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# ANSO study: Evaluation in an indoor environment of a mobile assistance robotic grasping arm

## *Étude ANSO : évaluation en environnement domestique d'un robot mobile d'assistance avec bras manipulateur*

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**Abstract**

*Objective.* – To evaluate the reliability and functional acceptability of the "Synthetic Autonomous Majordomo" (SAM) robotic aid system (a mobile Neobotix base equipped with a semi-automatic vision interface and a Manus robotic arm).
*Materials and methods.* – An open, multicentre, controlled study. We included 29 tetraplegic patients (23 patients with spinal cord injuries, 3 with locked-in syndrome and 4 with other disorders; mean ± SD age: 37.83 ± 13.3) and 34 control participants (mean ± SD age: 32.44 ± 11.2). The reliability of the user interface was evaluated in three multi-step scenarios: selection of the room in which the object to be retrieved was located (in the presence or absence of visual control by the user), selection of the object to be retrieved, the grasping of the object itself and the robot's return to the user with the object. A questionnaire was used to assess the robot's user acceptability.
*Results.* – The SAM system was stable and reliable: both patients and control participants experienced few failures when completing the various stages of the scenarios. The graphic interface was effective for selecting and grasping the object – even in the absence of visual control. Users and carers were generally satisfied with SAM, although only a quarter of patients said that they would consider using the robot in their activities of daily living.


*Keywords:* Assistive robotics; Robotic arm; Mobile robotic aid system; Tetraplegia; Grasping; Acceptability

**Résumé**

*Objectif.* – Évaluation de la fiabilité et de l'acceptabilité de l'usage d'un robot mobile d'assistance, Synthetic Autonomous Majordomo (SAM) composé d'une base mobile Néobotix avec bras télémanipulateur Manus, doté d'une interface de saisie automatique d'objet.
*Patients et méthodes.* – Étude multicentrique ouverte contrôlée sous l'égide de l'association APPROCHE. Vingt-neuf patients tétraplégiques d'âge moyen 37,83 ± 13,3 : 23 blessés médullaires, 2 Locked In Syndrome, 4 autres pathologies. Trente-quatre sujets témoins d'âge moyen 32,44 ± 11,2. La fiabilité de l'interface graphique du système de commande a été évaluée à travers 3 scénarii comportant différentes étapes : désignation de la pièce où se trouve l'objet, déplacement de SAM vers l'objet, désignation de l'objet à saisir avec ou sans contrôle visuel, saisie automatique de l'objet, déclenchement du retour de SAM. L'usage du robot et son acceptabilité ont été évalués par un questionnaire.
*Résultats.* – Le système est stable et fiable : il y a peu d'échec dans la réalisation des différentes étapes des scénarii aussi bien pour les patients que pour les témoins. L'interface graphique est efficace pour la désignation et la saisie de l'objet. SAM a été bien accueilli par tous les utilisateurs patients et thérapeutes. Mais seuls les patients envisageraient un transfert de l'utilisation du robot en vie quotidienne.


*Mots clés :* Robotique d'assistance ; Bras manipulateur ; Base mobile ; Tétraplégie ; Préhension ; Acceptabilité

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## 1. English version

### 1.1. Introduction

People with a severe motor impairment require assistance with their activities of daily living. The prevalence of severe motor impairments is difficult to estimate, since many different diseases and conditions give rise to this type of handicap: spinal cord injury, neuromuscular diseases, demyelinising diseases, neurological paralysis, strokes, locked-in syndrome, etc. Affected patients have no other choice than to depend on human carers for their activities of daily living. The development of new technologies has given rise to assistive devices that provide patients with personal independence in some areas, such as moving around and controlling their immediate environment. According to Brochard et al., the degree of handicap is one of the factors that most strongly influences the need for (and acquisition of) assistive devices [2]. It has also been emphasized that people with the need to compensate for severe motor impairment adopt computerized devices more readily than the general population does. Literature data evidence high levels of use and a fair level of satisfaction after the acquisition of technical aids – especially when the device is expensive or hard to obtain. [8] Since 1979 (with the publication of the Spartacus project's results on telemanipulator control by tetraplegic patients), research in the field of assistive robotics has focused on providing solutions for more complex acts (such as grasping objects) [9]. We have detailed the history of assistive robotics in a previous article on the AVISO project [12]. Although hi-tech assistive solutions have become increasingly sophisticated, few have been industrialized and bought by or supplied to patients. In fact, there are a number of technical, financial and human obstacles to more widespread use. In view of these difficulties, it is essential to expose prototypes to the end user as soon as possible and thus meet the latter's criteria for efficiency and acceptability.

The European-Union-funded ''Autonomic Networks for the Small Office and Home Office'' (ANSO) project followed on from the AVISO project. Both projects have been run by the ''Association pour la promotion des nouvelles technologies en faveur des personnes en perte d'autonomie'' (APPROACH) network, in collaboration with French Atomic Energy Commission (CEA) [12]. The AVISO study validated a graphic interface that enabled patients with motor handicap to control a robotic arm. The study results showed that interface was effective, with relatively few differences between patients and controls (given the severity of the handicap) and, above all, high levels of satisfaction. As an extension of the AVISO study, the ANSO project was designed to evaluate the device installed on a mobile base so that it could be used in a domestic environment (both close by the user and remotely). In the present study, patients and control participants evaluated the reliability of the SAM robot's graphic interface in a domestic environment. Firstly, we checked that objects could be reliably grasped even when they were outside the patient's and/or the camera's field of view. Secondly, we compared performance levels in patients and controls. Thirdly, we evaluated the impact of the user's familiarity with computer technology on the performance levels. Lastly, we evaluated the device's use and acceptability via a questionnaire.

### 1.2. Materials and methods

#### 1.2.1. Population

We performed an open, controlled study at two centres: the physical medicine and rehabilitation service at the Hopale Foundation in Berck-sur-Mer (France) and the Kerpape Rehabilitation Centre in Ploemeur (France) (both of which are institutional members of the APPROACH network). The inclusion criteria were as follows: patients aged 18 or over, normal cognitive function, and tetraplegia (with severe impairments of the arms limiting activities of daily living). The patients were being monitored on a regular basis by the physical medicine and rehabilitation services and were recruited into the study by telephone some time after their neurological injury. The patients' results were compared with those of control participants (16 carers, together with 18 non-carers with no experience of robotics, technical aids or handicap).

#### 1.2.2. Materials

The Synthetic Autonomous Majordomo (SAM) robot (Fig. 1) consists of a mobile base (the MP470 from Neobotix, Heilbronn, Germany) and a Manus robot manipulator arm (Exact Dynamics, The Netherlands) equipped with an interface for automated object handling. Via an intuitive interface, SAM can move around in a known domestic environment, grasp an object and to take it to a designated location (i.e., back to the

Fig. 1. SAM, the Manus arm on a Neobotix base.