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Activity Interventions for Cognitive Problems

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Improvements in the medical management of childhood and adolescent cancer now yield remarkable survival rates. However, several studies have demonstrated that childhood cancer and associated life-saving treatments frequently culminate in long-term impairments in neurocognitive functions [1-4]. These impairments include deficits in information processing speed, attention, working memory, delayed recall, and executive functions. Not only are these neurocognitive impairments problematic, they are associated with limitations in important everyday activities such as self-care, education and work-related activities [3,5,6]. These everyday activities are critical to long-term independence and favorable quality of life [7].

The neurocognitive impairments and associated activity limitations that arise among survivors of childhood cancer are very similar to the long-term problems that arise after acquired brain injury. In fact, impairments in information processing speed, attention, memory and executive functions, as well as fluctuations in mood and emotional regulation, are the signature sequelae of mild acquired brain injury [8,9]. As in the case of individuals who survive childhood cancer, individuals with acquired brain injury experience significant limitations in their ability to perform everyday activities at home, school, and in the community [10,11].

Given the detrimental effects of neurocognitive impairments and their impact on everyday activities, neurological rehabilitation professionals have conducted several studies examining the efficacy of intervention approaches to address these critical problems. The purpose of this paper is to provide an overview of the theoretical foundations and the current state of science examining activity interventions designed to address neurocognitive impairments and associated activity limitations. I will discuss the growing body of evidence examining activity interventions for survivors of childhood cancers, as well as lessons learned in neurological rehabilitation that may help inform future research and clinical practices.

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Theoretical Foundations

Prior to describing and examining activity interventions, it is important to first consider the biological and behavioral mechanisms that contribute to neurocognitive impairments. The International Classification of Functioning, Disability and Health provides a framework for identifying and examining key elements that interact along the continuum of health and function [12]. A given state of health (or disease) is associated with the integrity or impairment of body structures and functions, the absence or presence of activity limitations, the absence or presence of participation restrictions, the influence of environmental factors, and the personal characteristics of the individual (Figure 1). In the case of acquired brain injury (through exposure to pathology, toxins, or trauma), damage to the structures and functions of the brain is associated with impairments in neurocognitive functions (Figure 2). These neurocognitive impairments are not benign. Individuals with neurocognitive impairments have difficulty performing “real life” activities, ranging from basic self-care to more complex home, educational, and professional activities. While the type and severity of these activity limitations may vary, they can impede academic performance, return to work and productive participation in society [11,13-16]. Furthermore, these activity limitations and participation restrictions are associated with poor overall health status and poor quality of life [17-20]. Thus, interventions that are designed to prevent or address these negative consequences may need to address one or more of these domains of function.

Ideally, interventions designed to prevent neurocognitive impairments should focus on minimizing damage to the grey and white matter structures within the brain by reducing the severity or length of exposure to pathology, toxins, or trauma. However, once damage to the brain has occurred, intervention approaches should focus on addressing resulting neurocognitive impairments or activity limitations, accounting for the influences of environmental and personal factors. These intervention approaches can be divided into two categories: “bottom-up” and “top-down” (Figure 3) [21].

Bottom-up approaches focus on improving specific neurocognitive functions through “drill and practice” exercises. These approaches are based on the premise that improvements in neurocognitive functions may subsequently promote improvements in the performance of everyday activities. Drill and practice exercises frequently take the form of simple tasks such as “find the hidden object,” “learn and recall the following list,” or “complete the following sequence,” and can be delivered through paper-and-pencil or computerized methods.

Drill and practice exercises are derived from basic and translational studies that suggest that repeated practice of motivating and challenging tasks sharply increases synaptogenesis, and thus improves the coordination and power of complex neurological networks receiving and processing sensory stimulation [22,23]. Through the refinement of these sensory processing systems, neuromodulatory systems are stimulated, releasing specific neurotransmitters that support improved arousal, attention and complex neurocognitive functions (e.g., problem solving) [24,25].

Top-down approaches focus on improving the performance of everyday activities. These approaches are based on the premise that improvements in the performance of everyday activities may subsequently promote improvements in underlying neurocognitive functions [21]. Top-down approaches are frequently referred to as “activity interventions” because everyday activities are both the modality (intervention process) and the outcome of these approaches. Activity interventions involve the identification of problematic everyday activities; the derivation of goals, plans and iterative practice to address these problematic activities; and the development, modification, and implementation of successful strategies to facilitate generalization of learning to a variety of activities at home, school and in the community (e.g., managing medications, writing an essay, or handling money). In doing so, activity interventions not only address the performance of the selected activity, but they teach the client a process by which they can learn to identify and manage problems that they can later apply to other activities (i.e., generalization of learning). Generalization is particularly important if one hopes to see improvement in performance of everyday activities above and beyond those activities addressed in the context of neurological rehabilitation [26].

Activity interventions utilize the same active ingredients as drill and practice exercises – repeated practice of motivating and challenging tasks – and one more critical ingredient – practice of meaningful everyday activities. Through practice of meaningful everyday activities, activity interventions likely stimulate salience and associated motivational networks in the nervous system that have been associated with learning [27].

For individuals with neurocognitive impairments, meta-cognitive strategy instruction is an important adjunct to activity interventions. Meta-cognitive strategy instruction trains individuals to monitor and regulate their own behavior, identify and analyze problems that they encounter in everyday life, and develop and apply strategies to address the problems [28]. Each of these skills are associated with neurocognitive operations collectively referred to as executive or meta-cognitive functions [29-31]. However, the direct effects of meta-cognitive strategy instruction on neurological networks remains unclear.

While the neurological mechanisms of meta-cognitive strategy instruction require further examination, the behavioral mechanisms seem to be better understood. Meta-cognitive strategy instruction utilizes guided training (sometimes referred to as guided discovery) to cultivate clients’ own skills in identifying, analyzing and addressing problems with everyday activities. Studies suggest that individuals with neurocognitive impairments may best acquire, retain, and generalize learned strategies when they have the opportunity to face difficult challenges and overcome them through guided problem-solving [32,33]. Thus, rather than identifying and analyzing problems on behalf of the client and then instructing the client derived solutions, guided training coaches the client to learn these processes so that they may develop skills that can generalize beyond the everyday activities addressed in the context of rehabilitation.

State of the Science

The majority of studies examining interventions designed to address neurocognitive impairments and associated activity limitations after acquired brain injury have focused on bottom-up approaches. The combined evidence from four systematic reviews [34-37] and two meta-analyses [38,39] suggests that drill and practice exercises produce improvements in selected neurocognitive functions (e.g., information processing speed, attention) after acquired brain injury [34-39]. However, despite improving critical neurocognitive functions, drill and practice exercises do not seem to promote improvements in the performance of everyday activities [34-39].

In contrast, recent evidence suggests that activity interventions are effective in improving performance of meaningful everyday activities [40-47], and in some cases improving underlying neurocognitive functions after acquired brain injury [41,48-50]. Although further empirical examination is warranted, activity interventions show promise for promoting self-care, academic, and professional activities among individuals with neurocognitive impairments.

In a brief review of studies examining interventions to address neurocognitive impairments attributed to cancer and related-treatments, we are able to draw a few conclusions about the implementation of bottom-up and top-down approaches in this population. First, a few studies have demonstrated the feasibility of drill and practice exercises [34,35], activity interventions [51], or a combination of both [52,53] for survivors of childhood cancer, but as of yet the efficacy of these interventions in this population remains unclear. Variability in the level of outcomes measured (neurocognitive functions versus activity performance) limit further conclusions about the effects of interventions at either level. Furthermore, most of the studies have examined multi-component interventions that incorporate elements of bottom-up and top-down approaches, making it difficult to identify which critical ingredients contributed to study outcomes.

Lessons Learned and Implications for Research and Clinical Practice

To identify and evaluate efficacious interventions that address neurocognitive impairments and associated activity limitations, future studies need to clearly specify desired target outcomes and the potential active ingredients of interventions designed to address these outcomes.

One of the challenges in neurological rehabilitation research is the multi-factorial nature of the mechanisms and outcomes of interest. Neurocognitive impairments are multi-dimensional (multiple domains, multiple factors influencing each domain, and multiple consequences impacting the performance of everyday activities). It is neither possible nor desirable to isolate and study each of these factors individually. Rather, clear specification of critical concepts of functioning and disability and the predicted nature of their relationships is essential to establishing a consistent framework for evaluating mechanisms and outcomes of interventions. The International Classification of Functioning, Disability and Health provides a starting point for this task. In this paper, I examined two concepts from the Classification as potential target outcomes of intervention studies: neurocognitive

impairments and associated activity limitations. Assessment of neurocognitive impairments provide a direct measure of intervention outcome, allowing us to posit and evaluate mechanisms that contribute to decline and improvement. Assessment of activity limitations provides a heuristically valuable measure of changes in “real-life” [28]. Future studies examining the efficacy of interventions to address neurocognitive impairments should address outcomes at both of these levels, and include long-term follow-up to assess the retention and generalization of improvements at both levels.

Another challenge in neurological rehabilitation is the recognition that multi-component interventions are necessary to address the multi-dimensional nature of neurocognitive impairments. However, it is difficult to empirically examine the efficacy of multi-component interventions if the active ingredients of the intervention are not clearly specified. Conceptualization of interventions in terms of the mechanisms that they are designed to address may be a useful way to specify the active ingredients of the intervention. (For additional references on methods for specifying and validating active ingredients of behavioral interventions in rehabilitation, refer to published papers by Whyte & Hart[54] and Hildebrand & Lenze[55]). In this paper, I used the “bottom-up” and “top-down” models inherent in many neurological rehabilitation interventions as a gross framework for describing interventions designed to address neurocognitive functions and the performance of everyday activities. This gross framework may provide a starting point for future conceptual models that “drill down” on more specific biological and behavioral mechanisms of action.

Summary

Cancer and its life-saving treatments often result in long-term impairments in neurocognitive functions. Not only are these neurocognitive impairments problematic, they limit the ability to perform meaningful everyday activities critical to independence in the home, school and community. Activity interventions show promise for improving performance of everyday activities, as well as improving underlying neurocognitive functions. However, additional empirical examination is warranted. Future studies examining activity interventions should clearly specify the active ingredient of the intervention, and evaluate the impact of the intervention on neurocognitive as well as activity-based outcomes.

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International Classification of Functioning, Disability and Health

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Figure 1.
International Classification of Functioning, Disability and Health

Influence of Acquired Brain Injury on Functioning, Disability & Health

Figure 2.
Influence of Acquired Brain Injury on Functioning, Disability & Health

Bottom-up and Top-down Approaches to Neurocognitive Interventions **Figure 3.**

Bottom-up and Top-down Approaches to Neurocognitive Interventions