# Using the Virtual Action Planning-Supermarket for Evaluating Executive Functions in People with Stroke

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*Background:* Our objectives are (1) to establish construct validity by comparing task performance with the Virtual Action Planning-Supermarket (VAP-S) by patients with stroke to healthy matched control subjects, (2) to establish concurrent validity by exploring relationships between VAP-S performance and Executive Functions (EFs) and ecological validity by exploring relationships between VAP-S performance and the Observed Tasks of Daily Living-Revised (OTDL-R), a measure of Instrumental Activities of Daily Living (IADL), and (3) to determine which measures predict IADL performance in patients with stroke. *Methods:* The research group included 24 men and women, aged 44-65 years, poststroke and the control group included 24 matched healthy people. The VAP-S and the Behavioral Assessment of the Dysexecutive Syndrome (BADS) were administered to evaluate EF. The stroke patients were tested with the OTDL-R. *Results:* Significant differences between groups were found for 2 outcome measures of the VAP-S. In the research group, significant ($P \leq .05$) moderate correlations were found between the VAP-S number of purchases and the BADS key search subtest ($r = .48$) and between the VAP-S number of correct actions and both the BADS action program ($r = .47$) and key search ($r = .52$) subtests. An exploratory stepwise multiple regression showed that the VAP-S number of correct actions and the profile score of the BADS were able to predict 56.2% of OTDL-R performance for the clients. *Conclusions:* The VAP-S showed adequate validity and an ability to predict IADL performance, providing support for its use in cognitive stroke rehabilitation. **Key Words:** Functional virtual environment—executive functions—Instrumental Activities of Daily Living—stroke.


## Introduction

Stroke is a major cause of disability often resulting in motor and cognitive impairment and functional disability.[1] In addition, deficits in Executive Functions (EFs), attention, and memory (short and long term)[2,3] have been found in 43%-78% of individuals with acute stroke, depending on the type, duration, and location of the injury.[4] EF are defined as higher order functions needed to perform complex or nonroutine tasks.[5,6] They include forming, maintaining, and shifting mental set, corresponding to the abilities to (1) reason and generate goals and plans, (2) maintain focus and motivation to follow through with goals and plans, and (3) flexibly alter goals and plans in response to changing contingencies.[7] Deficits in EF are also present at the subacute phase poststroke as shown by Pohjasvaara et al[8] who found that 40% of their sample of 256 people who had a stroke 3-4 months before the

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Received February 26, 2013; revision received June 3, 2013; accepted July 8, 2013.

Presented, in part, at the Fifth International Workshop on Virtual Rehabilitation, August 2006, New York, NY.

The work was funded by Basse-Normandie County and supported by University Hospital of Caen, France.

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1052-3057/$ - see front matter

http://dx.doi.org/10.1016/j.jstrokecerebrovasdis.2013.07.013

beginning of the study showed deficits in EF and had more difficulty in performing Basic Activities of Daily Living and Instrumental Activities of Daily Living (IADL). Indeed, impairments in EF lead to difficulties in IADL[9,10] which are complex tasks that require interaction with the environment and manipulation of objects (such as a telephone, shopping, or a motor vehicle).[11]

Moreover, people who have deficits in EF may show increased distractibility and difficulty in learning novel tasks or performing well in real-life situations despite apparently intact basic cognitive abilities or success in traditional neuropsychological assessments.[12] Performance levels in IADL are indicative of independent functioning and strong predictors of rehabilitation outcomes and quality of life among different clinical populations.[11,13]

Accurate evaluation of cognitive and EF abilities is critical to developing intervention plans that increase functioning and reduce dependence on social and health services that are both costly and, at times, difficult to access. EF are usually measured using neuropsychological tests. Although these tests provide important information about the impairments, they have low ecological validity and, therefore, have limited ability to predict functioning in daily activities.[14] These EF assessments typically measure a particular component (eg, inhibition) during isolated tasks and in contrived situations. Such controlled activities do not mirror daily functioning where performance in several simultaneous tasks is required.[14,15] In addition, functioning is linked to the environment in which tasks are performed based on available cues.[12] Therefore, accurate measurement of EF will be better achieved by evaluating clients while they perform novel and complex activities that require planning, organization, and adaptation to a changing environment over an extended period and are performed in a functional environment.[16,17]

Virtual reality (VR) is a promising approach for the assessment of EF. VR enables users to be engaged in simulated, interactive environments that are similar to real-world objects and events.[18] The benefits of using VR to evaluate EF include the ability to objectively measure behavior in challenging but safe and ecologically valid environments while maintaining strict experimental control over stimulus delivery and measurement.[19] VR has been implemented in the rehabilitation of clients with stroke, and several studies have shown its feasibility for motor[20-23] and cognitive[24,25] rehabilitation. A virtual supermarket run on a video capture system was shown to be effective for the assessment and treatment of clients with stroke[26] and traumatic brain injury who had EF deficits.[27,28]

The Virtual Action Planning-Supermarket (VAP-S) is a virtual supermarket that was developed in France by Klinger and Marié[29,30] to meet the need for a clinically feasible and ecologically valid tool for planning, a component of EF. This was accomplished by assessing performance of a task that requires shopping for 7 items within the VAP-S (the VAP-S test task). Klinger et al[31] showed the feasibility of the VAP-S for clients with Parkinson disease who performed significantly worse than 5 healthy, age-matched controls. The VAP-S was shown to be a valid assessment for EF for people with schizophrenia[32] and people with mild cognitive impairment (MCI).[33] In both studies,[32,33] significant differences in performance within the VAP-S were found between the clinical population and healthy age- and gender-matched controls. Moreover, significant correlations were found between some of the VAP-S outcome measures and subtests from the Behavioral Assessment of the Dysexecutive Syndrome (BADS).[34]

The results of the studies described earlier underlined the potential advantages of the VAP-S for rehabilitation of people who have deficits in EFs. These advantages include its ease of use and convenience by both clients and therapists in both clinical and home settings and extensive outcome measures which are related to EF components. Indeed, the VAP-S provides a comprehensive record of temporal and spatial performance. Because of the importance of assessing EF poststroke and the scarcity of ecologically valid assessments for this population, the overall goal of this study was to establish the feasibility and validity of the VAP-S with people who had a stroke. Specifically, the objectives were (1) to establish construct validity by comparing VAP-S test task performance of clients with stroke to healthy age- and gender-matched control subjects, (2) to establish its concurrent validity by exploring the relationships between performance of the VAP-S test task and standard outcome measures of EF and its ecological validity by exploring the relationships between performance of the VAP-S task and an IADL measure, and (3) to perform an exploratory analysis to determine which of the earlier mentioned measures (ie, performance within the VAP-S and measures of EF) predicts performance of IADL in clients with stroke.

## Methods

### *Participants*

Forty-eight participants were recruited in a convenience sample and divided into research and control groups. The research group included 24 participants (22 men and 2 women, mean age ± SD = 58.9 ± 5.5 years) who had a stroke. Twelve had a right hemispheric stroke, 11 had a left hemispheric stroke, and 1 had a bilateral stroke. Two participants had a hemorrhagic stroke and 22 had ischemic stroke. Mean time since onset of stroke ranged between 3 and 82 months (mean ± SD = 33.3 ± 26.9 months). Participants were included in the study if they had a Mini-Mental State Examination[35] score greater than 24, performed the clock drawing test according to Shulman et al[36] (a score greater than 4), had no unilateral spatial neglect according to the star cancellation test from the