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Title: Experiences of cognitive training on primary breast cancer survivor's cognitive impairments at work: A longitudinal qualitative study

Short title: Experiences of cognitive training on work

Abstract

Objectives: Cancer-related cognitive impairment (CRCI) is associated with adverse work-related outcomes in women living with a history of primary breast cancer. We explored the perceived impact of receiving adaptive cognitive training (dual n-back training) or active control training (dual 1-back training) on CRCI. Furthermore, we explored the perceived transfer effects of cognitive training on **self-management methods for cognitive impairment** and work-related outcomes such as career development.

Design: Longitudinal qualitative study.

Methods: A "framework" analysis approach was used to analyse semi-structured telephone interviews completed by women with a history of primary breast cancer before training ($N = 40$), one month ($N = 30$) and six months ($N = 29$) post-training.

Results: Four main themes were identified: (1) impact of cognitive impairment at work, (2) perceived impact of adaptive cognitive training on impaired cognitive function, (3) perceived effects of training on self-management methods for cognitive impairment applied to support work and (4) perceived impact on women's career development and progression. Compared to baseline, women who received adaptive dual n-back training reported sustained improvement in multiple cognitive domains including memory and attention up to six months post-training when the follow-up interviews were conducted. Perceived improvements in cognitive function were associated with greater self-confidence and better emotional wellbeing in work. These improvements were found to lower dependency on **self-management methods** and enhance effectiveness as well as prompt career development or progression for many women. Although some findings of a similar nature were reported in the active control dual 1-back training group the perceived effects were more pronounced and consistent in the dual n-back group.

Conclusions: Adaptive cognitive training (dual n-back training) improves perceived CRCI experienced by women in the workplace, enhancing their self-confidence and general emotional wellbeing. These

perceived improvements, in turn, can decrease reliance on **self-management methods for cognitive impairment** and improve work efficiency and contribute to career development and progression.

Statement of contribution

What is already known on this subject?

- The diagnosis of breast cancer and its subsequent treatment can result in a series of short- and long-term sequelae including cancer-related cognitive impairment (CRCI) that adversely affect work-related outcomes such as workability.

- Women affected by breast cancer implement a series of coping strategies such as memory prompts and make adaptions like reducing working hours or load to manage these post-treatment sequelae at work.

- The effects of breast cancer diagnosis and treatment can limit career development and future prospects.

What does this study add?

- A comprehensive, longitudinal, qualitative account of the perceived impact of receiving 12 sessions of adaptive cognitive training (dual *n*-back training) or active control training (dual 1-back training) on cancer-related cognitive impairment (CRCI) experienced at work up to six months after training.

- Perceived improvements in cognitive impairment, enhance confidence and emotional wellbeing in the workplace, resulting in greater career progression or development for many women.

- Adaptive cognitive training reduces women's dependency and enhances the effectiveness of **self-management methods for cognitive impairment** applied to support workability, previously shown to provoke mixed emotions, with some reporting greater emotional distress.

Introduction

Breast cancer is the most prevalent malignancy worldwide, accounting for approximately 12% of all new cancer cases (World Health Organization, 2020). Advances in diagnostic techniques and treatment programs have led to increasing survival rates, with figures predicting that 77% will survive for at least 10 years (Office for National Statistic, 2019). Despite this positive advance in survivorship many women diagnosed and treated for breast cancer live with a series of adverse short and long-term sequelae including, cancer-related cognitive impairment (CRCI), fatigue and emotional distress (Joly et al., 2020; Carreira et al., 2021). Indeed, Koppelmans et al., (2012) showed that women treated with chemotherapy experience cognitive complaints for up to 20 years.

CRCI is a singular term used to describe the cluster of cognitive complaints experienced by individuals diagnosed and treated for cancer (see Padgett et al., 2020). Common complaints include difficulties with short- and long-term memory, processing speed, language, attention/concentration and executive function (Von Ah et al., 2013). CRCI has been shown to act as a barrier in the return-to-work process (Mehnert et al., 2013; Nilsson et al., 2013) and adversely impacts work-related outcomes **such as workability, career development, work output and work productivity, as well as longer-term sustainment of wor**k (Calvio et al., 2010; Von Ah et al., 2018; **see Von Ah et al., 2016, for a review**). **Multiple qualitative studies have shown that CRCI is also associated with a loss of self-confidence in workability, feelings of being overwhelmed and frustrated in the workplace, as well as feelings of letting down employers and co-workers as a result of suboptimal workability and efficiency (Kennedy et al., 2007; Munir et al., 2010).**

Work is considered central to the recovery process after a cancer diagnosis as it often signals the endpoint of the patient period and re-entry into a more 'normal' everyday life (Kennedy et al., 2007). **Figures have shown that the number of women diagnosed with breast cancer out of work is more than double that of healthy reference control populations (35.6% vs. 15.2%) (The Economist Intelligence Unit, 2017).** The economic burden created by the inability to work reduces quality of life (Meneses et al., 2012) in women affected by breast cancer. **Studies have shown that women** are more likely to become unemployed during the first five years of survivorship (Paalman et al, 2016; Grinshpun

& Rottenberg, 2019). Higher risk of unemployment, sickness leave or not returning to work has been linked to mental health disorders (Plym et al., 2019), post-cancer depression (Landeiro et al., 2018), cognitive impairment (Oberst et al., 2010), fatigue, pain-related conditions (Plym et al., 2019), high psychological job demands, employment support and suboptimal workability (Wang et al., 2018). Unemployment has also been associated with an increased risk of breast cancer mortality (Maruthappu et al., 2015).

Studies reveal that higher financial difficulty (or hardship), physical fatigue, cognitive impairment, emotional distress and lack of confidence are significant predictors of suboptimal workability and work productivity loss (Calvio et al., 2010; Carlsen et al., 2013; Zeng et al., 2016). Suboptimal workability, in turn, has been shown to increase women's risk of anxiety and depression as well as limit their future perspective (Ho et al., 2018). Raque-Bogdan et al., (2015) outlined that the experience of breast cancer diagnosis and treatment slows down, blocks or re-directs the long-term career path for many women.

Sandberg et al., (2014) revealed that women with breast cancer implement a series of coping strategies including changing the number of work hours, reducing the workload and using memory prompts to manage their work tasks. A recent **qualitative study** by Chapman et al (2021) identified, however, that women have mixed feelings towards self-management coping strategies **including cognitive support methods and work-based adaptations (i.e., changes in workload),** with **some women** reporting that these methods prompt adverse emotions. They also found that experiencing CRCI **(i.e., difficulties with memory)** reduced the effectiveness **of the cognitive support methods in the workplace.**

Computerised cognitive training programs such as memory training, processing speed training and executive function training have been shown to improve both self-reported cognitive complaints **(as measured by FACT-Cog and SSMQ)** and objective cognitive performance **in immediate and delayed memory recall, processing speed, cognitive flexibility, working memory and verbal fluency** (Von Ah et al., 2012; Kelser et al., 2013; Damholdt et al., 2016), as well as **reduce** symptoms of distress including, fatigue and depression (Von Ah et al., 2012) **in women affected by breast cancer**.

Similar findings were reported by Swainston and Derakshan (2018) when assessing the efficacy of working memory training (adaptive dual *n*-back training) in reducing emotional vulnerability by enhancing the processing efficiency **of women living with a diagnosis of primary or secondary breast cancer.**

Current Investigation

Despite the growing body of evidence demonstrating that breast cancer and its consequential CRCI detrimentally impact work- and work-related outcomes, no study to our knowledge has explored the impact of cognitive training on CRCI affecting work in women affected by primary breast cancer in early survivorship ($\leq$ 5 years). Calvio et al., (2012) found that poorer self-reported executive function is associated with worse work output in women affected by breast cancer. Studies have revealed that participating in adaptive cognitive training successfully improves executive functions including working memory (see Derakshan, 2020, for a review). In a recent study by Blacker et al., (2017), it was shown that dual *n*-back training was the most effective and reliable training intervention, with *n*-back eliciting both robust near transfer effects and significantly greater neural gains compared to other training groups. Substantiating evidence has also shown that receiving sessions of dual *n*-back training results in greater behavioural and neural training gains compared to the active control training (dual 1-back training) (Jaeggi et al., 2008; Owens et al., 2013; Au et al., 2014; Sari et al., 2016).

The current longitudinal study aimed to investigate the perceived impact of receiving 12 sessions of adaptive cognitive training (dual *n*-back training) or active control training (dual 1-back training) on the self-reported CRCI impacting women's workability over a period of six months. Further, the study also aimed to examine the perceived transfer effects of training on self-management methods for cognitive impairment and career development or progression. In the current study, self-management methods for cognitive impairment refer to methods such as notetaking and calendar alerts implemented by women in the workplace to help manage their CRCI and support work. As this is the first study to investigate the impact of adaptive cognitive training and active control training on the self-

reported CRCI impacting women's workability we elected to use a qualitative methodology due to its ability to provide a far more complete and more compelling articulation of the impact of the training in the workplace. We also selected this method to ensure that our participants were able to speak in their own words rather than confining them to categories and terms (Sofaer. 1999).

Our rationale for selecting 12 sessions of training over a two-week period was motivated by the findings from previous research by Swainston & Derakshan (2018, 2021), showing breast cancer survivors experienced sustained improvements in emotional resilience after participating in 12 sessions. Developing a greater understanding of the effectiveness of adaptive cognitive training on work-related outcomes will help promote the implementation of dual *n*-back training in the workplace, supporting women with a history of primary breast cancer to sustain work over time.

Method

Participants

Women were recruited between the 1st of February 2019 and 29th of February 2020 via purposeful sampling from advertisements presented on online breast cancer public and private support groups. All women were recruited as part of a randomised control trial. The RCT aimed to investigate the effectiveness of adaptive cognitive training in supporting women with a history of primary breast cancer enhance their workability (publication in preparation). The first 40 women were selected to complete the interviews.

Inclusion criteria included (1) a diagnosis of primary breast cancer, (2) six to 60 months post active treatment for chemotherapy and/or radiotherapy (whichever came last), (3) currently receiving endocrine therapy, hormone replacement therapy or target therapies, (4) aged 18 to 65 years at the time of enrolment, (5) attending paid work (i.e., employed or self-employed) and (6) experiencing a decline in workability as a result of cognitive difficulties.

Procedure

Using randomisation software (Sealed Envelope Ltd., 2017) eligible participants were allocated to either the adaptive cognitive training (dual *n*-back training) or the active control (dual 1-back training). Participants were asked to give online consent to take part in the study and verbal consent at the start of each of the three semi-structured telephone interviews to affirm that their interview could be audio-recorded for transcription. Participants were informed that the interviews were for research purposes only. After enrolment, participants were approached via email to organise a time for their baseline interview. Baseline interviews lasted on average 58 minutes (ranging from 39 to 97 minutes). Following the interview, participants were then asked to complete 12 online sessions of adaptive cognitive training (dual *n*-back training) or active control training (dual 1-back training) at home over two weeks. Sessions lasted approximately 30 minutes each day. After finishing the training program, participants were emailed or asked during their face-to-face lab sessions to schedule their repeat follow-up interviews at one-month post-training (interviews lasted on average 46 minutes; ranging from 27 to 76 minutes) and six months post-training (interviews lasted on average 55 minutes; ranging from 39 to 84 minutes) (see figure 1 for the flowchart of participants). Only the primary researcher and participant were present during the telephone interviews. Field notes were taken throughout to help guide the discussion. **Ethical approval was obtained from the local research committees including the Research Ethics Committee of the Department of Psychological Sciences, the College Research Ethics Committee at Birkbeck College, University of London, and the Economic and Social Research Council. The study was also prospectively registered with the International Standard Registered Clinical/soCial sTudy Number (ISRCTN; study number: ISRCTN11333136).**

Insert figure 1 here

Interview Schedules

Individual interview schedules were constructed for baseline and follow-up interviews by consulting qualitative research studies (i.e., Maunsell et al., 1999; Kennedy et al., 2007; Von Ah et al., 2013; Bolton et al., 2018; Klaver et al., 2019). Interview schedules were reviewed and several changes were made to

the wording or phrasing of the questions to ensure in-depth responses were elicited. The interview schedule was then piloted[1] with two women to further determine its appropriateness and viability. Both women were contacted by the researcher after voicing an interest in participating in the study. Following the completion of the pilot interviews, verbatim transcripts were reviewed by BC and EAG to check that the wording of the questions was provoking detailed and in-depth responses. No changes were required to the wording or phrasing of the questions; however, further probing questions were added and agreed by consensus. No changes were made to the interview schedules during the data collection.

To start with baseline interviews asked women questions about their breast cancer history and wellbeing during the active treatment period. Questions then focused on work, the post-treatment cancer-related cognitive impairment, the effect of these sequelae on workability, work contentment and self-management coping methods such as cognitive support methods implemented or work-based adaptions used to help support work function.

Both post-training interviews (one month, and six months) focused on investigating the perceived effects of cognitive training on the cognitive impairment(s) affecting workability, self-management coping methods such as cognitive support methods and work-based adaptations as well as contentment at work. Participants were also asked a series of questions relating to their training experience including how the training they underwent met their expectations. Questions followed the flow of the conversation. Open discussions were encouraged alongside the pre-planned questions to allow participants to outline their personal experiences.

Dual *N*-Back Training (Intervention) and Dual 1-Back Training (Active Control)

Standard versions of the dual *n*-back training and dual 1-back training (Jaeggi et al., 2008; Owens et al., 2013) were used. During, the task a single green box flashed up in one of eight positions on a 3x 3 grid. At the same time, one of eight possible consonants was spoken. Participants were instructed to

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[1] Participant one was not able to complete in the study as she was over 60 months post active treatment but matched all of the other criteria and participant two was mainly working voluntarily at the time of the interview.

simultaneously remember the location of the green square and its paired spoken consonant (see supplementary material for a more comprehensive description of the task; see figure 2 for an example of dual 3-back training).

Task difficulty for the dual *n*-back training (adaptive cognitive training; 1-back, 2-back, 3-back and 4-back) was determined by performance accuracy on the previous block of trials unlike the task difficulty for the dual 1-back training (active control) which remained fixed at 1-back across all 20 training blocks.

Insert figure 2 here

Qualitative Analysis

Interviews were audio-recorded and transcribed verbatim. Transcripts were then accuracy checked against the original recording. Participants were assigned an ID number to use in place of their name to ensure the maintenance of their anonymity. A "framework" approach (Ritchie and Spencer, 1994; Ritchie et al., 2003) was utilised to analyse the interviews due to its systematic nature and compatibility with large volumes of data (Gale et al., 2013). The framework approach described in the current paper sits within the thematic methodology and operates from a pragmatic position and a realism ontological position. The approach principally follows a constant comparison method (Glaser, 1965) and is grounded within the data. This method involves comparing interviews to identify similarities and differences in experiences. The relationships between initial themes were investigated to develop main themes and draw explanatory conclusions. Initially, we explored the associations and relationships between themes at an individual case level before looking at the relationships at a global level across the entire sample (i.e., looking for patterns of replication, similarities, and differences). This process involved moving backwards and forwards between the interview transcripts and thematic charts.

Preliminary analyses were carried out to compare women who were actively taking hormone therapy (i.e., Tamoxifen) to those not taking hormone therapy, as Castellon (2004) found more

excessive cognitive impairments associated with Tamoxifen use two to five years after diagnosis. In the current study, no differences were found in the experiences reported.

Following the telephone interviews, verbatim transcripts were examined using NVivo Pro 12 software (NVivo, 2018). The analysis was conducted using the five interconnecting steps (familiarisation, formation of the framework, indexing, charting and interpretation) that form the "Framework" approach. Grammatical errors were maintained to reflect participants' voices. Free codes (open coding) were formed by reading and re-reading each transcript line by line and taking note of relevant units of meaning. These free codes were then grouped into a series of coherent themes to produce a list of main themes and subthemes that reflected the shared experiences, forming the initial thematic framework (also known as the coding index). The coding index remained 'live' and was constantly refined throughout the process of data analysis. The coding index was applied to all of the interview transcripts before thematic charts were constructed to summarise the indexed data for each of the themes. To ensure the trustworthiness of our study, the names assigned to the themes 'gave voice' to participants' perceptions of their experiences following the completion of training. One set of themes was produced for the entire data set. All interviews were conducted, coded and analysed by BC, who had no previous relationship to participants. BC considered her own position in relation to the research topic as a female researcher with no personal experience of breast cancer, as well as, the influence of her views and beliefs on the impact of adaptive cognitive training and cognitive impairment at work in women living with a diagnosis of breast cancer to avoid obvious, conscious or systematic bias and achieve an 'empathic neutrality' (Ritchie & Spencer, 1994; Ritchie et al., 2003). The first ten interviews at each time point were selected before analysis to be independently analysed by BC and EAG, an expert in qualitative analysis. Only minor differences appeared in themes and these were resolved by mutual agreement. Regular consensus meetings took place throughout the coding and analysis process to increase rigor and trustworthiness. Interview transcripts were not returned to participants for review or correction, to ensure participants remained blind to their training group allocation. NVivo Pro 12 software (NVivo, 2018) was used to support data management and analysis, with all of the interviews

collected at one time point analysed before moving on to the next time point (i.e., one-month post-training interviews were analysed before moving on to the six months).

Results

Sample Characteristics

Table 1 shows the sociodemographic information, breast cancer and work characteristics of the 40 women who completed the baseline interviews. Mean age at diagnosis was 46 years (SD 6.24, ranging from 33 to 58 years) and mean time since active treatment was 23 months (SD = 13.0, ranging from 6 to 59 months). Sixty-five per cent of women were working full-time at the baseline interview. The attrition rate was approximately 28% from baseline to six-month post-training (see figure 1 for the flowchart of participants).

Insert table 1 here

Themes

Four main themes were observed across the interviews: (1) impact of cognitive impairment at work, (2) perceived impact of adaptive cognitive training on impaired cognitive function, (3) perceived effects of training on self-management methods for cognitive impairment applied to support work and (4) perceived impact on women's career development and progression.

Theme 1: **Impact of cognitive impairment at work (*Baseline Interviews)***

Women consistently reported experiencing a series of cognitive impairments, adversely affecting their workability and productivity. Many described that these impairments were provoking negative emotions including "frustration" and "sadness" both at work and in their personal lives as well as reducing confidence:

"*I feel inadequate, I've lost a lot of confidence in certain situations, especially at work*".
[participant 38]

Most described a dependency on self-management methods (i.e., notetaking) and checking processes to compensate for their CRCI, delineating that they had become part of the "norm" to function. Dependency seemed to be partially driven by the loss of confidence and trust. A couple mentioned dependency on the coping methods was contributing to their loss of confidence:

"*Simple things I've just…and that is where I lose that confidence because I feel like I have got to double-check everything*". [participant 19]

A few outlined that their perceived CRCI adversely affected their self-esteem and confidence which was impacting their engagement with co-workers and curtailing their career development and progression. Women spoke of noticing that they had become far more "hesitant" and "fearful" and had no "trust" in themselves and their abilities to take on more work:

"*Yeah, it is really affecting my self-esteem. Yeah, it makes me feel less intelligent for sure like I talk myself out of applying for any jobs or talk myself out of anything because I am thinking I am not really sure I would be able to do this or I'll be good enough. So just yeah, I really struggle*". [participant 24]

One-month post-training

Dual *n*-back training:

Theme 2: Perceived impact of adaptive cognitive training on impaired cognitive function

Most women spoke of noticing small to moderate improvements in cognitive domains including decision making, concentration/attention, problem-solving, word-finding, and short-term memory, positively impacting their workability and performance. As expected, short-term memory and concentration/attention were perceived to be the most impacted. Many outlined that training had not completely eradicated their CRCI but reduced its severity and frequency. Linkages were found between

cognitive function, confidence and general emotions (i.e., frustration), with improvements in CRCI elevating confidence, optimism and lowering frustration:

> "*I don't know where I've got this figure from but for some reason, I seem to think that I can concentrate for between 10 and 20 minutes longer than I did previously. I don't know why I think it is specifically 10 to 20 minutes longer, but… I don't know I've got this idea from somewhere maybe I have loosely timed*". [participant 10]

> "*I definitely feel better about myself and I do feel a bit more confident and much less tearful, much less victim like*". [participant 30]

Theme 3: Perceived effects of training on self-management methods for cognitive impairment applied to support work

This boost in perceived cognitive ability lowered dependency and reliance on self-management methods such as notetaking which, in turn, was promoting confidence in the workplace. One woman, for example, described feeling more professional and on par with her co-workers. Women also described feeling more "normal" and "capable. Many women spoke of how their self-management methods had become less detailed, more organised and efficient since the training:

> "*Well, it feels…you feel more…I feel more confident because I feel like my brain is…is taking more of the strain as it were so I don't need those props quite so much*". [participant 14]

Women experiencing little-to-no change with the self-management methods described having a high acceptance which had not changed since the training.

Theme 4: Perceived impact on women's career development and progression

Some women were considering or had already started to increase their number of working hours (either in a paid or voluntary capacity) and workload. This seemed to reflect the perceived improvements in CRCI enhancing work efficiency and confidence. A few women spoke of voluntarily putting themselves forward or applying for new work opportunities, something they would not necessarily have done before the training. Such a behaviour change suggests that dual *n*-back training

provokes greater self-confidence in workability. One woman mentioned she would have taken on work before the training but would not have felt as certain in her ability. A couple of women who stated that they were not content before the training outlined feeling more motivated to make a change:

> "*Just had more… actually no I volunteered to let someone shadow me which I probably wouldn't have done before and that was a confidence thing, I think. So, I've done that and like I said I've got more cases as well and more complex cases*". [participant 31]

> "*Before the training, I was considering quitting…I didn't want to do it anymore I just thought I can't do it…I feel like a fraud but now I am thinking of going a few hours on a Thursday as well so going from 21 hours to 25 hours*". [participant 38]

Dual 1-back training:

Theme 2: Perceived impact of adaptive cognitive training on impaired cognitive function

Many women in this group spoke of experiencing 'little' or 'slight' improvements in short-term memory and attention/concentration. Interestingly, a few mentioned, however, that it was challenging to attribute these changes solely to the training, with one woman explaining she felt the improvements could be linked to a combination of factors including the training sessions, better awareness and natural recovery. This response could be underpinned by doubts or uncertainty around how a 'simple' or non-cognitively demanding task could be responsible for these improvements:

> "*Even a little bit of memory coming back, and you feel more confident you don't feel like you are losing the plot*". [participant 20]

Theme 3: **Perceived effects of training on self-management methods for cognitive impairment applied to support work**

Mixed views of dependency and reliance on the self-management methods were found, with many describing that although they still applied the methods at work their reliance had lessened. A few attributed this to changes in cognition and its impact on confidence. In contrast, others described no noticeable change in dependency, with many indicating that self-management methods (i.e., notetaking)

were crucial. A couple of women did, however, express that the self-management methods had become more efficient and effective, reflecting a better perceived cognitive function, acceptance and more conscious awareness of the importance of using such methods:

> "*At work, I wouldn't say I have changed anything, but I am always… I am always trying to jot things down because I might be doing something at work and I think of something I need to do…actually, this is when I make mistakes a lot of the time when something comes into my mind that I need to do and I don't make a note of it and then just forget it and then I don't do it because I have forgotten it*". [participant 15]

Theme 4: Perceived impact on women's career development and progression

Most women outlined no change to their number of working hours or workload. Only a few in the active control group implied considering or were already starting to participate in new training courses or work opportunities. Women taking on new work opportunities or duties spoke about how growth in confidence associated with perceived cognitive ability was one of the factors influencing their decision.

Six months post-training

Dual *n*-back training:

Theme 2: Perceived impact of adaptive cognitive training on impaired cognitive function

Most women experienced sustained improvements in their perceived cognitive abilities including memory and attention when compared to pre-training. Some, however, outlined starting to notice a decline. These women described experiencing issues with memory and word-finding again, adversely affecting mood (i.e., creating frustrations) and beginning to impact work. This dip seemed to be linked to increased pressure, stress and fatigue as well as the outbreak of COVID-19[2]. Despite these evident declines most described a sustained improvement in their overall confidence. Many spoke of

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[2] Many of the post-training interviews were conducted during the COVID-19 national lockdown in the UK.

still feeling more "worthy", "recovered", "proud" and "in control". For some, confidence had continued to grow, and this was contributing to a greater acceptance and less concern when cognitive issues arose:

"Well, there was an improvement in that, but I do know for a fact the last couple of weeks, in particular, that's kind of been a bit of a problem as well at work and home but mostly at work…I just couldn't find the word that I need and then it made me panic". [participant 31]

"I think it is more the feeling being confident you know thinking I can handle things…I am not completely….my brain is not completely disabled I can handle things and if I don't remember something, I can come back…it is the mindset that has changed for me". [participant 24]

Theme 3: Perceived effects of training on self-management methods for cognitive impairment applied to support work

In line with the one-month interviews, most stated that their self-management methods were far less detailed and more efficient. Many also reported a sustained reduction in dependency which made them feel more "spontaneous", "better", "less tearful" and less "burdened" in the workplace. A few reported being highly dependent on these self-management methods, however, delineated that use had become more of a habit, suggesting that for some using self-management methods may not directly reflect their cognitive function. Two women spoke of reverting to using more methods, stating this was not linked to cognition or dependence but rather changes induced by COVID-19 (i.e., working from home). One woman mentioned that working from home because of COVID-19 had further lessened her need to use self-management methods as there were far fewer distractions than in the office:

"No, not at all and I mean I still write lists for things and I still do lists but not to the same extent as my work list used to be. I mean I have always used lists so that is never going to change but yeah…. yeah, they are just not so…it is not such an integral part of work now". [participant 40]

Theme 4: Perceived impact on women's career development and progression

Many women spoke of how improvements in perceived cognitive function and confidence impacted their desire to increase the number of working hours, workload, or types of work they were taking on, however, because of COVID-19 and circumstances outside of their control these developments had been curtailed for some. Women were taking on additional duties including, new projects or roles because of the growth in confidence associated with their cognitive ability. One woman, for example, spoke of feeling more confident that she could take on additional work without making mistakes because her thought processing was much clearer:

> "*I seem to remember last time we spoke I had loads of improvement like I was thinking of increasing my working hours but that didn't happen because of COVID and everything anyway*". [participant 38]

> "*Prior to the training and prior to kind of… there was a big difference I noticed. I don't think I would have felt confident doing as much as I am doing now if I hadn't had the training*". [participant 40]

Dual 1-back training:

Theme 2: Perceived impact of adaptive cognitive training on impaired cognitive function

Some women reported a slight sustained improvement in their focus/concentration, positively affecting their engagement with tasks and duties, however, most noticed a continuous decline. This seemed to be linked to fatigue and work pressure as well as the indirect effects of COVID-19. There were mixed experiences (incorporating both positive and negative) with memory, decision-making and word-finding, with most noticing a decline. Others felt they had remained stable over time albeit often attributing this to cognitive support methods or external changes within the company.

Theme 3: **Perceived effects of training on self-management methods for cognitive impairment applied to support work**

A moderate proportion outlined some noticeable improvements in the effectiveness and efficiency of their self-management methods despite there being no overall change in dependency, with many denoting a heavy reliance at work. Some described implementing more self-management methods

for cognitive impairment at work, linking this to improvements in efficiency and general acceptance. Being able to effectively use the methods seemed to be contributing to workplace confidence. Only a few in the group spoke of having a lower dependency which was still promoting their confidence:

> "*I think so I mean I certainly feel that I am not forgetting as many things as I was you know maybe a year ago let's say. So, I am remembering to write things down. It is all very well saying write things down to remind you, but you've got to remember to write them down, so I think I am actually better at writing things down and almost I think that is helping with my organisation as well*". [participant 7]

Theme 4: Perceived impact on women's career development and progression

A moderate proportion of women spoke about how their workload or number of working hours had noticeably grown in recent months, however, for most this was due to external circumstances outside of their control as opposed to personal desire. Only a couple of women mentioned starting to put themselves forward for new projects or tasks, which could reflect an improvement in self-confidence at work:

> "*I mean there has been a need in terms of some of the changes around me and I have been able to put my hand up for stuff and say yeah, I can take that on, so it has been obvious… my increased ability and confidence has enabled me to…to take things on*". [participant 8]

Discussion

This study aimed to investigate the perceived effects of adaptive cognitive training (i.e., dual *n*-back training) and active control training (i.e., dual 1-back training) on CRCI impacting the workability of women affected by primary breast cancer. The study also aimed to explore perceived transfer effects of this cognitive training on the self-management methods implemented by women to help manage CRCI in the workplace and career progression or development. Women reported improvements in CRCI following dual *n*-back training, enhancing confidence and general emotional well-being. These

perceived improvements contributed to a lower dependency on self-management methods such as notetaking and promoted career development and progression (i.e., increased workload). Whilst women reported sustained effects on CRCI up to six months, the outbreak of COVID-19 in the UK had curtailed and changed work for many.

In recent years, working memory training such as dual *n*-back training has grown in popularity due to its potential to generate both near and far transfer effects (see Soveri et al., 2017, for a review). Substantiating studies have shown transfer effects in cognitive domains including attentional control, working memory capacity (WMC) and general fluid intelligence (See Derakshan, 2020, for a review). Swainston and Derakshan (2018) also showed sustained far transfer effects in rumination and (trait) anxiety in women affected by breast cancer.

Comparisons between the baseline and the post-training interviews revealed that although dual *n*-back training had not completely eradicated CRCI, most women had experienced positive changes in their perceived cognitive function, compared to the active control group who completed the dual 1-back training. Most commonly women in the adaptive dual n-back training group described noticing evident improvements (or perceived training gains) in their (short-term) memory and attention/concentration which was, in turn, positively boosting confidence and emotional wellbeing. The possible similarities in improvements reported by both adaptive and control groups can be explained by both group's expectancy of the training effects (i.e., personal belief in training's effectiveness), as participants were blind to group status and believed that they were participating in a cognitive training study to improve their cognitive function and workability. Foroughi et al., (2016) found that placebo effects from recruitment posters significantly impacted cognitive training outcomes. Interestingly, however, more women in the active control group described attributing their positive changes to a combination of factors, suggesting uncertainty about the plausibility of dual 1-back training as a cognitive intervention.

Whilst women outlined experiencing some sustained effects following dual *n*-back training when compared to baseline, a proportion described noticing evident declines in their perceived cognitive function in the months before their six months follow-up, coinciding with the outbreak of COVID-19 in the UK. Swainston et al., (2020) found that COVID-related emotional vulnerability

experienced by women affected by primary breast cancer during the peak of the pandemic was associated with worse anxiety and depression as well as poorer cognitive function. Besides, they showed that those in receipt of the UK Government shielding letter were at greater risk of cognitive impairment. Similar findings were reported by Chapman et al., (2020) when assessing the impact of job insecurity created by COVID-19 on emotional distress and cognitive function. As women in the current study were not asked about the impact of the pandemic on their treatment, possible shielding or job security we cannot rule out that these factors may be playing a role in the perceived cognitive decline experienced. Despite this perceived decline many women in the dual *n*-back group described feeling more "worthy", "recovered" and "in-control", reflecting sustained improvements in emotional wellbeing, confidence and self-esteem in the workplace up to six months.

The dual *n*-back training, compared to the active control dual 1-back training, has been found to result in greater improvement in attentional control as assessed by performance on a modified flanker task under stress in high trait anxious participants (Sari et al., 2016). Equally, Sari et al (2016) also found significant training-related gains on neural measures of attentional control as assessed by a reduction in the SW/FW ratio, a known marker of trait attentional control (Putman et al., 2014). Similarly, the dual *n*-back training compared with active control training has resulted in greater improvement in measures of working memory capacity in subliminally depressed participants (Owens et al., 2013) and greater grey matter volume in brain regions implicated in working memory and cognitive control (Colom et al., 2016). Our findings of perceived cognitive function improvements between our training and control groups at one-month and six months post-training are in line with these objective markers.

Women in the dual *n*-back group spoke more prevalently about noticing a change in dependence on self-management methods such as notetaking, suggestive of greater cognitive effects. Women in both groups reported noticeable changes in the effectiveness and efficiency of their self-management methods at work regardless of dependency, for example, women outlined more concise or structured notes and a better ability to remember to use notetaking. It is possible that some of the changes experienced with the self-management methods may have been driven by women's reflections after the

baseline interviews and their (un)conscious decision to make improvements. Given that Chapman et al., (2021) identified that some women find cognitive support methods applied in the workplace to be problematic and to contribute to emotional distress, these findings also have important implications.

In line with studies showing that higher self-efficacy and confidence is associated with better workplace wellbeing (Singh et al., 2019) and work performance (Stajkovic & Luthans, 1998), women in the dual *n*-back group experienced improvements in confidence associated with post-training cognitive ability, positively enhanced perceived workability and performance. In a study by Munir et al., (2010), it was shown that CRCI adversely affects breast cancer survivors' confidence in their workability. Amir et al., (2008), identified that lack of confidence was one of the key challenges experienced by cancer survivors that return to work. Unexpectedly from one-month post-training, some women in the dual *n*-back group stated that they were thinking of or had begun the process of increasing their working hours and workload (either in a paid or voluntary capacity). In comparison, far fewer women who received dual 1-back training spoke of career developments or progression. Studies show that reduction in work hours and changes to work duties are two of the most common adaptions made by cancer survivors (Torp et al., 2012; Sandberg et al., 2014). Of focal importance, Hamood et al., (2019) found that work transitions such as being downgraded (or demoted) adversely impacts the quality of life of women affected by breast cancer. Our findings, therefore, indicate that perceived transfer effects of dual *n*-back training on cognitive function and the translation of this on career development or progression may have vital implications for women's overall quality of life. One possible explanation for this difference between the two groups which should, however, be considered is the availability of career opportunities. It is probable that for some women career opportunities or developments may not be obtainable regardless of their workability. Alternatively, it is also viable that women in the dual *n*-back group were experiencing greater objective cognitive training gains (i.e., genuine effects from the training) compared to the active control group as evidenced by greater career progression, despite the similarities in the subjective reports. Whilst some women reported taking on new duties because of growing confidence and many others wanted to increase their work, the outbreak

of COVID-19 had curtailed opportunities and adjusted the work experience for most women at the six months follow-up.

Taken together, these novel findings have important implications for occupational health services as they suggest that women who receive dual *n*-back training perceive experiencing positive improvements in CRCI, which in turn, boosts emotional wellbeing and confidence. Further, they indicate that these perceived improvements may have a beneficial effect on career development and the self-management methods for cognitive impairment implemented. This research should be interpreted with caution, however, because of the COVID-19 outbreak and should be replicated after work (and the economy) starts to 'normalise' to determine the true efficacy of the training at six months.

Limitations

The current study bestows a few limitations. Firstly, given that the study was longitudinal, and women with known CRCI (i.e., impaired short-term memory) were asked to recall their experiences over six months the impact of memory (or recall) bias should be considered when interpreting the results. Future research could ask women to keep a record of events or experiences to increase the reliability of their accounts. This research was also conducted during the COVID-19 outbreak in the UK which may confound the findings reported.

Conclusion

To conclude, working women who received 12 sessions of dual *n*-back training described positive improvements in their perceived cognitive function which significantly impacted emotional wellbeing and confidence, to a much greater extent than the active control dual 1-back group. Women also reported positive effects on dependency and effectiveness of the self-management methods for cognitive impairment applied to support work, as well as, on their career developments after the training.

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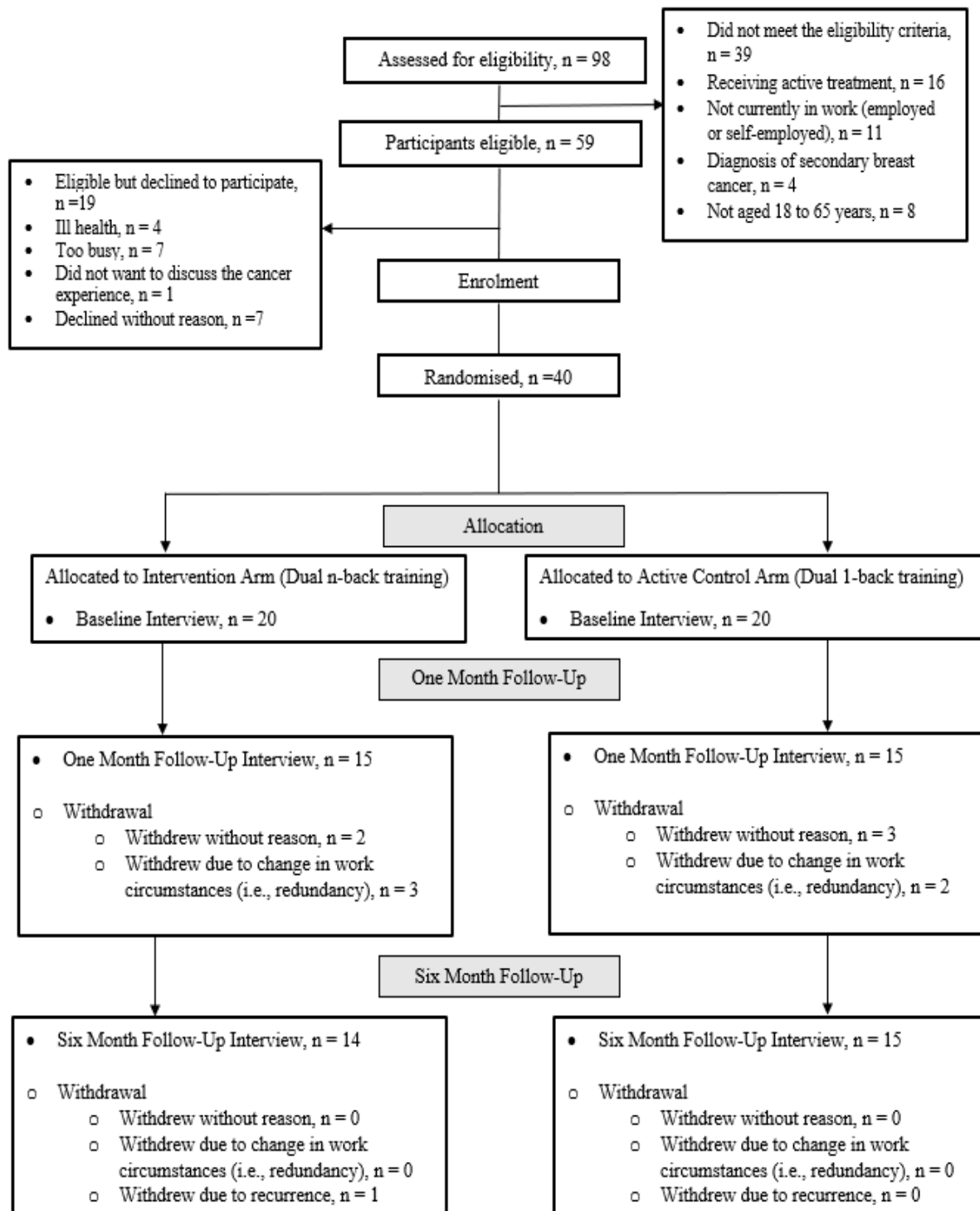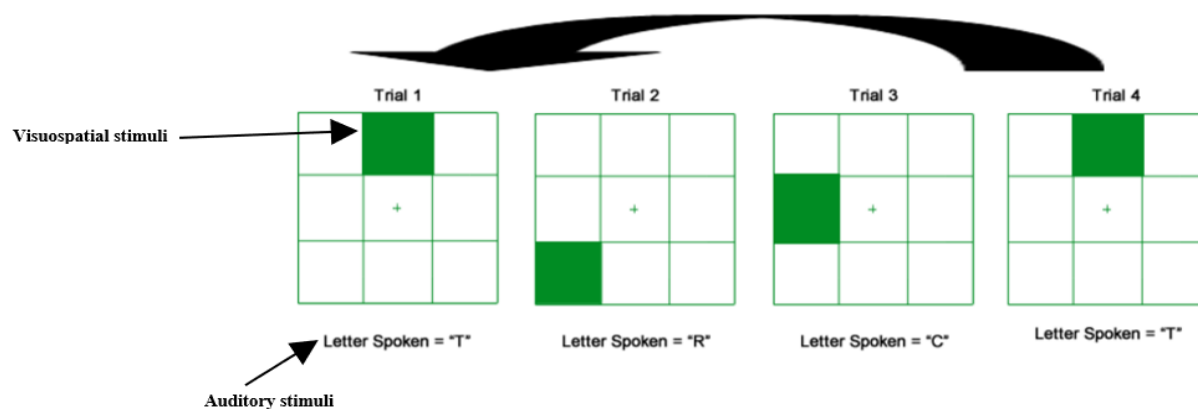**Figure 1**

Flowchart of participants

Figure 2

Dual 3-back training with a visuospatial and audio stimuli match.

Note. Participants were instructed to remember the position of the green box and its partnered spoken consonant and respond using the keypad when the stimulus (green box or spoken consonant) or stimuli (green box and spoken consonant) matched what was shown 3 trials earlier.

Table 1

Participant sociodemographic, clinical characteristics and work information at baseline.

	N = 40	*%*
Sociodemographic		
Age	Mean = 48.8 (Min = 34, Max = 60)	
Education		
Secondary education	2	5.0
Further education	8	20.0
Higher education	24	60.0
Work		
Full-time	26	65.0
Worked through treatment	19	47.5
Clinical		
Age at diagnosis	Mean = 46.2 (Min = 33, Max = 58)	

Type of breast cancer		
Ductal Carcinoma in Situ (DCIS)	3	7.5
Invasive Ductal Carcinoma (IDC)	23	57.5
Invasive Lobular Breast Cancer	3	7.5
Mixed IDC and DCIS	10	25.0
Ductal Carcinoma and Invasive Lobular	1	2.5
Grade		
Grade I	5	12.5
Grade II	10	25.0
Grade III	24	60.0
Type of treatment		
Chemotherapy	30	75.0
Radiotherapy	38	95.0
Surgical Procedure	40	100.0
Time since active treatment (months)	Mean = 23.1 (Min = 6, Max = 59)	
Hormone blocker therapy		
Yes	29	72.5
No	7	17.5
Prescribed but stopped	4	10.0
Herceptin	9	22.5
History of a psychiatric condition	8	20.0

Note. Six participants did not disclose their highest level of education, One participant did not state the grade of their breast cancer, Three participants did not specify if they received Herceptin