The nuts and bolts of Cognitive Remediation: Exploring how different training components relate to cognitive and functional gains

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ABSTRACT

Background: Cognitive Remediation (CR) is an evidence based treatment targeting cognitive and functional difficulties in people with psychosis. Despite the large number of effectiveness studies, only limited evidence exists for the active ingredients of this therapy. This study begins to fill this gap by exploring the relationship between CR ingredients, including alliance with a therapist, and therapy outcomes.
Method: This is a secondary analysis based on data from a published randomised controlled trial comparing CR + treatment-as-usual (TAU) to TAU alone. We considered the association between CR active ingredients including errorless learning, massed practice, strategy use and therapeutic alliance on the cognitive, functioning and symptom outcomes that significantly improved following therapy.
Results: Forty-six of the 96 participants were randomised to CR. After therapy the CR group showed significant improvement in non-verbal memory, functioning and approaching significance, improvements in executive functions. All therapy ingredients were inter-related but strategy use alone was associated therapeutic alliance. Cognitive improvements were associated with massed practice, number of useful strategies and therapeutic alliance, but improvements in functioning were associated only with therapeutic alliance.
Conclusions: These findings build the evidence base for the usefulness of specific therapy components. As for other psychological therapies it appears that therapeutic alliance may be an important factor in driving change for key CR outcomes, particularly functioning, in people with psychosis.

1. Introduction

There is now considerable evidence to support Cognitive Remediation (CR) as a useful intervention to reduce cognitive difficulties and improve functioning in people with psychosis (Wykes et al. 2011). Recent evidence also suggests that this intervention can reduce negative symptoms (Cella et al. 2016b). Despite these encouraging results there is still room to improve and optimise CR efficacy and to conduct studies exploring how best to roll out this intervention in the wider psychiatric services.

While most studies have focussed on establishing CR efficacy, we know relatively little about how specific CR techniques and methods contribute to therapy outcomes. For example, although there are a number of agreed scientifically based learning principles embedded in CR therapy ingredients (Wykes and Reeder 2005) it is not clear how, or if, they contribute to improved outcomes. This is vital as each therapy component could be modified or emphasised to improve efficacy.

Most CR programmes include massed practice which relies on intensive repetition and practice of cognitive tasks over frequent sessions. Practice levels vary between programmes and there is no clear indication of a dose-effect. It is obvious that very few sessions could not produce lasting changes. But there is consensus that high session number, and frequency, is important in determining therapy outcomes (Kluwe-Schiavon et al. 2013; Saperstein and Medalia 2016).

Most CR programmes aim to deliver task practice in the context of minimal negative feedback. This method is often referred to as errorless learning and is considered important for boosting motivation and produces better learning outcomes (Mazur 2013; Middleton and Schwartz 2012). Errorless learning is often achieved using titration, a technique that adjusts the task complexity to the individual's competence level often implemented by software. Errorless learning is also facilitated by scaffolding. Scaffolding usually requires the therapist's input, often in the form of modelling the approach to task practice with support gradually withdrawn to develop the client's autonomy. Recent research suggests that errorless learning in CR may be important to improve sensitivity to feedback and contribute to both cognitive and functioning improvements (Cella et al. 2014a). However, the specific contribution of different facets of errorless learning (e.g. titration or scaffolding) is not clear.

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Not all CR programmes depend on the involvement of a therapist but this is considered a powerful therapeutic ingredient. A therapist provides a complex mix of active ingredients which so far has been difficult to accurately quantify. The only study to evaluate their contribution demonstrated that their support is important for achieving session attendance and preventing dropout (Huddy et al. 2012). This study also found that therapeutic alliance predicted improvements on the clients' therapy goals but it did not find an association between therapeutic alliance and cognitive change.

Finally, several CR programmes teach strategic approaches to problem solving (e.g. Mendella et al. 2015). These are mostly based on teaching and encouraging the use of strategy to overcome cognitive difficulties. The rationale for the introduction of these elements is the notion that practice alone may be limited in achieving and maintaining cognitive gains. Strategy use is also thought to be important to boost not only cognitive performance, but also functioning levels as strategy use can be generalised to other tasks. Some CR programmes have linked the importance of strategy use to the development of metacognitive skills (Reeder et al., 2017; Reeder et al. 2016; Tsapekos et al. 2017). Understanding when to use a strategy, and correctly using it, requires knowledge of your own cognitive difficulties and the ability to be able to regulate strategy use (Cella et al. 2015). These are metacognitive skills.

Research in CR has focussed primarily on establishing the evidence for treatment efficacy but has neglected "how" each of its therapy building blocks contributes to the outcomes. The most obvious reason for this lack of research is how to measure these components. The advent of computerised CR has simplified how we record task practice as this information is, in many cases, easily retrievable from the CR software. In the CIRCuiTS software (Reeder et al., 2017) used in our recent studies it is also possible to consider other therapy components such as use of strategies. Complexities, however, still exist around the measurement of composite and perhaps less standard therapy ingredients such as the therapist input.

In this paper we aim to explore how specific CR therapy techniques are associated with therapy outcomes. In particular, this paper will explore the contribution of massed practice, errorless learning, strategy use and therapeutic alliance. As this is one of the first studies to investigate these components we will assume, in line with current theoretical models, that the hypothesised therapy active ingredients will contribute a small to medium degree to therapy outcomes.

2. Method

2.1. Design

This study uses data from a recently completed RCT (trial registration number: ISRCTN55488371). In brief this study is a randomised controlled trial comparing Treatment-As-Usual (TAU) to CR + TAU. Participants were assessed at: baseline (week 0), 12 weeks (i.e. post-therapy for the CR + TAU group) and 24 weeks. The main results of the trial have been recently published in Reeder et al. (2017). For the purpose of this paper's analyses we will use data only from the CR group. We will also consider only outcomes that in the main RCT analysis demonstrated significant improvement at post-therapy (12 weeks) rather than any influences over the follow-up period. These were non-verbal memory, non-verbal executive function and functioning levels. Reduction in symptoms was also observed so we will consider symptom dimensions in this study.

2.2. Participants

Participants had a DSM-IV diagnosis of schizophrenia or schizo-affective disorder, were aged between 17 and 65 years and had cognitive difficulties of at least one standard deviation below the normative mean in one of these cognitive tests: digit span (Wechsler 1993), the Wisconsin Card Sorting Test (WCST) (Heaton et al. 1993) or the Hayling Sentence Completion Test (Burgess and Shallice 1997). Participants were community patients recruited from local clinics belonging to the UK South London and Maudsley Mental Health National Health Service (NHS) Trust.

2.3. Cognitive remediation

CR was delivered by a therapist using CIRCuiTS, a web-based computerised CR software (Reeder et al. 2015; Reeder and Wykes 2010). The therapy targets cognition and metacognition using massed practice of basic cognitive functions and encouraging strategy use. Therapists support motivation, the use of metacognitive skills (i.e. regulation and awareness) and strategy use (Cella et al. 2015). They also support the transfer of learning to meet individual therapy goals. Therapists also provide scaffolding for CR tasks to ensure consistent successful performance (i.e. errorless learning).

CIRCuiTS tasks target attention, memory and executive functioning. Tasks increase in difficulty depending on individual performance to keep success high. The software also prompts the use of strategies and patients are asked to rate these for their usefulness. The aim of this rating is to develop a set of personalised strategies to improve task success and support the achievement of personal goals. CIRCuiTS records participants' performance and choices for every completed task. The software computes summary statistics for most variables.

CIRCuiTS was offered up to three times a week (maximum 12 weeks), for up to 40 sessions lasting approximately 1 h. Therapists were supervised, trained graduate psychologists. Therapy fidelity is ensured by computerised delivery and the rating of audio-recordings of therapist input using a modified CR Fidelity Scale (Stenmark 2006). Participants did not receive compensation to take part in therapy sessions.

2.4. Measures

A range of demographic and clinical characteristics was collected from clinical records and face-to-face interviews.

2.5. Cognitive outcomes

Memory was assessed with the Rey Osterrieth Complex Figure (ROCF) (Osterreith 1944; Rey 1941). This is a non-verbal memory test requiring participants to draw a complex figure from memory. The immediate recall raw score was used as the measure outcome. High scores indicate good performance.

Executive function was measured with the Wisconsin Card Sorting Task (WCST) (Heaton et al. 1993). This is a non-verbal test requiring participants to sort cards according to changing rules. The total number of errors was used as the measure outcome. High scores indicate poor performance.

2.6. Symptoms and functioning outcomes

Symptom severity was assessed with the Positive and Negative Syndrome Scale (PANSS) (Kay et al. 1987). For this study we extracted five factors from the PANSS: Positive Symptoms (Pos), Negative Symptoms (Neg), Disorganised (Dis), Excited (Exc) and Negative Emotion Depressed (Emd) (Cella et al. 2014b; Wallwork et al. 2012). Functioning was assessed using the Time use survey (Cella et al. 2016a; Short 2006). This is a semi-structured interview asking participants to retrospectively report the time spent in a variety of everyday activities such as work, education, voluntary work, leisure, sports, socialising, hobbies, resting, housework/chores, childcare and sleep. The key outcome computed was time spent in structured activities.

2.7. CR therapy ingredients

Massed practice was measured as the total number of tasks completed during therapy and the average number of tasks completed in each session.

Errorless learning was measured as the average success percentage achieved by participants in each the tasks completed. Every CIRCuiTS task has an independent algorithm calculating participants' success percentage which considers important task outcome such as error number, items missed or recollection precision.

Strategy use was measured as the total number of strategies selected while completing CIRCuiTS tasks. As participants were also asked to rate strategy usefulness on a 1–5 scale (with 1 being not useful at all and 5 being extremely useful) so we also considered the total number of strategies rated 4 and 5 (i.e. the most useful strategies).

Therapist contribution was assessed using the short form of the Working Alliance Inventory (WAI - Horvath and Greenberg 1989). This measure assesses the therapeutic bond, alignment of client's and therapist's on goals, and goal progress. Each participant completed the measure twice (after session 4 and at the end of therapy). The average of the two total scores was used for the analysis.

2.8. Analysis

The normality assumption for all the CR therapy ingredients was assessed using Shapiro-Wilks test. We explored the association between therapy ingredients and outcome change using correlations. As we were expecting therapy variables to be skewed and fail to meet normality assumptions we could not use partial correlation to account for baseline scores. To overcome this limitation, we computed relative improvement scores for each outcome using this formula: (change score × 100) / baseline score. This method allows considering participants' relative improvement using non-parametric correlation (e.g. Spearman Rho). We also considered the potential overlap between different active ingredients by using correlations.

3. Results

Forty-six participants were randomised to receive CR + TAU. Of those 38 received at least 20 h of therapy, which was considered the minimum dose necessary for engagement with the intervention. The participants average age was 38.7 (SD10.1) and were mostly men (i.e. 70%). Participants average premorbid IQ, as estimated by the Wechsler Test of Adult Reading (Holdnack 2001), was 94.2 (SD10.5). The majority of the participants were unemployed or not engaged in education (i.e. 79.9%). A large proportion of the participants recruited (80.4%) experienced their first psychotic episode >5 years prior to entering this study. At the time of the study all participants were prescribed antipsychotic medication (92% atypical and 8% typical antipsychotic); the median chlorpromazine level was 326.6 mg. There were no differences in these characteristics between those who undertook therapy and those who dropped-out.

3.1. Active ingredients association

On average participants in the CR group attended 28.6 sessions (SD 6.8) and completed an average of 4.8 tasks per session (SD 1.6). Table 1 shows the mean and standard deviation for the therapy characteristics considered in the analysis.

Table 2 shows the correlation between the CR ingredients considered. We found robust correlations between task practice and strategy use (i.e. all correlation coefficients above 0.5). This was expected as strategy use is prompted by our CR software. We also found that therapeutic alliance levels were positively correlated only with total strategy use and the number strategies rated useful.

Table 1
shows the average use of the active ingredients considered by the study participants.

(N = 38)	Mean	SD	Max	Min
Number of sessions (total)	28.6	6.88	41	20
Number of task (total)	137.5	58.3	257	34
Average number of tasks per sessions	4.8	1.6	7.8	1.4
Errorless learning (% success in tasks)	88.7	5.4	95.7	71.8
Average strategy use per session	7.22	4.2	21.7	0.56
Useful strategies (4 and 5)	213.1	144.1	736	13
Therapeutic alliance (WAI score)	63.1	10.85	84	43

3.2. Are CR characteristics associated with outcomes improvement?

The results of the correlational analysis show that task practice, measured as the average number of tasks per session, was associated with improvement in both non-verbal memory ($r = -0.4$, $p < 0.05$) and executive functions ($r = -0.38$, $p < 0.05$). The average number of useful strategies was associated with non-verbal memory improvements ($r = -0.29$, $p < 0.05$). Finally, therapeutic alliance was positively associated with both non-verbal memory ($r = 0.38$, $p < 0.05$) and executive functions ($r = -0.35$, $p < 0.05$) but also with improvements in functioning ($r = 0.4$, $p < 0.001$). Despite small reductions in both positive and negative symptoms after CR, none of the therapy characteristics was associated with this change.

4. Discussion

This is one of the first studies to begin to identify how the active ingredients of therapy relate to cognitive and functioning outcomes in CR. The computer output allowed us to test the different aspects of therapy and, for most putative active ingredients, we were able to show an association with cognitive and functioning outcomes.

In terms of their inter-relationships, the number and intensity of tasks was related to the use and usefulness of strategies. But surprisingly errorless learning was not correlated with any measures of task practice or strategy use. This is validation that there is a high level of successful performance during CR that is supported by the therapist so that it does not dip below 80%. With the majority of participants having an average success rate on tasks between 83 and 92%, variability on this parameter is restricted and is less likely to produce significant correlations. This was particularly true for detecting an association with strategy use, which, similarly to errorless learning, had restricted variability. This is because both errorless learning and strategy use are essential components of our CR programme.

Significantly therapeutic alliance was related to the number and usefulness of strategies. This relationship (as perceived by the participant) may reflect the participant's willingness to attempt different strategies which may then contribute to better cognition. This is a potential model to identify in the next generation of studies.

But the purpose of this study was to try to identify those ingredients that were useful for outcomes. We found evidence supporting the usefulness of intensive task practice to support cognitive improvements. Mass practice is a technique used by all CR programmes. There is debate regarding the optimal number of session, their frequency and duration, but it is clear that mass practice is a necessary and likely useful ingredient (Fiszdon et al. 2016). Practice quantity, however, may be influenced by practice quality. In other words, practicing with the support of a therapist, while using strategies and on engaging and tailored tasks may be different to non-tailored practice. Extensive good quality practice may be able to offer extra benefits and the field may benefit from more rigorous monitoring of task practice quality and adherence to the optimal administration method.

The most striking result of this study is the association between therapeutic alliance and both cognitive and functional improvements. This result provides empirical support for the importance of positive

Table 2
shows correlations between active ingredients.

	Total number of tasks	Average task per sessions	Average strategy per session	Useful strategies (4 and 5)	Errorless learning
Total number of tasks	–	–	–	–	–
Average task number per sessions	0.81**	–	–	–	–
Average strategy use per session	0.56**	0.57**	–	–	–
Useful strategies (4 and 5)	0.68**	0.51**	0.94**	–	–
Errorless learning (% success in tasks)	NS	NS	NS	NS	–
Therapeutic alliance	NS	NS	0.37*	0.33*	NS

therapeutic alliance as a potential driver of outcome change. The only previous study in CR investigating the role of therapeutic alliance suggested that this is a significant predictor of clients' perception of therapy goals improvements (Huddy et al. 2012). This study partially replicates this result suggesting that there is an association between therapeutic alliance and functioning improvements, as measured by a time use survey.

A recent study found that the quality of therapeutic alliance significantly influence the outcomes of Cognitive Behavioural Therapy for psychosis (CBTp) (Goldsmith et al. 2015). For those with a good therapeutic alliance, more sessions of CBTp was beneficial, but for those with a poor therapeutic alliance, attending more sessions produced worse outcomes. It may be that, in a similar fashion, therapeutic alliance could have a positive or negative effect on CR outcome and this potentially could be examined in larger studies. In the meantime, as we now have preliminary evidence that a good alliance is beneficial, we should pay more attention to this aspect and ensure appropriate training and supervision are available to identify early signs of disengagement and poor therapeutic relationship. We investigated the effect of perceived success in one of our previous studies as our participants had indicated that it affected how they felt about the programme. This analysis demonstrated that success on tasks early in the programme led to improved outcomes and was associated with higher self-esteem. But when individuals were not successful on tasks or did not improve their outcomes then this led to worse self-esteem (Rose et al. 2008). This led us to adjust our programme and our therapist training to ensure consistent successful task practice.

A potential mechanism identified in our data suggests that working alliance leads to greater strategy use. This is in line with our therapy model and would lead us to speculate that a good working relationship with a therapist is prompting individuals to use more strategies. If this is the case, this is important as it shows that therapists may be able to promote a particular approach to task which is in line with the use of metacognitive skills.

Our results not only highlight therapeutic alliance as important for cognitive outcomes but suggest it is the only variable associated with improvement in functioning. It seems therefore plausible to hypothesise that therapists play a significant role in facilitating the transfer of cognitive gains to people's everyday lives. This association may work through improvement of cognitive outcomes, through the transfer process or through extra-CR processes including enhancing self-efficacy. All of these hypotheses, however, need further investigation. Our data demonstrated that therapeutic alliance is important for both strategy use and functional improvement but that there was no direct relationship between functional improvements and strategy use. It may be that the transfer of strategy use to everyday life is facilitated by the therapist's support through changes in motivation. Again this hypothesis needs empirical support.

This study has both strengths and limitations. We adopted the approach of identifying correlations which does not answer the question of whether there is shared variance. For instance, it is obvious that the number of sessions and the number of strategies attempted will be correlated and although this is a limitation for the analyses, it is also a strength as it provides some validity in the measurement of the variables. We limited the number of active ingredients of therapy, but, as is common in psychological therapies, there is a link between active ingredients and participant characteristics. By not considering these cognitive, personal or clinical characteristics we will have missed potential explanations of our results. Improving CR effectiveness may not only require the correct balancing of the intensity and quality of its active ingredients, but will also require studies that will help to understand the influence of therapy non-specific factors and their interaction in the process of therapy. These process studies with self-report from the participants' viewpoint are now fuelling the understanding of how therapies work (or not) (Kilbride et al. 2013). In addition, studies of moderators may help to uncover which participants' characteristics or process influence therapy improvements and, as importantly, what combination of characteristics heralds poorer outcomes. One of these studies should explore how we can improve and monitor therapists' training and supervision to maximise positive therapeutic alliance.

The effective optimisation and personalisation of CR approaches will require further and much larger systematic studies exploring therapy ingredients and their interaction with clients' characteristics, therapists' skills and the process of therapy.

MC study idea and conducted preliminary analysis. MC and TW prepared the database and conducted the final analysis. MC and TW wrote the first draft of the paper. MC and TW wrote and approved the final version of this manuscript.

Prof. Til Wykes jointly owns the IP for CIRCuiTS along with King's College London. Dr. Matteo Cella declares no conflict of interest.

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