Using a Physical Model of a Supermarket to Assess and Treat Stroke

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Key Words: Simulated shopping task, Stroke, Rehabilitation, IADL, Executive functions

Abstract

Stroke is one of the most common factors leading to significant functional limitations in adulthood and often results in cognitive and higher cognitive (executive function) deficits. Although shopping is considered to be one of the most significant Instrumental Activities of Daily Living (IADL), only a small percentage of the adult population who have had a stroke continues to shop. During the course of stroke rehabilitation, it is difficult to perform assessment and training in a real supermarket environment due to administrative, physical and safety issues. Virtual reality technology has been utilized to partially resolve this problem by enabling the use of safe functional virtual shopping environments during rehabilitation. In this paper, we present another alternative to simulated shopping, namely, the "Super-Model" environment; a physical replica of a supermarket that provides an intermediate stage in the sequence between virtual shopping and the real-life task. A description of the environment as well as suggested assessment and treatment activities are provided and illustrated by a case study. This medium appears to provide a meaningful addition to the repertoire of tools occupational therapists use in order to enhance community participation after rehabilitation of people who had a stroke.

Introduction and literature review

Stroke is a primary cause of disability in adulthood, and one of the most common causes of significant physical and cognitive limitations that curtails

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the achievement of functional independence and reduces quality of life (McKinney, Blake, Treece, Lincoln, Playford, & Gladman, 2002). Instrumental activities of daily living (IADL) include primary areas of occupation that are affected even by a mild stroke (Insel, Morrow, Brewer, & Figueredo, 2006; Jefferson, Paul, Ozonoff, & Cohen, 2006). Individuals who live in the community one year after stroke have indicated dissatisfaction with their decreased level of participation and have emphasized the importance of targeting participation in IADL and leisure activities during rehabilitation (Hartman-Maeir et al., 2007).

Shopping is a complex IADL that is required for independent community living and also serves as a common leisure activity (Rand, Katz, & Weiss, 2007). However, only a small percentage of the adult population with stroke continues to perform shopping independently or with the assistance of a companion (Hartman-Maeir et al., 2007). Enabling a return to shopping thus constitutes one of the treatment goals during the post-stroke rehabilitation process.

Shopping requires planning, preparing a shopping list, selection and purchase of items, choosing a method of payment and performing the actual payment (Yalon-Chamovitz et al., 2006). In order to perform this task, several basic cognitive abilities are required, including memory, categorization, attention and orientation. Higher cognitive abilities, i.e., executive functions (EF), such as organization, planning and problem solving, are needed as well (Brown, Rempfer, Hamera, & Bothwell, 2006).

Due to time and technical constraints rehabilitation does not always incorporate sufficient ecologically-based training tasks, nor assessments of the abilities, especially executive functions, necessary to return to complex daily living activities, such as shopping, using public transportation and cooking (Rand, Weiss, & Katz, 2009). Thus, it is important to find motivating and ecologically valid assessment and intervention tools that will facilitate the transfer of skills attained in treatment to daily life (Katz & Maeir, 2011) and will be feasible for use in a clinical setting (Kizony, Josman, Katz, Rand, & Weiss, 2008; Rand et al., 2009; Rand et al., 2007).

In recent years, a number of functional virtual environments, and in particular, virtual supermarket environments have been developed to assess executive functions for a variety of populations including stroke (Josman, et al., 2006; Rand et al., 2007; Lee et al., 2003), traumatic brain injury (Castelnuovo, Lo Priore, Liccione, & Cioffi, 2003) Parkinson's disease (Klinger, Grumbach, Chemin, Lebreton, & Marie, 2006), schizophrenia (Josman, Elbaz-Schneiderman, Klinger, & Shevil, 2009), and mild cognitive impairment (Josman, Klinger, &

Kizony, 2008). It has also been used as an intervention tool in several populations such as stroke, (Jacoby et al., in press; Rand et al., 2009) and mild cognitive impairments (Kizony, Korman, Sinoff, Klinger, & Josman, 2012). The results have demonstrated their potential effectiveness for assessment (Josman et al., 2006; Lee et al., 2003; Rand et al., 2007) and intervention (Rand et al., 2009) of post-stroke clients through the use of virtual shopping tasks

Despite their advantages, virtual environments are less amenable to the creation of realistic sensory-motor demands, in particular, aspects related to the manipulation and handling of objects (Rizzo & Kim, 2005). Thus, the question arises whether an intermediate stage is needed in the sequence between virtual and real-life shopping. A review of the literature revealed only one documented physical mock-up of a supermarket - a cashier's work station - used to study the ergonomic characteristics of a shopping environment and the work habits of employees (Das & Sengupata, 1996).

In order to test the need for an intermediate stage between a virtual and a real set-up, a physical mockup of a shopping task, referred to as a "Super-Model" environment, was developed and built in the Department of Occupational Therapy in the Geriatric Rehabilitation Hospital at the Sheba Medical Center. The "Super-Model" has been designed to replicate the physical and cognitive aspects of shopping in a real-life supermarket setting. The purpose of this paper is to demonstrate its potential for post-stroke rehabilitation by providing suggestions for assessments procedures as well as therapeutic tasks based on models for cognitive intervention in occupational therapy. A use-case example is presented.

"Super-Model" Physical Mockup

As shown in Figs. 1 and 2, the "Super-Model" is located in a 4.2 X 3.8 m room, used primarily to provide individualized treatment sessions (although it can accommodate several clients at the same time). The "Super-Model" consists of 24 shelves set up to create three shopping areas. The shelves are stocked with packages of real products organized into categories comparable to the different aisles found in a real-life supermarket. Some of the packages are empty but many are filled with weighted material in order to replicate their actual mass, adding to the participant's sense of realism and providing a greater motor challenge and sensory feedback. The participants use a shopping cart to travel short distances, and to store the purchased products. The products are

purchased at a cashier's station with simulated money (see Fig. 2). Background music or recorded sounds from a real supermarket may be played or the environment may be kept quiet.

Figure 1
The "Super-Model" environment

The advantages of the "Super-Model" are that it aims to provide a close-to-real-life shopping experience in a supermarket, enabling actual contact with and manipulation of real products. Yet the tasks take place in a small, safe setting where motor and cognitive difficulties can be readily graded to suit the personal rehabilitative needs of the clients (e.g., limitations in mobility). Nevertheless, a fully realistic simulation of real-life store in a physical mockup is difficult to achieve due to differences in the actual dimensions of the shopping area and the authenticity of the shopping tasks.

Figure 2
The "Super-Model" environment

Suggested Assessment Procedures within the "Super-Model":

"Four-Items" Assessment

The "Four-Items" task was developed as a simple test of cognitive and motor ability for use in the VMall virtual supermarket environment (Rand et al., 2007). Subjects were required to "buy" four different grocery items that appeared on a written list and were located in two different aisles on the upper and middle shelves in the VMall. A similar task can be used in the "Super-Model" environment with minor differences in content. In addition, the "Four-Items Modified Task", was developed. This task includes the use of simulated money in order to assess budget management. Clients need to purchase four items from a displayed list within a given budget, taking into account the amount of money given to them (which is a greater sum of money than required to buy the items on the list, provided they do not select products that are more expensive (e.g., those of a different company or a product which differs in quality). For example a one liter carton of 3% milk costs NIS 5.70 while a carton of 1% milk costs NIS 6.50).

Outcome measures of this assessment include: Time of performance until the purchase of the first item, total shopping time, the efficacy of strategies use; sequence of shopping (by tracking the numbers affixed to the top of the shelves when the client moves from one shelf to another), return to a certain shelf more than once, self-monitoring, the ability to correct oneself and the type of corrections made are also recorded. In addition, the interaction of the subject with the environment and significant comments by the subject are also examined.

The type of errors made during this task include: not purchasing all four items, purchasing the wrong product/type of product, and budgetary mistakes (e.g., overspending).

Training within the "Super-Model" Physical Mockup

There are a number of therapeutic goals that can be achieved in the physical mockup setting, which aim to enable clients to participate in meaningful daily activities via training of specific skills and meta-cognitive strategies using ecologically valid shopping tasks. The complexity of IADL such as shopping enables the training of motor (See Table 1), cognitive or metacognitive skills and strategies (See Table 2) in single, dual or multiple tasks as required eventually in real life.

Implementation of the "Super-Model" as a therapeutic environment should be based upon models of interventions or treatment approaches commonly used in occupational therapy. From the sensory-motor aspect, the task specific approach (Bass-Haugen, Mathiowetz, & Flinn, 2008) or NeuroDevelopmental Treatment approach (Levit, 2008) may be used and the tasks designed by the therapist should follow their assumptions. However, in the work presented in the current article, the focus has been on a cognitive and meta-cognitive perspective in accordance with the functional difficulties displayed by the clinical case study presented below. From the cognitive aspect, techniques from the neurofunctional approach, which targets functional and activity level rather than impairment, may be used (e.g., backwards or forwards chaining (Giles, 2011). In addition, intervention may also be based on Toglia's Multi-Context Approach (Toglia, 2011; Toglia, Johnston, Goverover, & Dain, 2010) that focuses on self-generating and training of strategies and the transfer of those to other contexts and activities for better performance and participation. Since shopping is a familiar task it may encourage the client to initiate the use of strategies that can be trained in the "Super-Model" in a variety of tasks and then transferred to other contexts. According to Toglia (2011), an appropriate selection of strategies gives a client efficient tools for handling complex cognitive situations. "Self instructional" and "checklist support" are given as examples for strategies in case of difficulties with executive functions (Toglia et al., 2010). By using the Multi-Context approach we can help clients to increase their self-monitoring skills, and manage task errors over a wide range of activities (Toglia, Goverover, Johnston, & Dain, 2011). It should be noted that only near or intermediate transfer, i.e. transfer of strategies to similar contexts and activities, can be achieved using this approach since the "Super-Model" is a limited context for intervention (i.e., "supermarket" for shopping only).

Table 1
Opportunities for motor intervention in the "Super-Model"

	Grading the Motor Requirements
Therapeutic Goals	
Mobility	• Means of mobility: wheelchair / walker (with a shopping basket) / supermarket buggy • Grading of independence of mobility: performance with physical assist by the therapist / performance with supervision of the therapist / independent performance
Balance	• Performance while seated: reaching nearby shelves / bending to reach shelves while sitting in a wheel chair • Performance while standing: reaching high shelves / bending to reach low shelves • Motor dual tasking (standing or walking while searching for a product)
Walking	• Performance of transitions and walking in the supermarket: with physical assist by the therapist / supervision of the therapist / performs independently
Range of Motion and Strength of upper extremities	• Which hand is used by the client: use of healthy extremity / use of affected extremity • Muscle strengthening: lifting products of different weights • Endurance: increasing the number of products / accessing products found on more remote shelves

Table 2
Opportunities for cognitive intervention and training strategies in the "Super-Model"

Grading the Cognitive requirements		
Category	**Strategy**	**Therapeutic activity**
Visual perception	• "When you search for a particular product search for the logo which usually appears on the product itself"	• Identify products according to their logo • Differentiate between similar products (e.g., cottage cheese versus soft cheese, same product by different companies)
Memory and spatial orientation	• "Try to remember which aisles are located next to each other and plan the order of your purchase accordingly"	• Remember which products are customarily bought / names labels Use of list as a memory strategy • Remember products not on the list (while increasing the degree of difficulty) • Remember the location of the aisles in which products were obtained on a previous occasion
Attention	• "When the task is interrupted, first stop! and try to return to the last item on the list you were looking at before"	• Task that includes divided attention / shifting attention • Adding a product that is not on the list according to demand during the task • Adding distractors: Public announcement regarding a sale, telephone call while shopping, other shoppers in the supermarket
Sorting and categorization	• "When you make a shopping list, organize the products you intend to buy by categories"	• Dividing and sorting into different categories (for example, canned goods, legumes, bakery products) • Sorting into similar categories (for example, dairy products: cheese versus yogurt) • Sorting according to different criteria (brand names, percentages of fat, products without sugar)

Sequence	• "Find all the products on the list that are located in the same area and only then move on"	• Efficient sequencing during the shopping task • Preparing a list according to a specific recipe
Planning	• "If you have a budget you need to manage, you should look for cheaper products" "Pay attention to special offers /sale"	• Performing a number of tasks simultaneously (multitasking) • Price comparison • Budget management • Problem solving (e.g., what to do in case in case a product is missing • Efficient behavior in the supermarket (buying all the products on the list that are from the same aisle/area and then move on) • Shopping while speaking of the phone • Shopping with other shoppers on the same time

Case Study

The participant, RY, is a 74-year-old man who, prior to a stroke, lived at home with his wife. He was employed as a taxi driver and was accustomed to shopping weekly. RY was admitted for acute care to the department of neurology following a left cerebellar hemorrhagic stroke. The stroke was accompanied by dizziness and difficulty maintaining balance with mild weakness on the right side of his body, without distinct hemiplegic signs. After two weeks he was transferred to a rehabilitation center where he was given daily treatment in occupational therapy, physical therapy and speech therapy. Upon admission to rehabilitation, RY had full range of motion in both upper extremities with the exception of limited right shoulder flexion and right wrist extension near the ends of these ranges. His general cognitive function, as tested by the MMSE, was within normal range (29/30) but the Clock Drawing test was deficient (6/10) (Rouleau, Salmon, Butters, Kennedy, & McGuire, 1992). RY was not completely aware of his cognitive deficits and displayed a lack of judgment that was apparent, for example, by walking without supervision even though he was forbidden to do so. In addition, RY demonstrated difficulty in performing complex tasks independently and had

executive function deficits as demonstrated by the "Zoo-Map" (1/4) and "Rule Shift Card" (0/4) subtests from the Behavioral Assessment of the Dysexecutive Syndrome (Wilson, Alderman, Burgess, Emslie, & Evans, 1996) together with the "Using the Telephone" (4/25) and "Paying Bills" (17/25) subtests from Executive Function Performance Test (Baum et al., 2008).

Occupational therapy treatment included motor and cognitive aspects, according to goals set together with the client. RY was able to learn and apply new cognitive strategies, and maintain them over time. One of the most important goals for RY was to be able to help his wife again with everyday tasks such as shopping. Therefore assessment and training in the "Super-Model" environment appeared to be an appropriate for RY. Two months after the rehabilitation process began RY was ready for intervention within the "Super-Model" as a part of the preparatory phase to be discharged home. The assessment and intervention were done by the same occupational therapist.

Pre-Intervention Assessment

RY was assessed with the original and modified versions of the "Four-Items" tasks in the "Super-Model". During the assessment process no mediation was given to RY by the therapist. The coding procedure was conducted during real-time observation. RY's performance time during the original task was 6 minutes and 40 seconds and during the modified task it increased to 10 minutes and 3 seconds. These times are considerably longer than those of participants of comparable age and no neurological deficit (e.g., a healthy woman of the same age performed the original task in 50 seconds and the modified task in 1 minute and 46 seconds). Observation of RY's performance of the two tasks revealed that he used inefficient strategies to complete both tests. Difficulties in planning and organizing his search were noted; although the products were placed on only two shelves, he bought items according to the order on the list rather than buying them sequentially from the two adjacent shelves on which they were located. Moreover, he returned to the same shelf a number of times, and passed a total of 14 different shelves. In addition, he did not appear to make use of the category names on the shelves (representing aisles) in order to locate the different products. Finally, difficulties in shifting attention and in initiation were observed; RY remained at the same shelf in the same area for lengthy periods and did not readily move to another area when he did not find a particular product.

In addition to the problems mentioned above, difficulty was also observed in performing a complex task (multi-tasking), mental fixation, confusion

between concepts, and associativity during the performance of the modified "Four-Item" task.

Intervention

The "Super-Model" intervention was provided, with the therapist present, at a frequency of two to three 45-minute sessions per week. Additional occupational therapy treatments were given in the clinic for a total of five sessions per week. The intervention within the "Super-Model" included the training of efficient strategies to cope with the problems identified in EF using the Multi-Context approach (Toglia, 2011). According to Toglia et al. (2011), external strategies, such as a checklist, can lessen the load on working memory, decrease impulsive actions and improve task organization. It also supports shifting from one step of the task to the next. The results of the "Four-Item" task showed that RY was unable to use a checklist efficiently since it was not structured according to categories. Thus, before each "shopping" session, RY was asked to prepare a list of items to acquire in accordance with the products he was accustomed to buying, and to categorize them according to their locations in a supermarket. In addition, mediation during the sessions was given when necessary (e.g. What would you do now? Please check again.) Initially, great difficulty in categorization was observed and so the ability to identify the category names on the shelves while shopping was emphasized. Moreover, RY was reminded to obtain all the products from the same category, and to check which categories could be found in the same area, thereby improving his efficiency and shortening the duration of shopping. Another strategy was to mark the list each time he completed purchasing products from a particular category.

After each session, performance was analyzed with RY and he was asked to point out the strategies he had used and learned, and he was taught how to continue to use them during subsequent sessions as well as in other activities. As he continued the intervention, RY was able to more independently describe what strategies he was using as well as initiate the strategies needed in order to perform the task in a more efficient way. More specifically, RY began to pay more attention to the item categories and to remember where the different shelves were located. The level of difficulty was increased during successive sessions by adding more items to the shopping list and the number of different categories from which to shop. Finally RY was asked to shop from a 25-item shopping list that was made for him (including some but not all familiar products, thereby making the task more challenging). Simultaneously,

preparation prior to shopping focused on budget management and use of money, including correct identification of coins and bills, giving an exact amount of money for purchase or, alternatively, calculating the change he was to receive.

After five intervention sessions conducted in the "Super-Model", RY's progress in EF related to the shopping task was re-assessed. RY was instructed to use strategies learned during the intervention. Although a direct comparison to the pre-intervention assessment was not possible due to differences in the number of products and level of difficulty of the re-assessment, considerable improvement in the use of strategies during the performance of the shopping activity was observed. In this assessment, the shopping list included 25 products that were divided among 12 different categories; a much more challenging task than the original four products in only two categories he had previously performed. In addition, the level of difficulty was increased, such that during the purchase of some of the products, RY needed to pay attention to the name on the item's label, the weight of the product or the percentage of fat.

To summarize, an improvement was observed in all the components of the performance needed for the shopping. Performance time decreased, a more efficient strategy for planning and organizing the search (i.e., sequence of buying) was used, RY almost never returned more than once to the same shelf (since he was able to find most of the products located in the same area and only then went on to the next area). He also identified the correct products in accordance with their label, size and percentage of fat, thereby showing improvement in visual perception. In addition, RY displayed good use of the strategy of using a checklist and he was now able to mark the products he bought, and monitor himself throughout the entire task. Finally, RY paid for the items purchased using the exact amount of money including bills and coins.

Summary and Limitations

Deficits in executive functions may hinder the success of the rehabilitation process, and it is therefore necessary to integrate assessment and training of metacognitive strategies during intervention (Toglia et al., 2010; Toglia et al., 2011). In recent years evaluation for executive functions in clinical conditions alone has been shown wanting because it usually involves pen and paper assignments, which do not reflect real function in everyday life activities. Therefore more ecological assessments are required (Kizony et al., 2008; Rand, Basha-Abu Rukan, Weiss, & Katz, 2009).

The above case study was provided to demonstrate how a physical shopping mockup can be used as an effective environment for the assessment and intervention of deficits in EF related to shopping task in clients following a stroke.

The ecologically-valid assessments performed in this study (i.e. the Four Item tests) provided important information regarding the efficiency of strategies that RY used in order to complete the tasks. This information was then used, as suggested by Rand et al., (2007), to plan the intervention as described above.

The intervention in this case study included a combination of working on basic cognitive components and of higher reasoning skills, while adding to the level of difficulty by considering budget management, problem solving and the need to perform complex tasks. Specifically, the intervention included metacognitive training in order to internalize the strategies that were found to be inefficient during the assessment, for more efficient shopping.

Shopping was used as a representative common daily activity that requires a combination of cognitive and motor abilities, including the ability to perform two or more activities simultaneously (dual tasking / multitasking). It also requires the ability to adapt to unexpected occurrences during performance (Kizony, Levin, Hughey, Perez, & Fung, 2010). Moreover, while shopping, efficient executive skills that involve planning and organizational skills, are required to understand categories or relevant abstract ideas that are related to consumer behavior (Rempfer et al., 2003). For this reason, the intervention in this case study focused on the learning of the skills necessary for efficient shopping and providing relevant strategies. Brown et al. (2006) demonstrated that knowledge of skills for the shopping task could be used as a bridge mediating between cognition and performance of the skills necessary during the performance of the actual task. Thus, it is important to provide clients with information regarding the skills needed for shopping during the intervention process.

Despite the many advantages of the "Super-Model" mentioned above, there are also several disadvantages. Most of the products in the environment were not at their true weight. Moreover, it was not possible to create a separate refrigerated area for products that must be kept cool, and some clients were observed to have difficulty understanding why products were not found in a refrigerator. There were only three different "shopping areas" within which they could navigate. It was not possible to introduce the need to consider and teach strategies to ensure that products were not outdated. Moreover, there was only one cash register, thus it was not possible to include consideration of which line to go to in order to save time. These all limit the ability to train the transfer of strategies to multi-contexts as suggested by Toglia (2011). Although, the "Super-Model" environment is less dynamic than a real supermarket environment, and is not expected to replace training and

intervention in the actual environment, it does offer a feasible alternative to help the clients as part of their preparation to return to the community following their hospitalization in a rehabilitation unit.

A specific limitation of this case study was the short duration of the intervention (only five sessions) due to the fact RY was discharged about 2 weeks after the intervention began, and therefore there was no opportunity to train the strategies in various contexts to ensure the transfer of the strategies learned in the "Super-Model" to a real supermarket environment or to other daily activities as suggested in the Multi Context approach (Toglia, 2011).

Conclusions

The "Super-Model" is a safe therapeutic environment that physically simulates a shopping task and provides training that can be graded according to the needs of the client. This environment does not aim to serve as a substitute for carrying out tasks in a real shopping environment; rather it provides opportunities to engage in realistic tasks during an intermediate stage prior to the transition to a real supermarket environment in the community. It provides the opportunity to train clients in a more ecological environment which is relevant, and may thus ease the transfer of skills trained to other real-world activities. We are currently carrying out a study to compare between the performance of a shopping task in a video capture-type virtual reality environment (the Virtual Interactive Shopper within the SeeMe http://www.virtual-reality-rehabilitation.com/products/seeme/what-is-seeme), the "Super-Model", and a real shopping environment (cafeteria) in post-stroke population (Hadad et al., 2012). The results of this study are expected to map the similarities and differences between the three platforms and to provide data concerning ways in which intervention protocols for the "Super-Model" may be best implemented. Further research is recommended in order to examine the transfer of the strategies for functioning acquired during simulated shopping into real life environments.

Acknowledgments

Occupational therapist from the Geriatric department and the Dept. for Acquired Brain Injury in the Sheba Medical Center, who provided packages of products and helped to build the "Super-Model" environment.

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