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Introduction

An acquired brain injury (ABI) is damage to the brain that occurs after birth (Rees et al., 2007). ABI includes a wide variety of conditions such as traumatic brain injuries (TBI), strokes, hypoxias, infections, tumours, encephalopathies, and neuro-surgical conditions (Slomine & Locascio, 2009). In the United States, 1.7 million Americans sustain a TBI annually and 795,000 survive a stroke every year (Centers for Disease Control and Prevention, 2013). Residual cognitive deficits exhibited after an ABI can substantially inhibit an individual's ability to learn and relearn basic skills and to problem solve. (Lindqvist & Borell, 2010; Slomine & Locascio, 2009). Limitations in these areas can further hinder individuals with ABI from participating in desired daily living activities and performing occupations they previously engaged in before the injury (Silver et al., 2011; Tam & Man, 2004; Topolovec-Vranic et al., 2010).

There are several different domains in cognition, which includes attention, memory, visual processing, organization, problem solving, and executive functioning (Toglia, 2005). Attention is one of the foundational domains in cognitive function (Averbuch & Katz, 2005). Attention requires an individual to maintain focus on specific information for a particular amount of time while modulating environmental distractions. The amount of time required for focusing is dependent on the task demand and the cognitive capability of the individual. For new learning to occur, an individual must be able to select relevant information for a sustained period so that he or she can retrieve or compare information from memory (Averbuch & Katz, 2005). Memory, the storage and recovery of information, is crucial for retainment of information in learning and relearning contexts (Lundqvist et al., 2010; Westerberg et al., 2007).

Individuals with ABI often have cognitive deficits that interfere with the transfer of learning gained from clinical interventions to real-life contexts (Melton & Bourgeois, 2005). Both *generalization* and *transfer of skill* are two key concepts related to transfer of learning. While *generalization* refers to the application of skills in a different context from the original learning environment, *transfer of skill* refers to the application of a particular skill to a related task similar to the learning context and environment (Toglia, 1991). In addition, there are two main types of transfer of skill. *Near transfer* involves the application of a learned skill to another task that is slightly different from the original task, while *far transfer* describes the application of the learned skill to another task that is completely different, but conceptually similar to the original task (Toglia, 1991). For individuals with ABI, near and far transfer of skills from practice in the clinic to in vivo activity performance is more likely to occur when there is close proximity between the skills practiced and the real life tasks (Ehlhardt et al, 2005; Giuffrida et al., 2009; Toglia et al., 2010).

For many individuals with ABI, generalization of skill to varied environments is difficult to attain when the context changes significantly (Finn & McDonald, 2011; McGraw-Hunter et al., 2006). A study by Finn and McDonald (2011) found that for individuals with mild cognitive impairment, there was no generalization of improved self-reported memory functions or perceptions of control over memory following 30 sessions of the Lumosity Brain Training Games (Lumos Labs Inc, San Francisco, CA). The authors hypothesized that generalization did not occur due to the large discrepancy of contexts between the training exercises and everyday activities (Finn & McDonald, 2011).

Cognitive rehabilitation practitioners commonly utilize a cognitive remediation approach to facilitate recovery in individuals with ABI. The cognitive remediation approach focuses on improving and restoring deficits in the cognitive domains for the overarching purpose of restoring meaningful daily living skills (Giuffrida et al., 2009). The foundational premise behind the design of computer-based cognitive retraining (CBCR) programs is to retrain cognitive skills and restore cognitive deficits through repetitions in controlled computer activities. With the rapid advancement and ease of accessibility of technology, CBCR has become a popular media in cognitive remediation therapy (Li et al., 2013; Yip & Man, 2009, 2013). A number of studies have examined the effectiveness of CBCR in cognitive rehabilitation and have successfully demonstrated improvements in cognition using neuropsychological measurements with ABI individuals presenting with various levels of cognitive deficits. (Li et al., 2013; Lundqvist et al., 2010; Tam & Man, 2004; Topolovec-Vranic et al., 2010). However, since CBCR programs focus on strengthening skills in various cognitive domains, it is unlikely that CBCR programs can provide adequate opportunity for individuals to practice every variable that they will encounter in real life contexts (Cicerone et al., 2011; Johansson & Tornmalm, 2012).

There is limited evidence on generalization of clinic practiced cognitive skills to daily performances in the ABI population (Cicerone et al., 2011). A few studies have shown that interventions that are ecologically valid, limit context variance, and purposely address skill generalization are successful in generalizing cognitive skills to daily living contexts (Guiffrida et al., 2009; Toglia et al., 2010; Yip & Man, 2013). However, these studies did not utilize a CBCR program as the cognitive remediation intervention. There is a paucity of research that directly studies the generalization or transfer of improved cognition from CBCR interventions to improved performance in daily living tasks (Giuffrida et al., 2009; Johansson & Tornmalm, 2012; Melton & Bourgeois, 2005; Toglia et al., 2010).

This study utilized the Parrot Software program (Parrot Software, West Bloomfield, MI) as the CBCR intervention. Changes in overall cognition, and attention and memory skills were assessed with a neuropsychological test, the Montreal Cognitive Assessment©(MoCA) (http://www.mocatest.org), while a performance-based medication-box sorting task evaluated generalization to a novel daily living task. Thus, the primary purpose of this exploratory study was to investigate the occurrence of generalizing gains in global cognition, attention, and memory skills from a CBCR program to a daily living task in individuals with ABI. Accordingly, our two null hypotheses stated that a) the Parrot Software program would not improve overall cognition, and/or attention and/or memory skills as measured by the MoCA, and b) the change in cognition would not generalize to improved performance in a novel daily living task.

Methods

Study Design

This exploratory study utilized a quasi-experimental single group repeated-measure design. The implementation of a non-intervention period compensated for the lack of a control group and controlled for the maturation effect within the group. Phase one of the study consisted of a demographic questionnaire, cognitive screening and baseline assessments using the MoCA© original version 7.1 and a baseline medication-box sorting task. Following a minimum of a two-week non-intervention period, phase two of the study began with a pre-test measurement using a second medication-box sorting task. Intervention consisted of eight hours of CBCR over eight weeks. Following intervention, phase three consisted of a post-test assessment using the MoCA© alternative version 7.2 and a third medication-box sorting task.

Participants and Recruitment

A convenience sample of participants presenting with ABI from the Brain Injury Network of the Bay Area (BINBA) program, located in Larkspur California, were recruited for the study. After obtaining approval from Dominican University of California's Institutional Review Board for the Protection of Human Subjects, posted flyers, announcements at the facility, and e-blasts to the greater BINBA community commenced. The investigators responded to all enquiries and completed initial screenings with interested participants via telephone, email communications, or in person at the BINBA facility. To meet the requirements of the screening phase, all participants must have had a diagnosis of ABI for a minimum of one-year prior to the study's execution, be 18 years of age or older, and demonstrated fluency in the English language. After meeting initial screening inclusion criteria, participants advanced to phase one of the study and completed a brief demographic questionnaire, the baseline MoCA 7.1, and a medication-box sorting task. Participants advanced to phase two of the study if they demonstrated deficits in overall cognitive functioning and deficits in both attention and memory as evidenced by scores of less than six on the attention subtest, less than five on the memory subtest, and a below the norm (< 26) finding on the MoCA 7.1. Additionally, to be included in the study, potential participants had to receive a score less than the maximum of 14 on the baseline medication-box sorting task.

Individuals who presented with cognitive deficits secondary to neuro-degenerative conditions, disorientation, visual perception or visual acuity impairments, as well as individuals with bilateral upper extremity motor impairments that interfered with computer use were not included in the study. Failing the MoCA 7.1 orientation subtest and/or an inability to complete the baseline medication-box sorting task were grounds for exclusion.

Intervention

Developed by Dr. Frederick F. Weiner, the Parrot Software program is an interactive Internet rehabilitation platform that is commercially available through Internet access or by CD software. The target populations for the program are individuals presenting with cognitive deficits secondary to stroke and various forms of brain injury. The Parrot Software program contains over 100 different modules targeting cognitive reasoning, memory and attention, reading, speech and language, vocabulary and grammar, and word recall. (Weiner, 2009).

For this study, participants completed eight modules at their own pace in a one-hour session for a total of eight hours. If a participant completed the assigned module before the session concluded, the participant repeated the module until reaching the one-hour time limit. The eight modules in this study paralleled the modules used in Li's et al. (2013) study where participants demonstrated significant increase in attention and memory as measured by a neuropsychological assessment. Four of the chosen Parrot Software modules addressed attention, *Visual Instructions, Attention Perception and Discrimination, Concentration,* and *Visual Attention Training*, and four addressed memory, *Remembering Written Directions, Remembering Visual Patterns, Remembering Written Letters,* and *Remembering Written Numbers*. Each module allowed for repetitive practice and the difficulty level systematically increased within the module.

Instruments

The MoCA is a reliable screening tool to identify cognitive impairments in individuals with stroke, TBI and brain metastases (Dong et al., 2010; Olson et al., 2008; Pendlebury et al., 2012; Schweizer et al., 2012; Wong, Lam, et al., 2013; Wong, Ngai, et al., 2013). The MoCA has a total score of 30 and it measures the cognitive domains of visual perception, executive functioning, attention, memory, orientation, abstraction, and delayed recall (Nasreddine et al., 2005). The MoCA was found to be more sensitive than the Mini-Mental State Examination (PAR Inc., Lutz, FL) in detecting deficits in the cognitive domains of executive function, attention and delayed recall with individuals after acute stroke (Pendlebury et al, 2012). There is also evidence to support its usability in detecting vascular cognitive impairments in individuals with sub-acute and chronic stroke, haemorrhagic TBI as well as brain metastases (Olson et al., 2008; Wong, Lam, et al., 2013; Wong, Ngai et al., 2013). The MoCA is available in three versions in the public domain. Though varied in item content, all three versions maintain the same construct content. For the purpose of this study, the MoCA 7.1 served as both a screening tool for inclusion and a baseline measurement, while the alternative version 7.2 was used as a post-test measurement. The variance in the two versions served as a guard against a learned effect from repeated assessments.

Medication management requires an individual to attend to and organize written information. The medication-box sorting task assessed the participants' abilities to attend and recall information in order to perform the novel task of organizing two medication boxes of one week's worth of medications with a minimal number of errors. The participants received five prescription medication bottles containing beads of varying colors that represented pseudo-prescription medications, and two weekly medication boxes; one labeled morning and the other evening. The investigator provided instruction for the participant to read the directions on the medication bottles and organize the medications into the medication boxes based on frequency per day, time of day, and days per week. To guard against a learned effect of the instrument, there were slight variations between the frequency per day, time of day, and days per week instructions in the baseline, pre-test, and post-test medication-box sorting tasks. In addition, each assessment also contained zero to five over-the-counter (OTC) medication bottles used as distractors. The added distractors increased the variability of the three medication-box sorting tasks and closely simulated the real-life situation of using both prescribed and OTC medications. Rolling a dice before each assessment allowed for randomization of OTC bottles to be included in the medication-box sorting task during each assessment. Number one to five on the dice represented the numbers of OTC bottles added to the assessment, while the number six designated non-inclusion of OTC bottle in the assessment.

Each morning and evening medication box had a compartment for each of the seven days of the week labelled Sunday through Saturday. Placement of a pseudo-prescription or one of the OTC medications into an incorrect compartment scored as an error. Fourteen was the maximum number of correct responses a participant could score and zero correct was the minimum.

Data Collection

To maintain reliability of the repeated measurements, the same investigator completed all measurements with each participant in all phases. The first phase include the baseline measurements using the MoCA 7.1 and the initial medication-box sorting task. After the two-week non-intervention period, each participant completed the pre-test measurement using a different version of the medication-box sorting task. All participants waited no less than two weeks and no more than three weeks between the baseline measurements and the beginning of intervention. During the waiting period, before beginning of the CBCR intervention, no participant received any form of cognitive skill training or rehabilitation. Following the eighth Parrot module, participants waited a minimum of 24 hours before taking post-test measurements. Post-test measurements included the MoCA 7.2 and the post-test medication-box sorting task. All participants completed post-test measurements within one week of completing the eighth Parrot Software training module.

Data Analysis

Demographic data, MoCA, and medication-box sorting task scores were entered into Microsoft Excel and imported into SPSS software version 12.0 (SPSS, Inc., Chicago, IL) for data analysis. Descriptive statistics outlined the characteristics of the participants. Due to the small sample size, the results from the medication-box sorting tasks were tested for normality distribution using the Anderson Darling Test. Since they failed the Anderson Darling Test ($p<.01$), the scores from the medication-box sorting tasks cannot be assumed as distributed normally. Hence, the mean score values of the baseline, pre-test, and post-test medication-box sorting tasks were analysed using Friedman one-way repeated measures analysis by ranks due to the non-parametric nature of the scores. The mean values of MoCA baseline and post-test measurements, and changes in these measurements were analysed using two-tailed paired samples *t*-tests at .05 significance level. Eta-square determined the effect size of the MoCA results while Pearson product-moment correlation coefficient was used to search for relationships between extraneous variables (age, education level, self-reported medication management, previous experience with CBCR and types of ABI) and scores on the MoCA and medication-box sorting task measurements.

Results

The investigators screened 25 adults with ABI and 13 met the inclusion criteria. One participant dropped out during the intervention phase due to difficulties with completing the Parrot Software modules. The remaining 12 participants completed the study in its entirety and were included in the data analysis. The average age of the participants was 61 (SD = 15.79) and the majority (83%) were male. The diagnoses included strokes, TBIs, and brain tumours (Table 1).

MoCA Scores

Significant statistical difference in baseline and post-test global cognition scores was found after CBCR intervention. The mean overall increase was 3.25 with a standard deviation of 2.90 (t (11) = 3.89, p = .03). The eta-squared statistics (η^2=.58) indicated a medium effect size (Cohen, 1988). However, the results showed no significant effect on either the attention or the memory sub-scores. The mean increase for attention sub-scores was 0.42 with a standard deviation of 0.90 (t (11) = 1.60, p = .137). The mean increase for memory sub-scores was 0.75 with a standard deviation of 1.76 (t (11) = 1.47, p = .17) (Table 2). Therefore, these results allow for partial rejection of the first hypothesis that the Parrot Software CBCR would not improve overall cognition, and/or attention and/or memory skills as measured by the MoCA.

Medication-box Sorting Task

On the other hand, the results do not allow for rejection of the second hypothesis that the effects of the changes in cognitive skills would not generalize to improved performance in a novel daily living task. Based on the Friedman test, X^2(2)= 2.38 (p = .30), there was no significant differences among the baseline (M = 0.58, SD = 2.02), pre-test (M = 1.67, SD = 2.74), and post-test (M = 1.17, SD = 4.04) medication-box scores. In addition, there was no significant correlation between randomised OTC bottles and pre-test (r (10) = -.45, p = .15) or post-test (r (10) = .186, p = .56) scores of the medication-box sorting tasks.

Ancillary Results

In regard to the medication-box sorting tasks, the investigators compared the baseline, pre-test, and post-test scores of the participants who reported medication self-management (n = 6) and participants who reported they did not self-manage medications (n = 6). The Friedman tests showed no significant difference for those with experience in medication management and those without experience ($X^2(2) = 0.20$, $p = .91$; $X^2(2) = 4.00$, $p = .14$ respectively).

The investigators also compared the overall MoCA scores of participants with previous CBCR experience ($n = 7$) and participants without previous CBCR experience ($n = 5$). There was a significant different ($t\ (10) = 3.91$, $p = <.01$) in overall increase in MoCA scores for participants without previous CBCR ($M = 5.80$, $SD = 2.39$) experience compared to participants with CBCR experience ($M = 1.43$, $SD = 1.51$). Lastly, there was no significant effect on MoCA or medication-box scores based on extraneous factors such as age, education level, or type of ABI diagnosis.

Discussion

The primary purpose of this exploratory study was to search for occurrence of generalization from gains made in global cognition, attention, and/or memory from the Parrot CBCR program to a performance-based task. Approximately 34% of the variance in the MoCA scores were found to be due to the Parrot CBCR program. The medium effect size of MoCA scores from baseline to post-test suggests that the Parrot CBCR program may be an effective intervention tool to increase global cognitive skills in individuals with ABI. In addition, its low cost and ease of Internet access for multiple users on one group account might afford facilities at varying levels of care and community-based organizations an opportunity to implement a relatively simple intervention aims for improving global cognition in individuals with ABI.

However, significant improvement did not emerge in the cognitive domains of attention and memory. These findings contradict the results found by Li et al. (2013). The previous study found statistically significant changes in individuals with chronic ABI in both attention and memory after utilizing the Parrot CBCR program. The lack of statistical significant changes in attention and memory in this study may be due to the differences in the study samples. Participants were included in this study as long as a cognitive impairment was demonstrated based on the standard cut off score of 26 out of 30 on the MoCA baseline assessment. As a result, the participants in this study had a broad range of severity in global cognitive impairment and majority of them had moderate to severe impairments in attention and/or memory. This differed from the Li's et al. (2013) study that used a more narrow inclusion criterion and excluded those with severe cognitive impairments in attention and memory. Using the Cognistat assessment (Cognistat Inc., Montreal, Canada) as their screening tool, Li et al. (2013) recruited a group of participants (N=11) that were more homogeneous with mild to moderate impairments in attention and memory. The differences in inclusion criteria may have led to the disparity of results and that the Parrot CBCR program may have different effects for individuals with different severity of cognitive impairments. In addition, similar to Li's et al. (2013) study, participants in both studies completed eight 1-hour modules in the Parrot program. With more severe impairments in attention and memory, the participants in this study may have required different practice intensity and frequency. As a result, the Parrot CBCR program did not appear to improve any singular cognitive domain but global cognition instead. One other possible explanation was the differences between MoCA and Cognistat. While MoCA gives a maximum of five points in delayed recall, Cognistat gives 12. Cognistat allows for category and multiple-choice prompts. MoCA, on the other hand, does not allow for any prompt and therefore, if participants were not able to provide a straight recall, they did not receive any point for the missed item. These differences may have affected the sensitivities of the two assessments in detecting small, but significant, changes in memory, with Cognistat being more sensitive than MoCA.

Statistically, there were no significant changes in medication-box scores among the baseline, pre-test, and post-test measurements indicating that the improvement in global cognition did not generalize to better performance in the novel daily living task of medication-box sorting task. These results are consistent with the findings of Ehlhardt et al. (2005) which showed that generalizing skills practiced in significantly varied contexts were difficult for individuals with ABI to accomplish. While the chosen CBCR modules exposed the participants to repetitive practices in the domains of memory and attention, the CBCR program was considerably different in context from the context of the medication-box sorting task. The lack of generalization of global cognitive skill gained from the CBCR program to the medication-box sorting task also coincides with findings by Toglia et al. (2010), suggesting that effective interventions should incorporate focused training that targets skill transfer and generalization. The multi-contextual approach used by Toglia et al. (2010) specifically addressed generalization in each intervention session by systematically modifying activities and changing the context to resemble real life tasks. The context of the CBCR intervention in this study remained the same throughout the eight sessions and was not approximated to the context of the medication-box sorting task.

A second possible explanation might be that the medication-box sorting task was too challenging for this population. Being a novel activity, the task requirements may have been beyond the cognitive capabilities of the participants in spite of their overall improvement in cognition, especially for those who had severe impairments in attention and/or memory. In addition, even though Li et al. (2013) found that eight hours of practicing on the Parrot CBCR program brought about improvement in attention and memory in individuals with mild to moderate cognitive impairment post-ABI, there is not adequate evidence to determine the optimal hours and frequency of practice. Hence, the eight 1-hour weekly CBCR sessions may not have been effective to significantly enhance attention or memory and promote changes in performance for the population in this study.

Experience in previous medication self-management was one of the questions on the demographic questionnaire completed by the participants. Contrary to the assumption that medication management skills may be able to transfer across contexts, the results of the study indicate that even for those participants who reported medication self-management at home were not able to perform the medication-box sorting task successfully. Since the demographic questionnaire did not differentiate the methods of medication management, such as with or without use of a medication box, this result may suggest that the context and task demands of medication self-management play an important role in transfer of skill. The medication-box sorting task used in this study may have differed greatly from medication management methods employed at home by the six experienced participants. Thus, transfer of skill across context was not evident.

Even though previous experience with CBCR would be considered as a confounding factor, our results showed no interference. On the contrary, the finding indicated a significant improvement in global cognition for those participants without previous CBCR experience over those with CBCR experience. A possible explanation is that individuals without previous CBCR experience could have been more intrinsically motivated to use the computer-training program since it was a novel task and therefore spent more energy "learning" in this new context. The findings may also indicate that those participants with previous CBCR experience might have reached a plateau or that CBCR intervention might have a ceiling effect, where continuing CBCR sessions would have little effect on improving cognition. Likewise, Gaitan et al. (2013)

and Kwok et al. (2011) reported similar findings when utilizing a CBCR intervention with individuals with mild cognitive impairments, supporting the notion that providing the 屠ust right challenge· can improve outcomes.

While the results from this study are inconclusive, the study generates possible implications for the advancement of cognitive rehabilitation and occupational therapy practice. The findings presented above confirm that CBCR as a stand-alone intervention may not be an effective rehabilitation method to facilitate generalization of skill and performance improvement in individuals with ABI. These findings accord with the recommendation from the Cognitive Rehabilitation Task Force of the American Congress of Rehabilitation Medicine Brain Injury Interdisciplinary Special Interest Group (Cicerone et al., 2011). While technology continues to progress, the field of rehabilitation must also continue to evolve. As CBCR programs continue to gain popularity (Yip & Man, 2009), they will continue to provide convenient opportunities for individuals with cognitive impairment to participate actively in their recovery process. The results of this study, at a minimum, expand awareness that although cognition may have increased after using a CBCR program, detection of these changes may be only exclusive to neuropsychological measurements. Since performance improvement is the primary focus in occupational therapy, the use of neuropsychological measurements only without confirmation with an ecologically valid performance-based assessment does not allow therapists to accurately assert progress in daily living tasks after therapy. Furthermore, the gain in cognition obtained through CBCR programs may need to be thoughtfully generalized to daily living tasks through systematic, individualized therapy in a multitude of contexts.

Limitations

The study is limited by the small sample size. In addition, convenience sampling yielded a group of participants from a single community-based program, whose ages widely span from 34 to 84. Therefore, generalization of the results to the larger ABI population will not be appropriate. Due to the use of an unconventional, non-standardized measurement tool, the medication-box sorting task, a power analysis to determine the sample size needed to reach statistical significance was unobtainable. The investigators allowed all individuals who met the inclusion criteria to participate in the study. However, this also may have promoted the likelihood of a heterogeneous group, especially since all participants were from the same community-based day program.

In designing the study, the investigators wanted to utilize a novel and yet functional task. Since it is common for individuals with ABI to take multiple medications, hence the medication-box sorting task. However, the medication-box sorting task developed by the investigators as a measurement has not undergone testing with a population of individuals with ABI and there was a potential for learned effect when completing the task multiple times. While the former concern was incidentally addressed in this small-scale exploratory study, the investigators chose to utilize two methods to address the latter limitation, the variance in each of the medication-box sorting tasks and randomisation of the OTC distractions. Nevertheless, whether the medication-box sorting task was an appropriate tool for this study sample remains questionable.

Another limitation to the study was the self-report demographic questionnaire. Participants could have inaccurately provided answers to items in the questionnaire, especially since all participants had varying degree of cognitive impairments. One of the questions in the demographic questionnaire asked for experience with medication self-management, but it may not have been specific enough to delineate the methods for managing medications at home. Therefore, the validity of any results related to the demographic questionnaire remains doubtful.

Conclusion

Individuals with ABI often have persistent and chronic residual cognitive deficits. The cognitive domains of attention and memory are often most notably affected. These deficits can affect activities of daily living, social participation, and the overall quality of life. With the advance in technology and Internet accessibility, CBCR has become one of the more frequent remediation approaches used due to its popularity and convenience. Recent research shows that CBCR programs can be effective in remediation of cognitive deficits in individuals with ABI, but there is limited research that examines the occurrence of the generalization of skill to a novel activity of daily living.

To address this gap in literature, this study evaluated the occurrence of skill generalization from gain in cognition attained from a CBCR program to a performance-based medication-box sorting task. Essentially, the investigators discovered while a CBCR program may have increased the participants' global cognition, but the improvement was not demonstrated in a performance-based context. This study provides supportive evidence to maintain utilization of a CBCR program as an adjunctive therapeutic modality only. The exploratory nature of this study and the small sample size warrant replication with a larger more homogeneous sample. Furthermore, future research should investigate ecologically valid assessments and interventions that utilize functional activities that are salient to the population. In combination, future studies should include interventions that can bridge the gap between CBCR and improved performance in necessary and desired daily living tasks.

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