psychiatric hospital in Hong Kong. The program was developed in line with the current knowledge in cognitive remediation, including the combination of both the drill-and-practice and the strategic approaches. The drill-and-practice approach was implemented using the Chinese version of the CogniPlus (see https://www.schuhfried.com/en/cogniplus/), a computer-assisted software training package that provides high intensity practice on specific cognitive skills areas of attention, vigilance, working memory, long-term memory, executive functions, and spatial processing, for a total of 16 sessions. The CogniPlus software uses a game like interface and designs that could promote participation by young people. Based on cognitive assessment results (MCCB and HKLLT), the therapist assigned participants to work on an individualized set of training modules (cognitive domains which they have below average performance) for two to three sessions within each week. Each session lasted for approximately 1 h. From the second session onward, sessions began with a 5-min review of the home assignment of the previous session, with the therapist reviewing the cognitive strategies used by the participant in the previous week. After that, the client was engaged in a 40-min CogniPlus session assigned by the therapist. After each computerized training session, the therapist provided feedback and evaluated the client's performance, assisted the client in identifying how specific cognitive skills could be used in daily life, and set action plans for the client to practice the cognitive skills at home.

Based on the strategic approach in cognitive remediation, the other elements of the CACR program included two psychoeducational talk sessions and four bridging sessions. The two psychoeducational sessions covered basic concepts of brain development, components of cognitive functioning, cognitive impairment in schizophrenia, and how cognitive remediation strategies could help the clients enhance their daily functions such as study and work. The four bridging sessions were conducted alongside the practice and drill sessions, with the therapist guiding the client to apply the cognitive skills in daily contexts such as household management, and organizing and participating in social or leisure activities or in the workplace. The format of the 1- to 1.5-h bridging sessions were either with an individual or a group, depending on the objectives of the session. Activities for a bridging session included a tea party, table and board games, cooking, budgeting, tutoring for academic study, and simulated work skills training.

2.3. Outcome measures

The primary outcome of the CACR program was measured using the MATRICS™ Consensus Cognitive Battery (MCCB) and the Hong Kong List Learning Test, 2nd Edition (HKLLT). The secondary measures included mental well-being measured by the Chinese Short Warwick-Edinburgh Mental Well-being Scale (C-SWEMWBS), perceived occupational (functional) competence measured by the Occupational Self-Assessment (OSA), and the client's functional status before and after training, such as engagement in training, education, and work placement. Changes in psychiatric symptoms were monitored using the Positive and Negative Syndrome Scale (PANSS). All of the assessments were conducted before the training and again after it to evaluate potential changes. For the experimental group, we also conducted a follow-up assessment at 3 months after the completion of the CACR.

2.3.1. Cognitive functioning

The MATRICS Consensus Cognitive Battery (MCCB) was developed for measuring cognitive performance in adults with schizophrenia and related disorders. It has a set of 10 individually administered tests, including speed of processing, attention/vigilance, working memory, verbal learning, visual learning, and reasoning and problem-solving (Nuechterlein and Green, 2006). A Chinese version of the MCCB, standardized by (Shi et al., 2015), was used in this study. We conducted all subtests except the social cognition subtest, because the remediation program did not provide an intervention for social cognition.

We also administered the Hong Kong List Learning Test, 2nd Edition (HKLLT), to assess various memory processes and verbal learning (Chan et al., 2000). That test has been validated with a variety of normal and clinical populations, including individuals with schizophrenia. The test required subjects to recall a list of 16 target words told to them in random order, immediately, after a 10-min delayed recall, and after a 30-min delayed recall. Subjects were then asked to identify wordings in a 32-item list, which consisted of 16 target words and 16 distracter items in the recognition task. The scores were summarized in three categories: acquisition, retention, and retrieval, and the resultant breakdown provided information on the evaluation of organization strategies in learning and memory (Chan et al., 2006).

2.3.2. Mental well-being

We administered the Chinese Short Warwick-Edinburgh Mental Well-being Scale (C-SWEMWBS) to measure the mental well-being of the subjects (Ng et al., 2014). The Chinese version has demonstrated very good reliability and validity in measuring mental well-being in persons with psychiatric illness. Subjects were requested to respond using a 5-point Likert scale. The total score could range from 7 to 35, with a higher score reflecting a higher level of mental well-being. A total score below 23 indicates poor well-being.

2.3.3. Occupational functioning

The Occupational Self-Assessment (OSA) is an occupational therapy instrument designed to obtain clients' perceptions of their own occupational competence. Clients were requested to give ratings on their perceived competence to participate in a list of 29 daily activities (occupations). The OSA can be used in monitoring functional changes and care planning. The OSA has demonstrated very good reliability to monitor changes in occupational performance over time (Kielhofner et al., 2010; Kielhofner et al., 2009). We used the Chinese version of the OSA, which was translated and validated by Wang (2004).

2.3.4. Psychiatric symptoms

We administered the Positive and Negative Syndrome Scale (PANSS) for monitoring changes in psychotic symptoms over the intervention and follow-up period (Kay et al., 1987). The 30-item PANSS uses a 7-point scale to rate levels of psychopathology, ranging from absent (1) to extreme (7). The clinician collects information in a clinical interview or from reports made by hospital staff or caregivers during the previous week. The PANSS has four subscales—the positive scale, the negative scale, the general psychopathology scale, and the composite scale—for better presentation of the subjects' mental state. The PANSS has cut-off scores for delineating the severity of symptoms, and a change in PANSS scores of more than 25% indicates significant changes in the subject's mental state and requires special attention (Leucht et al., 2005).

2.4. Procedures

All potential subjects were informed about the nature of the clinical research, the purpose and procedures, its risks and benefits, and their rights to withdraw at any time. Those who agreed to join were requested to sign a consent form. A traveling allowance of approximately USD6.5 (HKD50) was provided to clients for every session that they joined, but participants needed to pay the treatment fees for their CACR sessions (around USD7.7, HKD60). A total of 75 potential subjects were screened using the selection and exclusion criteria (Fig. 1), and 45 eligible subjects were randomly assigned to the experimental group and the control group using a mobile phone app for generating random numbers. The experimental group received both the TAU program and the CACR, while the control group received only the TAU program. The study was a single-blind study, with only the assessors blinded to the subjects' group membership and with the therapist who conducted the CACR and the clients both being aware of whether they were assigned to the intervention group or the control group.

The subjects in the intervention group were assessed before and after joining the CACRC program, and again 3 months after the program had ended. To minimize the delay of intervention for the waiting-list control group (TAU only), the control subjects joined the CACRC as soon as the posttests of both groups had been conducted. Subjects in the control group were assessed only before and after treatment and not at the 3-month follow-up.

2.5. Data analysis

We first compared the demographic and functional profile of the treatment and control groups using Chi-squares statistic and independent *t*-test to see if there are differences in these characteristics at baseline. After we made sure there are no major differences between groups at baseline, we used repeated measures ANOVA (General Linear Model) to analyze the changes in the treatment and control groups (between-group variation) over pre- and post-intervention measures (within-group variation). The significance of F test for group x time interaction will indicate if there are significant differences in outcomes

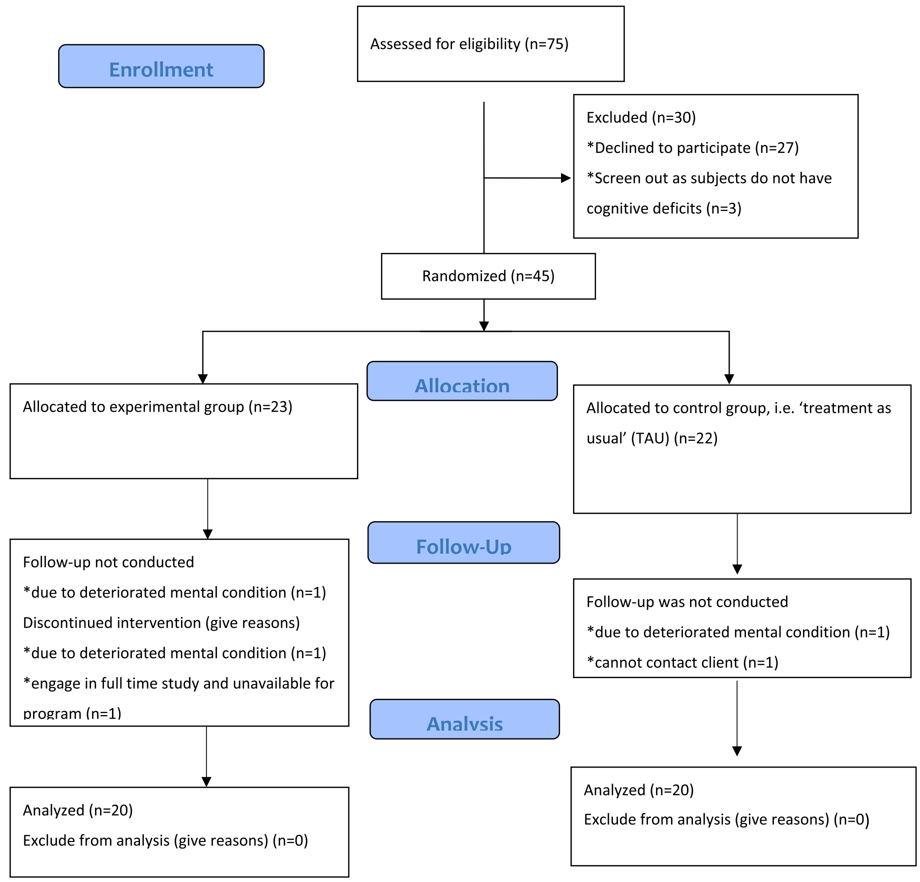

Fig. 1. CONSORT flow diagram for studying the cognitive remediation program for young people with psychosis.

between the two groups. The amount of missing data from the analysis is small, as there were only two drop-outs from both groups, and there were less than 5% of missing data for all the outcome measures. For the experimental group, we analyzed the changes in outcome over pre-, post-intervention, and follow-up over the three time points, and can obtain contrast in outcomes comparing post- with pre-intervention, and follow-up with post-intervention.

3. Results

There were 20 participants each in the control group and the experimental group. The mean age of participants ($N = 40$) was 21.9 (SD = 3.40), with a range from 15 to 28 years old. There were slightly more females (54.5%) in the experimental group than in the control group (50%) (Table 1). A majority of the participants (62.5%) were neither working nor studying, whereas the rest were working part-time (10%) or full-time (7.5%), studying full-time (10%), or attending a rehabilitation program (10%). There were no significant differences between the groups in terms of age, gender proportions, diagnoses, or functional status, nor in their pretest scores on the MCCB, HKLLT, Occupational Self-Assessment, PANSS, and WEMWBS scores (Table 1). From the record of program implementation, we noted that the participants took an average of 15.1 (SD = 5.6) weeks to complete the program. The mean duration between the post-treatment assessment and the follow-up assessment was 14.5 (SD = 2.6) weeks. The participants of the experimental group completed a median of 16 session of drill-and-practice session, 4 session of coaching. The mean completion rate of homework assignments is 76.8% (SD = 1.40).

Using Repeated Measures Analysis of Variance (ANOVA), we compared the changes in outcome measures between the experimental group and the control group (Table 2). After Bonferroni corrections, the Time x Group interaction terms were significant for the scores on the HKLLT long delayed recall ($F = 8.96$, $p < .05$), the MCCB neurocognitive composite ($F = 12.24$, $p < .001$) and speed of processing ($F = 7.78$, $p < .05$), and the mental well-being measure of C-WEMWBS ($F = 4.28$, $p < .05$).

We analyzed the changes in outcomes in the intervention group ($n = 20$) over the pretest, posttest, and follow-up periods (Table 3). We estimated the within-group contrast between post- and pre-treatment scores, and between follow-up and post-treatment scores. There were significant changes in the following outcomes over both the post-treatment versus pre-treatment assessment and the post-treatment versus the follow-up assessment ($p < .05$): HKLLT, the MCCB neurocognitive composite, the MCCB speed of processing, MCCB Verbal Learning, MCCB Reasoning & Problem Solving, the OSA perceived competence subscale, and the PANSS negative symptoms.

We surveyed the functional status of participants between the pretest and posttest (Table 4). Two participants (10%) in the control group moved from idling to working. Four of the participants (20%) of the experimental group changed their status, three from not being in training and not studying or working, to one (5%) working and two (10%) studying, and one participant (5%) changed from working to studying. There were no significant associations between changes in functional status and their participation in the control or experimental groups ($\chi^2 = 0.23$, ns).

4. Discussion

The intervention group had significant increases in neurocognitive composite scores, and specifically in areas of verbal learning and speed of processing, when compared with the control group. The effect sizes of these changes were small ($\eta_p^2 = 0.17$ to 0.24), and this is consistent

Table 1
Comparison of participant profiles and the pretest scores of the treatment and control groups.

Categorical variables	Group				χ^2
	Control		Experimental		
	(*n* = 20)		(*n* = 20)		
	n	%	*n*	%	
Gender					
Male	10	55.6%	8	44.5%	0.40
Female	10	45.5%	12	54.5%	
Diagnosis					
Psychosis	11	68.8%	5	31.3%	3.87
Schizophrenia	8	36.4%	14	63.6%	
BAD	1	50.0%	1	50.0%	
Educational level					
F1-F3	1	25.0%	3	75.0%	1.74
F4-F5	6	60.0%	4	40.0%	
F6-F7	7	50.0%	7	50.0%	
Diploma or higher diploma	4	57.1%	3	42.9%	
Degree or above	2	40.0%	3	60.0%	
Functional status at pretest					
Not working or studying	13	52.0%	12	48.0%	1.37
Out-patient Occupational Therapy program	2	50.0%	2	50.0%	
Full-time study	2	50.0%	2	50.0%	
Full-time open employment	2	66.7%	1	33.3%	
Part-time open employment	1	25.0%	3	75.0%	
Interval variables	M	SD	M	SD	*t*
Age	22.3	3.36	21.46	3.67	0.74
MCCB pretest scores					
Trail Making Test (TMT)	41.45	8.62	43.60	12.45	0.64
Symbol Coding (SC)	37.05	6.18	35.95	8.91	0.45
Category Fluency (CF)	43.45	12.06	40.15	11.57	0.89
Continuous Performance Test (CPT)	44.40	9.89	41.15	11.69	0.95
Working Memory (WM)	40.65	8.67	42.10	11.45	−0.45
Hopkins Verbal Learning Test (HVLT)	39	10.42	37.80	10.88	0.36
Brief Visuospatial Memory Test (BVMP)	39.85	9.35	41.45	12.04	−0.47
NAB Mazes	45.35	9.61	43.30	9.80	0.67
Verbal Learning (VerbL)	39.00	10.42	37.80	10.88	0.36
Reasoning & Problem-Solving (RPS)	45.35	9.61	43.30	9.80	0.67
Neurocognitive Composite (NC)	37.85	8.82	36.80	11.15	0.33
Hong Kong List Learning Tests (HKLLT)	25.15	17.14	30.35	22.50	−0.08
Occupational self-assessment					
Competence	56.50	8.05	53.80	9.49	1.01
Environment	24.10	3.67	24.10	5.31	0.00
PANSS					
Positive symptoms	9.45	4.11	8.05	1.93	1.38
Negative symptoms	8.70	2.41	9.65	3.30	−1.04
WEMWBS	21.20	3.55	19.75	4.34	1.18

with some review of cognitive remediation for early schizophrenia or young people with schizophrenia (Revell et al., 2015). When we analyzed the changes in outcome measures for the intervention group over the pretest, posttest, and follow-up periods, we found significant changes in all aspects of neurocognitive function in the HKLLT and MCCB, with the exception of working memory and attention/vigilance. On the whole, the positive impact of the CACR program tends to be small with this sample of young people with schizophrenia. The small effect size could also be partially attributed to the fact that both the treatment and control groups are attending the TAU while the CACR is being implemented. For the secondary outcome measures, the results showed that the treatment group had significantly greater positive changes in mental well-being and in perceived competence in occupational performance.

There are several key observations from the study. First, our findings support that the CACR program is effective in improving general cognition (MCCB neurocognitive composite). Among the specific cognitive MCCB domains, we found significant improvement only in the domains of verbal learning and speed of processing. When we compared our results with those of other studies of similar cognitive remediation programs (e.g., Barlati et al., 2013; Reeder et al., 2017) that combined computerized cognitive function training and coaching on strategic and metacognitive processing, the range and magnitude of changes in our study's cognitive function tests (MCCB and HKLLT) were relatively less positive. Several factors may have contributed to the less positive result in this study, we believe. Our CACR program had a lower intensity than many studies on CR have had. For instance, many programs delivered more training sessions than our study (e.g. up to 28 session in Reeder et al., 2017), and larger effect sizes tended to associated with greater improvement in areas like verbal memory (McGurk et al., 2007). It is also possible that the impact of cognitive remediation for young people with early schizophrenia is smaller when compared with older and more chronic populations (Revell et al., 2015).

Second, the evidence provide partial support on the transfer of cognitive training to everyday living. Our findings showed that 20% of the participants in the treatment group and 10% of those in the control group changed their functional status from idle to that of studying or working. The intervention group also had significant positive changes in mental well-being and perceived occupational competence. These results are consistent with those of previous studies, which pointed out that only 40% of participants in cognitive remediation reported a transfer of learned skills to everyday living, and only 45% reported improved confidence (Contreras et al., 2016b). We suggest that the data capture for functional changes or a transfer of learning to everyday living should be further refined in future studies of cognitive remediation programs. The other outcome indicator that is used often in studies of cognitive remediation is functional status—that is, whether the client is engaged in work or study (Au et al., 2014; Man et al., 2012; Reeder et al., 2017). However, it may require a longer period of follow-up (longer than the three months in our study) to capture changes in functional status.

Third, we found that there were no significant differences in changes of symptoms when we compared the control and experimental groups. However, when we examined the experimental group over pre-, post-treatment, and follow-up, there was a significant reduction in negative symptoms. This is consistent with the results of latest reviews on cognitive remediation (Linke et al., 2019). Future studies of cognitive remediation would need to continue to monitor and study the relationship between declines in negative symptoms and cognitive improvement.

Last, the feedback from the therapists and research participants indicated that the characteristics of the trainer made an impact on the effectiveness of training, through enhancing the motivation of participants (Garrido et al., 2013). This finding echoes the results of a qualitative study by Contreras et al. (2016a, 2016b), which highlighted that trainers who were supportive, adaptive, and instructive were instrumental in achieving better training outcomes in CR. In future studies, we advise including focus group evaluation meetings to capture how learning and coaching might impact functional outcomes.

4.1. Study limitations

There are several limitations in the design of the study that could affect the impact of this study. First, the study could fulfill some of the requirements of a randomized controlled trial, e.g. the program and outcomes measures are standardized, and participants are randomized to control and experimental groups. We could however only use a single-blind design, as it is not possible to blind the therapists and subject about their participation in cognitive remediation program. These could potentially introduce bias in the study results. Second, we find the sample size of 40 would not provide adequate statistical power

Table 2
Comparison of outcome measures between the experimental group ($n = 20$) and the control group ($n = 20$).

Measures	Control		Experimental		Time × group	Between group	Time	
	M	SD	M	SD	F	F	F	
HKLLT[a]								
Total learning Pre	27.44	16.47	32.00	22.15	5.25	2.78	71.15**	0.14
Total learning Post	45.78	25.40	64.00	21.87				
Short delayed recall Pre	32.89	25.24	35.06	26.42	3.35	1.23	26.74**	0.10
Short delayed recall Post	45.00	42.18	60.44	26.02				
Long delayed recall Pre	33.44	23.81	33.63	27.55	8.96*	1.43	36.94**	0.22
Long delayed recall Post	43.22	25.35	62.38	24.50				
MCCB[a]								
Neurocognitive composite Pre	37.85	8.82	36.80	11.15	12.24*	0.29	57.04**	0.24
Neurocognitive composite Post	40.95	10.21	45.25	9.21				
Speed of processing Pre	38.20	7.50	37.30	11.58	7.78*	0.51	9.19*	0.17
Speed of processing Post	38.45	6.86	43.30	10.67				
Attention vigilance Pre	44.40	9.89	41.15	11.69	4.24	0.26	6.26*	0.10
Attention vigilance Post	44.75	10.49	44.75	9.55				
Working memory Pre	40.65	8.67	42.10	11.45	0.30	0.78	1.61	0.01
Working memory Post	41.80	9.02	44.95	8.92				
Verbal learning Pre	39.00	10.42	37.80	10.88	3.43	0.09	33.40**	0.08
Verbal learning Post	43.40	9.19	46.35	9.21				
Visual learning Pre	39.85	9.35	41.45	12.04	1.89	1.64	20.18**	0.05
Visual learning Post	44.55	11.66	50.30	7.28				
Reasoning and problem-solving Pre	45.35	9.61	43.30	9.80	1.87	0.00	10.30*	0.05
Reasoning and problem-solving Post	48.05	10.94	50.00	10.46				
PANSS[a]								
Positive symptoms Pre	9.45	4.11	8.11	1.97	4.64	0.32	4.11	0.11
Positive symptoms Post	7.70	1.49	8.1	2.69				
Negative symptoms Pre	8.70	2.41	9.32	3.02	1.02	3.07	156.39**	0.03
Negative symptoms Post	7.60	1.27	7.37	1.01				
OSA								
Competence Pre	56.60	8.05	53.80	9.49	3.73	0.00	4.47*	0.08
Competence Post	56.85	7.61	59.30	10.86				
C-WEMWBS								
Pre	21.20	3.55	19.75	4.34	4.28*	0.01	3.97	0.10
Post	21.15	3.62	22.40	4.64				

[a] Bonferroni correction was applied to these outcome variables with multiple subscales in the test. The *p*-values were divided by the number of tests conducted within the outcome variable.

* $p < .05$.

** $p < .01$.

for data analysis. The effect size of changes in the MCCB neurocognitive composite score is low ($\eta_p^2 = 0.24$), which is lower than our assumption of an effect size of 0.35. For future study with similar population of young people with schizophrenia, an effect size assumption of 0.25 to 0.30 would be more appropriate. In considering a suitable sample size, it is also necessary to take note of the potentially high attrition rate in cognitive remediation program (Bowie, 2019), although the attrition rate in this study tends to be low (11.1%). Third, there is a need to reconsider the use of some outcome measures. We found that the Occupational Self-Assessment (OSA) is not a most relevant measure of outcomes, as it surveyed perceived competence in many aspects of daily life. It would be more suitable to include a measure of daily cognitive difficulties as a more specific measures, and a possible example is the subjective scale to investigate cognition in schizophrenia (SSTICS) to assess patients' subjective experiences of cognitive impairment (Stip et al., 2003).

5. Conclusions

The CACR program is effective in improving participants' overall cognitive function in the domains of verbal learning, speed of processing, and attention/vigilance, with medium sizes of effect. Among secondary outcome measures, the study's CACR participants showed significant improvement in their mental well-being and significant, positive changes in their functional status. The study's results provide preliminary support for the importance of CACR programs for young adults with psychosis. Therefore, we suggest that future studies use different outcome indicators and measures, in an effort to better capture the transfer of training to everyday living.

CRediT authorship contribution statement

Authors	Responsibility in project
Andrew M. H. Siu	Conceptualization, methodology, resources, formal analysis, writing, visualization, project administration.
Rita S. H. Ng	Conceptualization, methodology, resources, writing, project administration, supervision, investigation.
Magdalene Y. C. Poon	Conceptualization, methodology, writing, project administration, supervision, writing - review & editing
Catherine S. Y. Chong	Investigation, data curation, writing - review & editing
Clara M. W. Siu	Investigation, data curation, writing - review & editing
Sally P. K. Lau	Investigation, data curation, writing - review & editing

Declaration of competing interest

All authors declare that they have no financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work in this study.

Table 3
Comparisons of treatment group ($n = 20$) measures from pre- and post-intervention and from post-intervention and follow-up measures.

Measure	M	SD	Post vs. Pre	FU vs. Post	Pre- vs FU η_p^2
HKLLT[a]					
Total learning Pre	30.35	22.5	52.85**	21.62**	0.70
Total learning Post	63.12	21.49			
Total learning follow-up (FU)	68.71	22.44			
Short delayed recall Pre	32.89	25.24	34.31**	7.71*	0.49
Short delayed recall Post	45.00	42.18			
Short delayed recall FU	65.69	24.98			
Long delayed recall Pre	33.44	23.81	37.75**	16.41*	0.61
Long delayed recall Post	43.22	25.35			
Long delayed recall FU	70.89	24.79			
MCCB[a]					
Neurocognitive composite Pre	36.80	11.15	57.61***	60.46**	0.76
Neurocognitive composite Post	45.25	9.21			
Neurocognitive composite FU	47.75	8.99			
Speed of processing Pre	37.30	11.58	13.15*	31.78**	0.49
Speed of processing Post	43.3	10.67			
Speed of processing FU	43.30	11.02			
Attention vigilance Pre	41.15	11.69	11.76*	3.87	0.27
Attention vigilance Post	44.75	9.55			
Attention vigilance FU	43.30	11.20			
Working memory Pre	42.1	11.45	1.52	2.92	0.10
Working memory Post	44.95	8.92			
Working memory FU	44.95	8.85			
Verbal learning Pre	37.80	10.88	26.95**	33.87**	0.61
Verbal learning Post	46.35	9.21			
Verbal learning FU	48.35	8.85			
Visual learning Pre	41.45	12.04	16.70**	13.60**	0.45
Visual learning Post	50.30	7.24			
Visual learning FU	51.30	6.41			
Reasoning & problem-solving Pre	43.30	9.80	9.22*	26.56**	0.46
Reasoning & problem-solving Post	50.00	10.46			
Reasoning & problem-solving FU	54.50	6.262			
OSA					
Competence Pre	53.8	9.49	5.80*	10.71**	0.27
Competence Post	59.30	10.86			
Competence FU	60.45	10.11			
CWEMWBS					
Pretest	19.75	4.34	5.09	11.75*	0.29
Posttest	22.40	4.64			
FU	24.05	4.42			
PANSS[a]					
Positive symptoms Pre	8.17	2.01	0.021	0.088	0.004
Positive symptoms Post	8.22	2.76			
Positive symptoms FU	8.06	3.54			
Negative symptoms Pre	9.44	3.05	9.31*	5.5*	0.32
Negative symptoms Post	7.39	1.04			
Negative symptoms FU	7.50	1.10			

[a] Bonferroni correction was applied to these outcome variables with multiple subscales in the test. The p-values were divided by the number of tests conducted within the outcome variable.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 4
Comparison of functional status of subjects in the experimental and control groups in the pre- and post-intervention periods.

Group		Status Change between Pre and Post-treatment period: No change	Improved status	Total
Control	n	18	2	20
	Row %	90.0%	10.0%	100.0%
	Total %	45.0%	5.0%	50.0%
Experimental	n	17	3	20
	Row %	85.0%	15.0%	100.0%
	Total %	42.5%	7.5%	50.0%
	n	35	5	40
	Total %	87.5%	12.5%	100.0%

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