IVS 3

INTENSIVE VISUAL SIMULATION

A UNIQUE TECHNOLOGY DEDICATED TO
MOTOR PLANNING AND CENTRAL CONTROL OF MOVEMENT

Juin 2020

CONTENTS

OUR MISSION

Created within a public-private cooperation ecosystem, **Dessintey develops intensive rehabilitation technologies** to help patients recover and regain improved levels of autonomy.

Our mission is to **assist patients** throughout their healing and rehabilitation journey. Our technological solutions aim at **increasing, diversifying and personalising** their daily practice program from the moment they join the rehabilitation center until they return home.

This mission is rooted in the finding that on average, patients only spend 10% of their time exercising in rehabilitation centres which is far below the guidelines.

Dessintey is thus committed to responding to the universal challenge of dependency with a project situated in a threefold context:

• The ageing population, the increase in associated diseases.

• Control of human and financial resources within specialized structures.

• Major technological developments (augmented reality, artificial intelligence, etc.) paving the way for new patient therapy prospects.

By way of this mission, Dessintey's foremost challenge is to improve the quality of life of patients with disabilities.

Nicolas FOURNIER
Davy LUNEAU
Prof Pascal GIRAUX

Co-founders of Dessintey

Dessintey

UPPER LIMB IMPAIREMENT
A MAJOR CHALLENGE FOR THE DAILY LIVES OF PATIENTS

How can you wash, dress or eat with upper limb deficiency or painful upper limb?

Partial or total upper limb impairments due to stroke, orthopaedic trauma or chronic pain, have a significant impact on the patient's quality of life.

Mobility and coordination deficits on arms, hands and fingers induce troubles in carrying out activities of daily life such as eating, getting dressed and washing.

Sveen et al., 1999; Lai et al., 2002; Franceschini et al., 2010; Veerbeek et al.,2011

Autonomy and quality of life mainly depend on upper limb motor function.

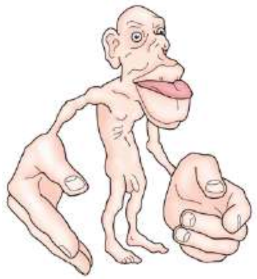
The upper limb and the hand have 23 degrees of freedom which have to be combined to produce all possibilities of movements. Skills such as reaching, grasping and manipulating objects as well as recognising shapes or textures are among the high number of hand skills

Each movement is based on a number of varied and complex synchronisations.

Effective rehabilitation of the upper limb means understanding the vast range of movements and the extreme precision required for hand function.
To ensure each patient has a maximum chance of recovery, early start of therapy, intensity and diversity of exercises are key for successful rehabilitation.

After a **stroke**,
80% of patients regain a good walking ability
and only **20%** upper limb function.

Debelleix et al., 1997; Hendricks et al., 2002

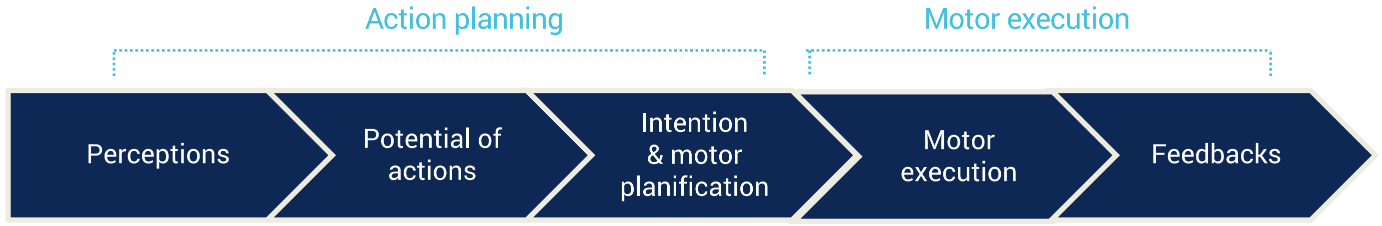


Map of the motor cortex by Canadian neurosurgeon Wilder Penfield in the twentieth century

ACTION PREPARATION QUICKLY ALTERED IN PATIENTS

Upper limb rehabilitation calls for an understanding of the individual components of the movement.

- **Action planning :** Potential of actions – Intention & motor planification
- **Motor execution : P**erformance of movement and biofeedback



Motor control - Principle

For many patients, **this first phase of action planning is altered, non-existent.** They lose awareness of their own body, but also the memory of motor functions and projection in time.

To illustrate this point, a healthy subject immobilised for only 10 to 12 hours at the wrist presents deficits in the performance of pointing and dexterity actions.

Facchini et al., 2002 Ngomo et al., 2012; Roll et al., 2012; Fortuna et al.,2013; Ikeda et al., 2019

Studies **particularly** point to deficits in the preparation and performance of the movement with:

- decrease in cortical recruitment during command of the movement
- decrease in motor imagery capacity
- difficulty for subjects to evaluate and to process proprioceptive information in real time to control the movement

Without representation of the movement, i.e. without this essential stage of action planning, it cannot be effective and precise.

THERAPIES MOSTLY FOCUSED ON MOTOR EXECUTION

To ensure each patient has a maximum chance of recovery, early start of therapy, intensity and diversity of exercises are key for successful rehabilitation.

Typically, upper limb rehabilitation is based on techniques that **focus more on motor execution and control of action (feedbacks)**

Motor planning and intention

- Visuomotor simulation training
  - Action observation
  - Motor imagery
  - Mirror therapy

Motor execution and control

- Task-oriented therapy
- CIMT
- Muscle strengthening
- Robot-assisted therapy

The concepts of motor planning and intention are integral to the performance of movement.
In these areas in particular, post-stroke, pain-suffering or trauma patients have deficits which hamper their ability to progress.

Rehabilitation of patients cannot therefore only focus on the training of the gesture by the performance of the movement.

Integrating these visuomotor simulation training approaches into the therapeutic arsenal can **specifically stimulate the central control of movement** and bolster patients' abilities in the action planning (Potential of actions – Intention & motor planification).

"Seeing a movement is almost like doing it"

Visuomotor simulation training approaches stimulate brain plasticity

« VISUOMOTOR SIMULATION TRAINING APPROACHES »
ACTION OBSERVATION – MOTOR IMAGERY – MIRROR THERAPY

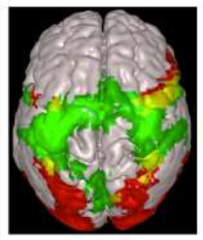
A number of research teams have for many years been uncovering specific visuomotor neurons that are involved both in the vision and recognition of action but also in the production of movement.

These two types of **neurons are called canonical or mirror neurons**. Therefore, the same specific areas of the brain are activated:

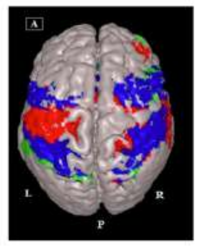
- when we see someone performing an action and when we perform that action ourselves.
  Rizzolatti et al., 1996; Gallese et al., 1996; Lee et al., 2013

- both when we perceive a familiar object and when we handle it.
  Jeannerod et al.1995; Iacoboni et al. 2005; Murata et al., 2016

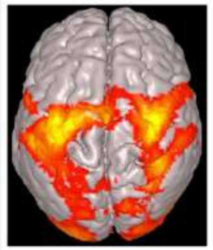
"Seeing a movement or performing it activates roughly the same areas of the brain. Seeing a movement is almost like doing it."



Observation
(red + yellow)



Motor imagery
(blue)

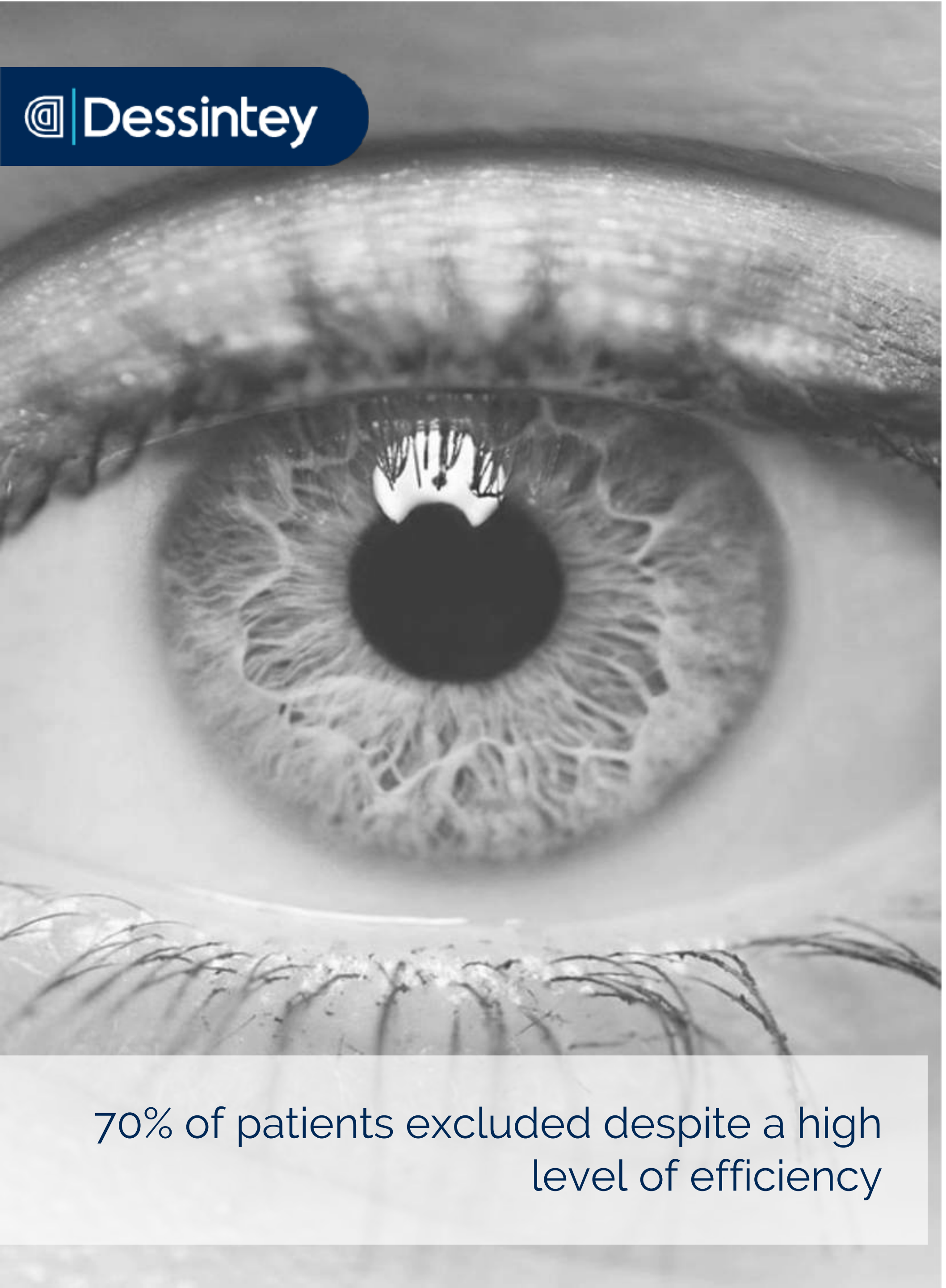


Motor performance

Raffin et al., 2012

Various studies conducted by the **scientific community demonstrate the effectiveness of mental representation techniques** in rehabilitation for post-stroke, pain-suffering or trauma patients:

- Action observation — *Lee et al.,2013; Sarasso et al.,2015; Zhang et al., 2018*
- Motor imagery — *Barclay-Goddard et al., 2011; Kho et al., 2014; Guerra et al., 2017*
- Mirror therapy — *Pollock et al., 2014 ;Thieme et al., 2018; Zhang et al, 2018, Gandhi 2020*



LIMITATIONS
OF « VISUOMOTOR SIMULATION TRAINING » APPROACHES

Vision is therefore closely linked to motor planning and the learning processes, especially for upper limb movements.

Visuomotor simulation approaches
ACTION OBSERVATION – MOTOR IMAGERY – MIRROR THERAPY

- automatically activate the sensorimotor cortex through perception
- show a high level of scientific evidence
- prevent exclusion of the limb or learned non-use
- help in rebuilding the body image / help in the body awareness
- are complementary to other conventional active therapies

These techniques are effective BUT about 70% of patients are excluded from them in current clinical practice **due to their unsuitability for patients presenting with:**

- cognitive disorders
- attention deficits
- learning disabilities
- aphasia
- neglect
- body image disorders
- spasticity, etc.

In addition, **clinicians are confronted with the following problem situations**:

- time-consuming
- little or no patient autonomy
- lack of training and protocol during care

It is clear that the patients who need it most are those who are excluded, especially in the first few days following a stroke, which is a critical period for recovery.

The concept of the IVS3 (Intensive Visual Simulation) system stems from this observation: developing an innovative tool to boost patient rehabilitation and enable early and intensive treatment.

Dessintey

High definition image acquisition and processing system

Laterally and depth-adjustable patient's integrated screen

3 axes ajustable monitor with high grade interactive displays touch screen

IVS 3

INTENSIVE VISUAL SIMULATION

intelligent algorithm-based therapy assistance

Ergonomic work surface with object storage space

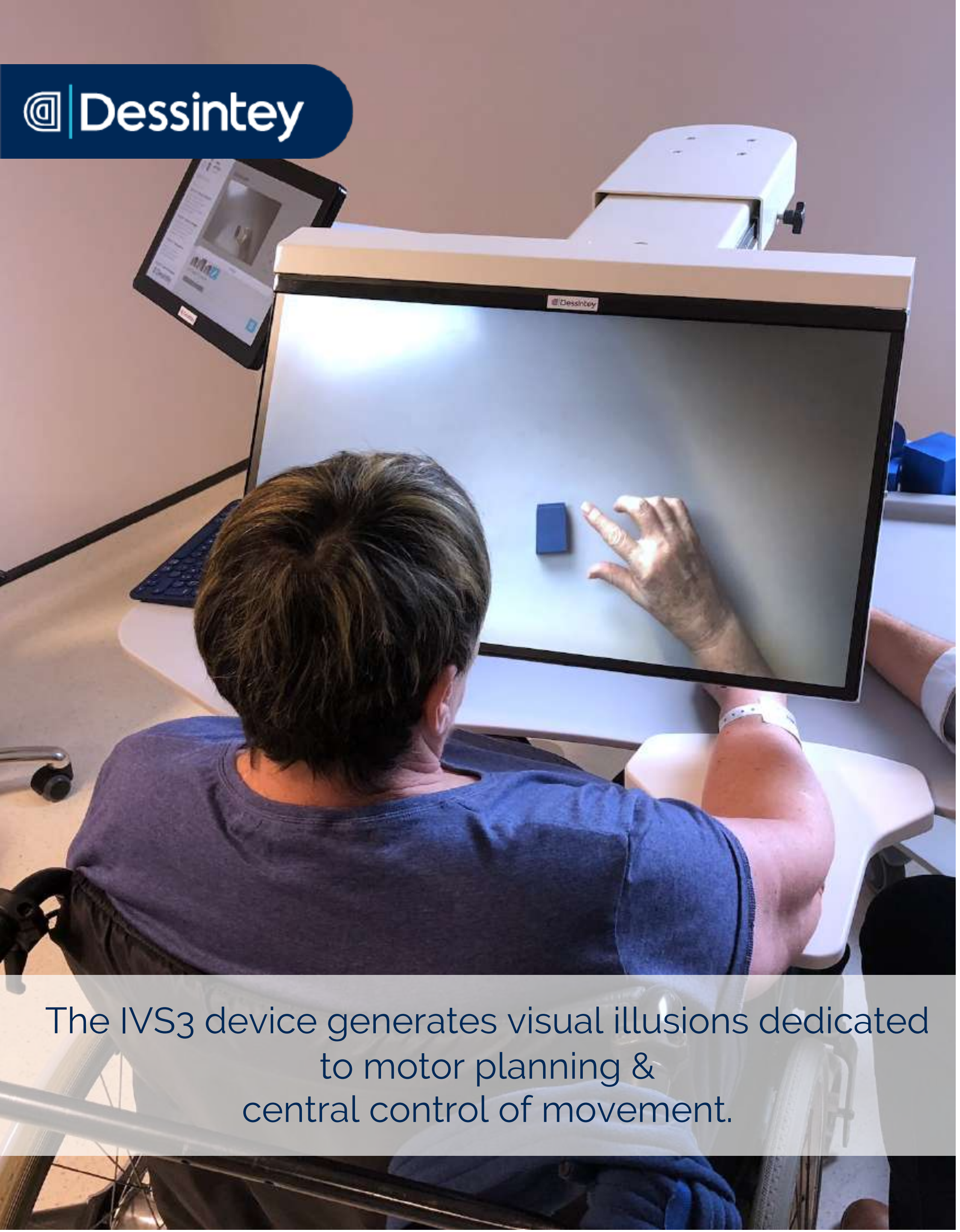
Embedded industrial computer system

Height adjustable table with three electric actuators & electronic control unit

Secure power supply system

Movable table including wheel locking system

A UNIQUE TECHNOLOGY DEDICATED TO
MOTOR PLANNING AND CENTRAL CONTROL OF MOVEMENT



The IVS3 device generates visual illusions dedicated to motor planning & central control of movement.

OUR SOLUTION IVS3 – INTENSIVE VISUAL SIMULATION

The "IVS3: Intensive Visual Simulation 3" system is an innovative rehabilitation device dedicated to the care of patients suffering from stroke, chronic pain (CRPS), or complex trauma of arm or hand.

Patients subject to paralysis or pain disorders experience discrepancy between movement control and the visual and sensitive feedback they receive: it is indeed very challenging to relearn a movement when faced with constantly negative feedback, which conveys a sense of failure.

"In a trial-and-error learning model, the constant failure of an attempt at movement inhibits the return of voluntary motor skills. ***This is the learned non-use phenomenon****"*

Prof. Pascal GIRAUX, Head of the PMR Department, CHU St Etienne

The IVS3 system generates visual illusions, **a unique technology dedicated to motor planning and central control of movement.**

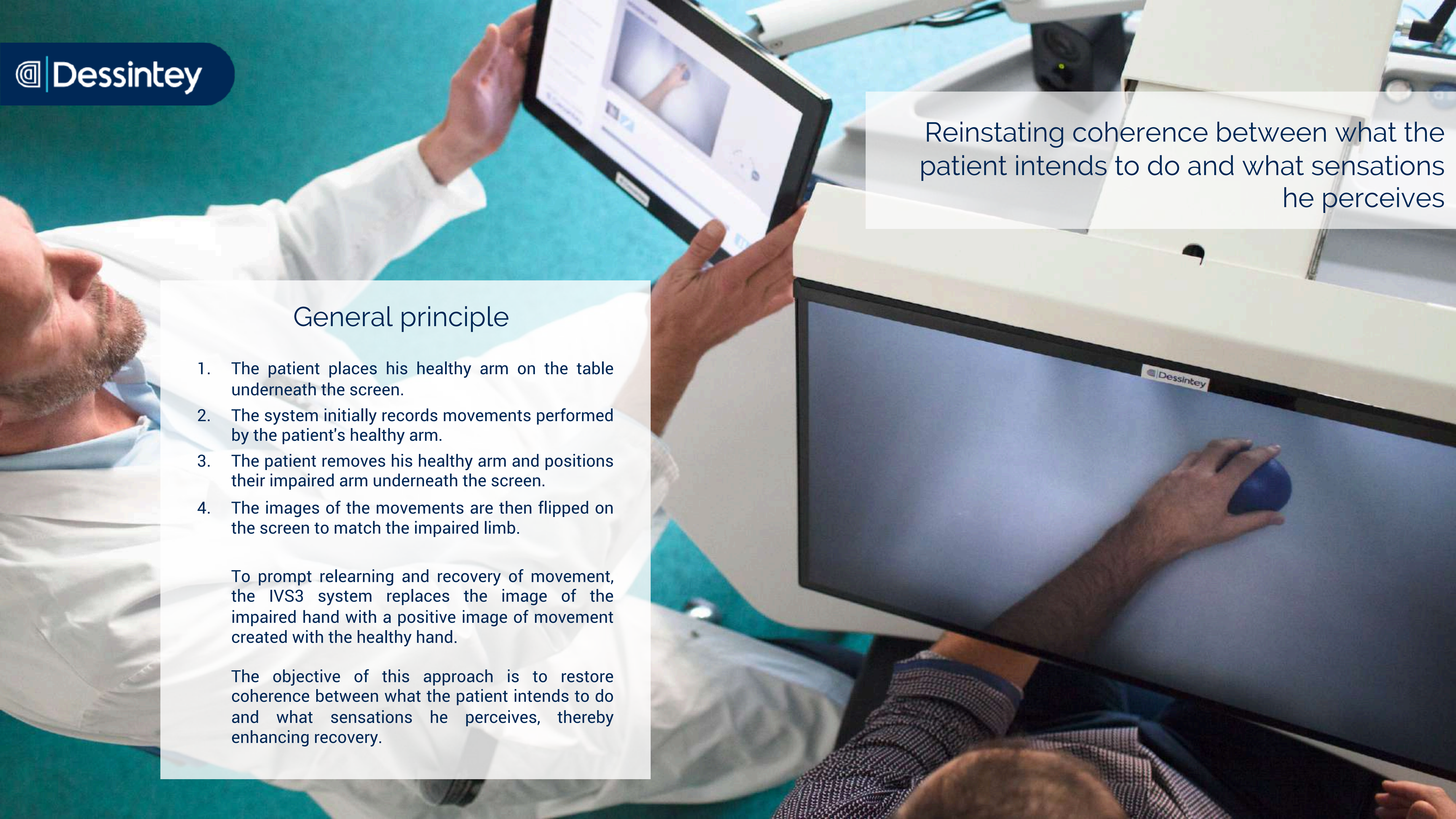
IVS3 is based on the fundamental principles of visuomotor simulation training. It replaces the image of the paralysed arm with a positive image of movement performed by the healthy arm.

Reinstating coherence between what the patient intends to do and what sensations they perceive, **prompts relearning**.

The IVS3 system **stimulates brain plasticity** and enables patients and therapists to work specifically on :

- **Action planning**
- **Potential of actions**
- **Intention & motor planification.**

This technology forms an invaluable part of the therapeutic arsenal of upper limb motor rehabilitation.



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Reinstating coherence between what the patient intends to do and what sensations he perceives

General principle

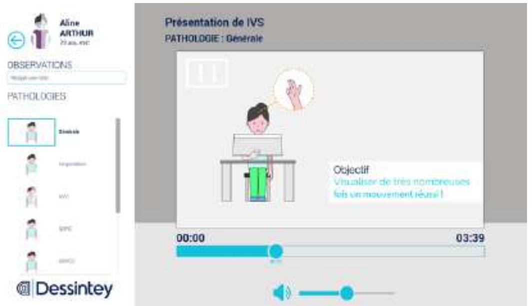
1. The patient places his healthy arm on the table underneath the screen.
2. The system initially records movements performed by the patient's healthy arm.
3. The patient removes his healthy arm and positions their impaired arm underneath the screen.
4. The images of the movements are then flipped on the screen to match the impaired limb.

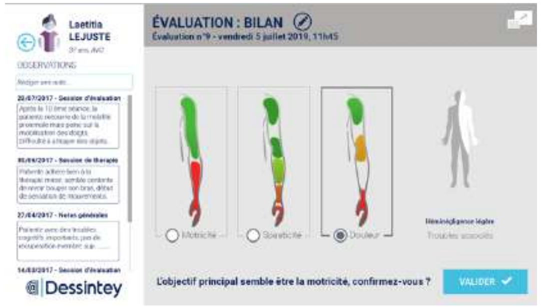
To prompt relearning and recovery of movement, the IVS3 system replaces the image of the impaired hand with a positive image of movement created with the healthy hand.

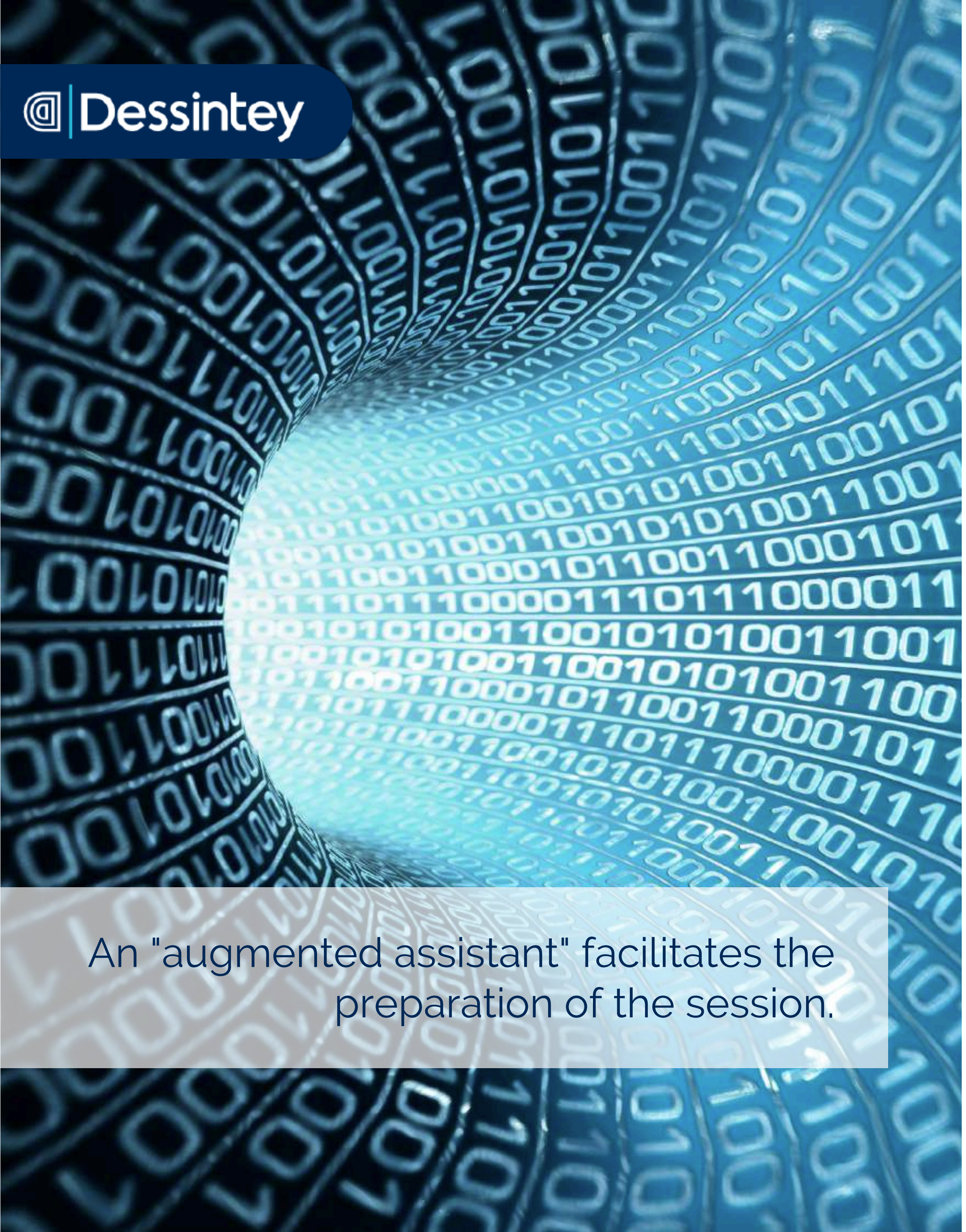
The objective of this approach is to restore coherence between what the patient intends to do and what sensations he perceives, thereby enhancing recovery.

A PATIENT-CENTRIC SOLUTION DEVELOPED WITH CLINICIANS

- PRESENTATION
- EVALUATION
- CARE PROGRAMS
- OVER 800 EXERCISES
- ACTIVITY REPORTS







An "augmented assistant" facilitates the preparation of the session.

THE TECHNOLOGICAL PLATFORM WITH A PERSONALIZED THERAPY PROGRAM

IVS3

The IVS3 system :

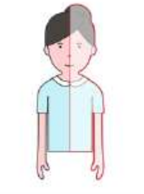
- Offers a variety of exercise sequences based on the clinician's evaluation. **It learns and identifies the movements that best suited to the patient's deficiencies.**
- Integrates **intelligent algorithm-based therapy assistance** to facilitate the clinician's day-to-day work.
- Suggests tips to the therapists according to the various kinds of pathologies when preparing the sessions
- manages the planning of the sessions and the entire patient program.

Showcasing more than 10 years of research, this device was awarded **1st prize by the French Society of Physical Medicine and Rehabilitation (SOFMER) innovation contest** in October 016.

"A personalized care program suited to each patient"

THE IVS3 SYSTEM IN DAILY PRACTICE

What are the pathologies?



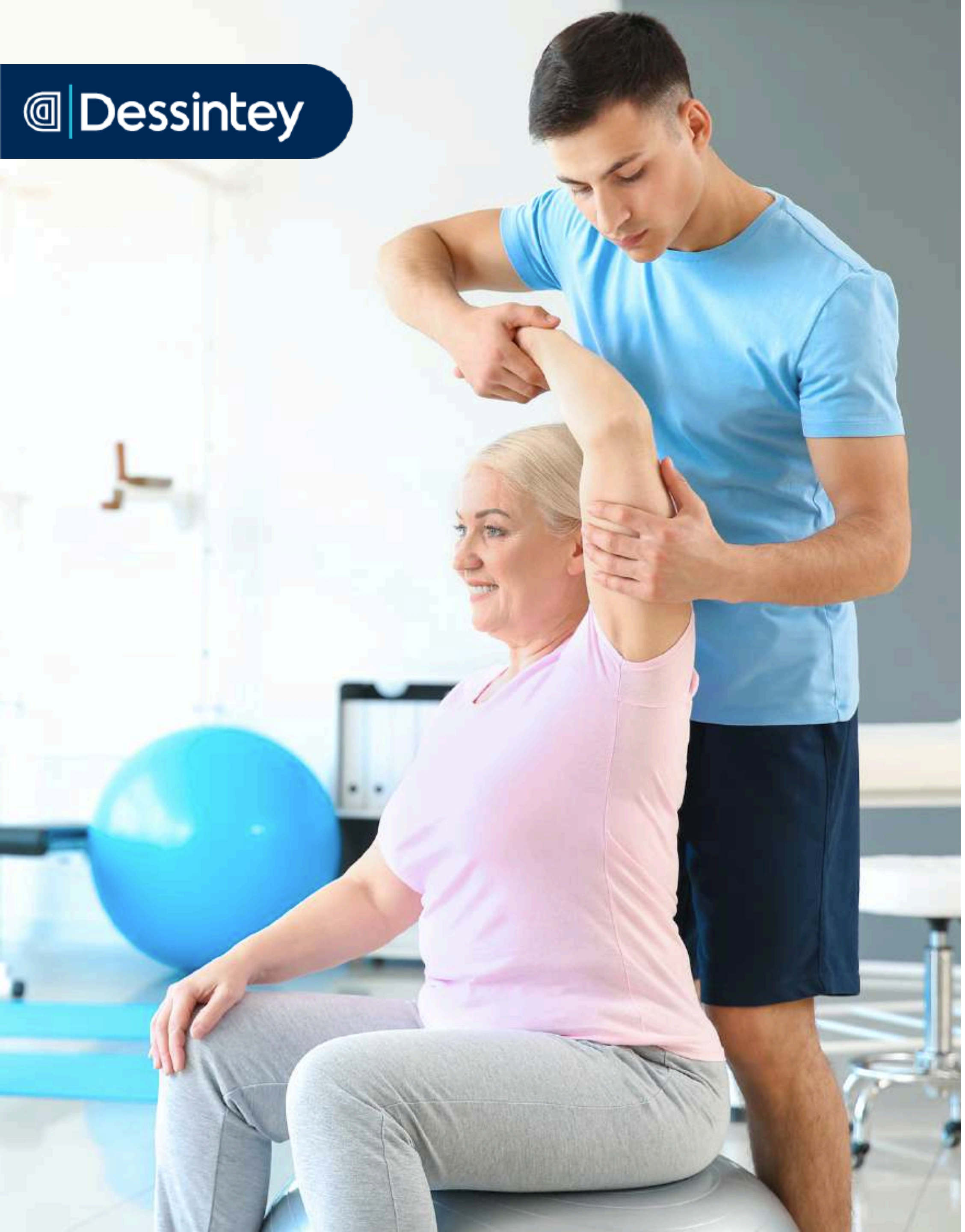
- Stroke
- CRPS
- Cerebral palsy
- Brain injuries
- Hand trauma
- Immobilization
- Amputation

What are the rehabilitation goals?

- Improving motor recovery
- Reducing central pain
- Reducing spasticity
- Treatment of hemineglect
- Body awareness

Model protocol:

- 1 or 2 sessions a day
- 5 days a week (frequency depends on the rehabilitation goal)
- Between 4 to 6 weeks
- 10 to 30 min per session (depending on tiredness, associated disorders).
- 4 to 10 different movements per session, with 6 to 10 repetitions per movement,
- 1 to 2 loops (global repetition)



ARM STUDIO

IVS3, an essential component in the continuum of rehabilitation

The ARM STUDIO is an environment made up of different rehabilitation devices and techniques, designed to promote recovery and strengthening of complex arm and hand skills.

The aim is to provide a technical environment for intensive upper limb therapy.

This concept is based on three fundamental principles:

- early and intensive therapy
- varied and complementary treatments and stimulation
- patient adherence and motivation

It is based on complementary approaches so as to work on all the stages of motor control:

- **Intensive Visual Simulation:** to work on movement planning and intention
- **Robotics:** to assist and facilitate the performance of the movement
- **Task-oriented training and activities of daily living**
- **Other approaches:** to work specifically on spasticity, neglect, etc.

COMPLEMENTARY TECHNIQUES BASED ON THE RECOVERY STAGE

MOTOR RECOVERY STAGE

REACH: Flaccid, Severe impairments

GRASP: Moderate impairments, Low impairments

ROBOTICS with motorized movements

ROBOTICS with antigravity system

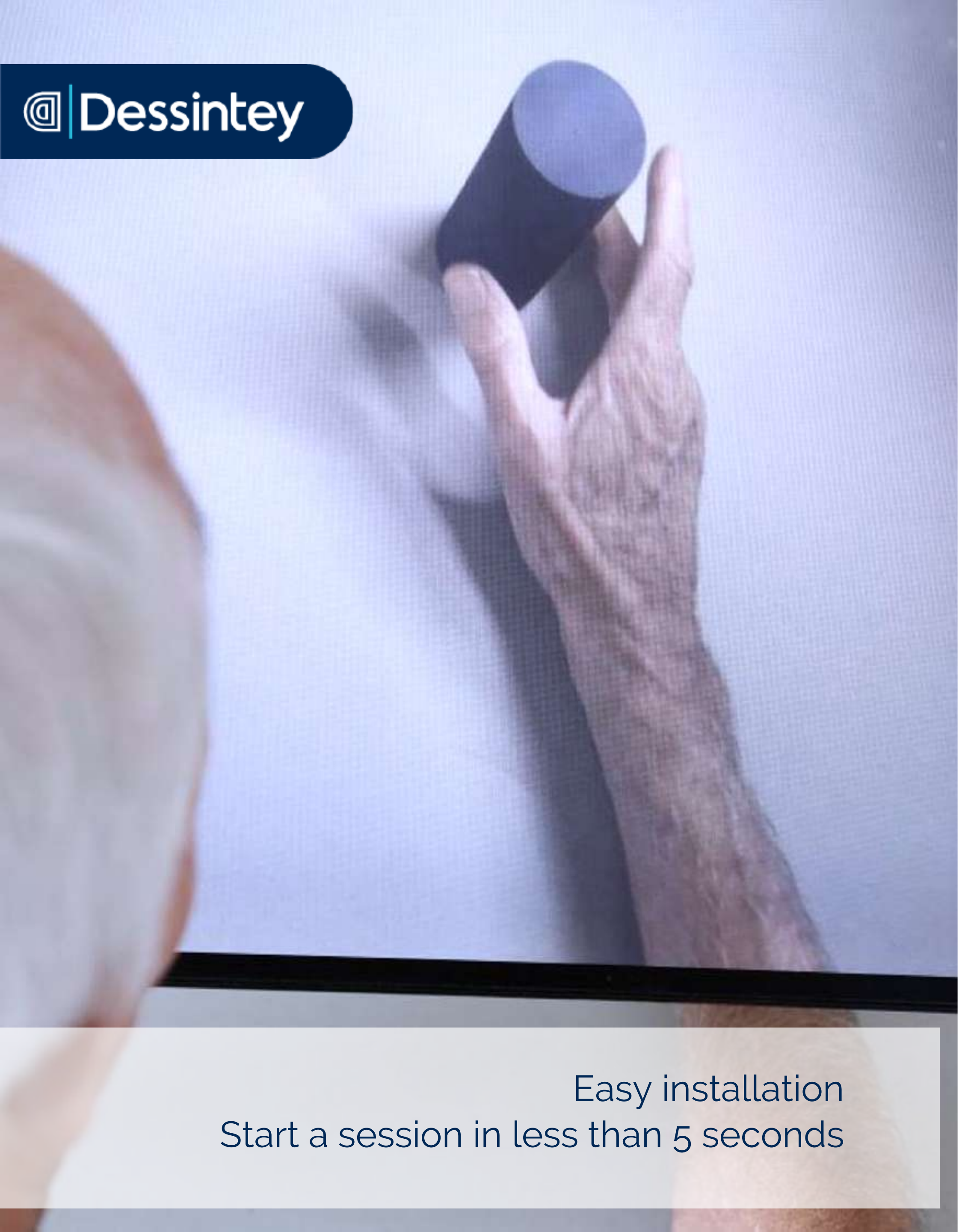
IVS3 Intensive Visual Simulation

Hands-on therapy

Tasl oriented training

CIMT

Strenghtening



WHY IVS3?

Compared to conventional approaches of visuomotor simulation training, the IVS3 system provides:

1. **Intense immersion** allowing the patient to focus on their movement;

2. **Early start of therapy** in the rehabilitation process, accessible to flaccid patients;

3. **Simply understandable method**, which is essential for patients with cognitive, attention or frontal lobe disorders, language impairment, exclusions or severe chronic pain;

4. Sustained participation and **possible autonomy even in fatigue-prone patients;**

5. **Simple**, **quick** and comfortable **installation** with straight-ahead vision;

6. **Work in the whole grasping space**, allowing functional work, object grasping in particular;

7. **Unilateral work** and attention focused on the injured limb only;

8. **Fine-tuned dexterity work**: meticulous tweaking of the movements worked, amplitude and speed;

9. **Construction of personalized sessions** with a wide range of movements;

10. **Full monitoring of work and progress** achieved by the patient;

SCIENTIFIC STUDIES

The illusion principle developed by IVS3 is inspired by visuomotor simulation training approaches. They have proven its effectiveness in rehabilitation:

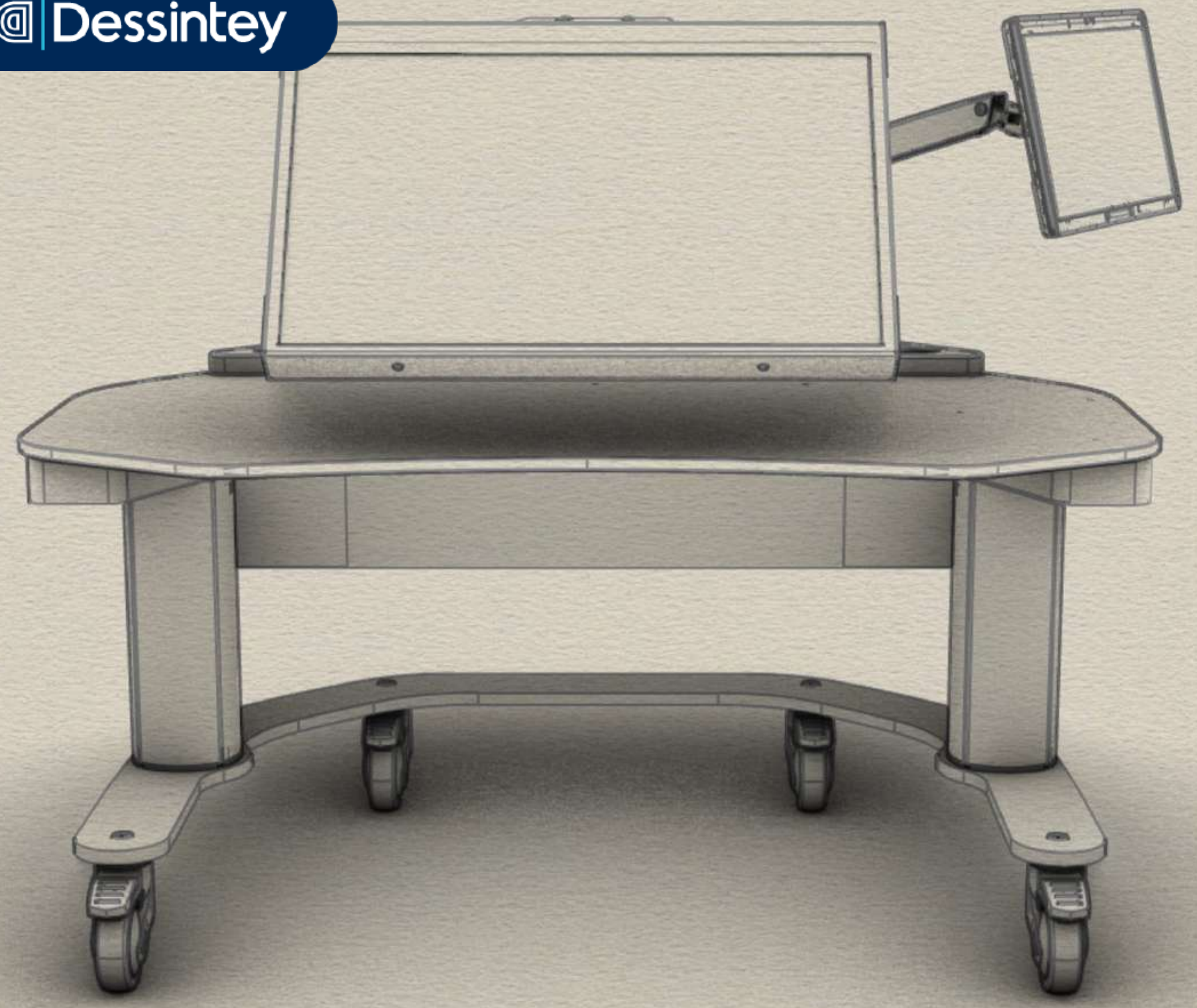
- Action observation — *Lee et al.,2013 ; Sarasso et al., 2015; Zhang et al., 2018*
- Motor imagery — *Barclay-Goddard et al., 2011; Kho et al., 2014; Guerra et al., 2017*
- Mirror therapy — *Pollock et al., 2014;Thieme et al., 2018; Zhang et al, 2018, Gandhi 2020*
- Mirrored visual feedback — *Hoermann at al., 2017 ; Ding et al., 2019*

Research works on the concept of the IVS3 system has also prompted several publications:

- "Rééducation du membre supérieur par rétroaction visuelle modifiée"
  P.Giraux et al. 2003
- "Illusory movements of the paralyzed limb restore motor cortex activity"
  P.Giraux A. Sirigu 2003
- "Training With Virtual Visual Feedback to Alleviate Phantom Limb Pain"
  C.Mercier A. Sirigu 2009
- "Faisabilité de l'association Thérapie Miroir Informatisée et dual-tDCS dans la rééducation du membre supérieur après AVC"
  J.Touly et al. 2019

Studies initiated since the CE marking, and currently in progress:

- **STROKE :** 1 multicentric study (Les 3 soleils, Pasori, Clinalliance) in the Paris region
- **STROKE :** 2 clinical studies at Saint Etienne university hospital
- **CRPS** : 1 observational study at the Nîmes university hospital
- **UNV**: 1 study at the Orléans university hospital



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EQUIPMENT

MADE IN FRANCE

IVS 3

Software platform
« GUIDED » session

Patient file MODULE
Presenting the principles to the patient
Evaluation MODULE
Free session MODULE
Progress MODULE

This technological platform provides patients a personalized therapy program. Based on the clinician's evaluation, the IVS3 device learns and recognizes the exercises best suited to the patient's deficiencies.

INCLUDING the functionalities of the "FREE" version with:

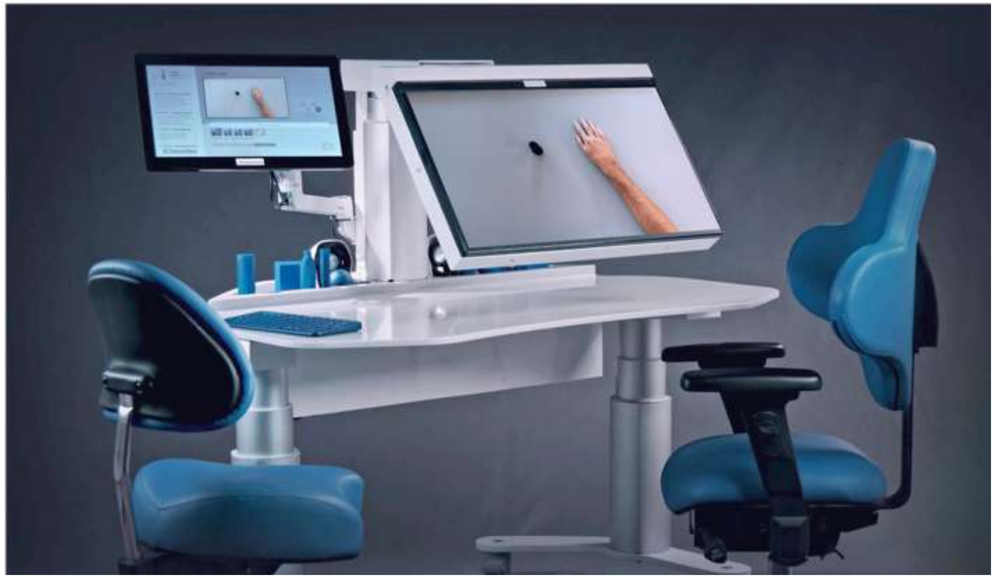
Guided session MODULE

- Personalised therapy program including tips: intelligent algorithm-based therapy assistance
- Movement data base (containing approx. 800 exercises)

Activity report/Exercise monitoring MODULE

OBJECT PACK for gripping exercises

OPTIONS



DESCRIPTION
PATIENT & PRACTITIONER CHAIR
ARM REST

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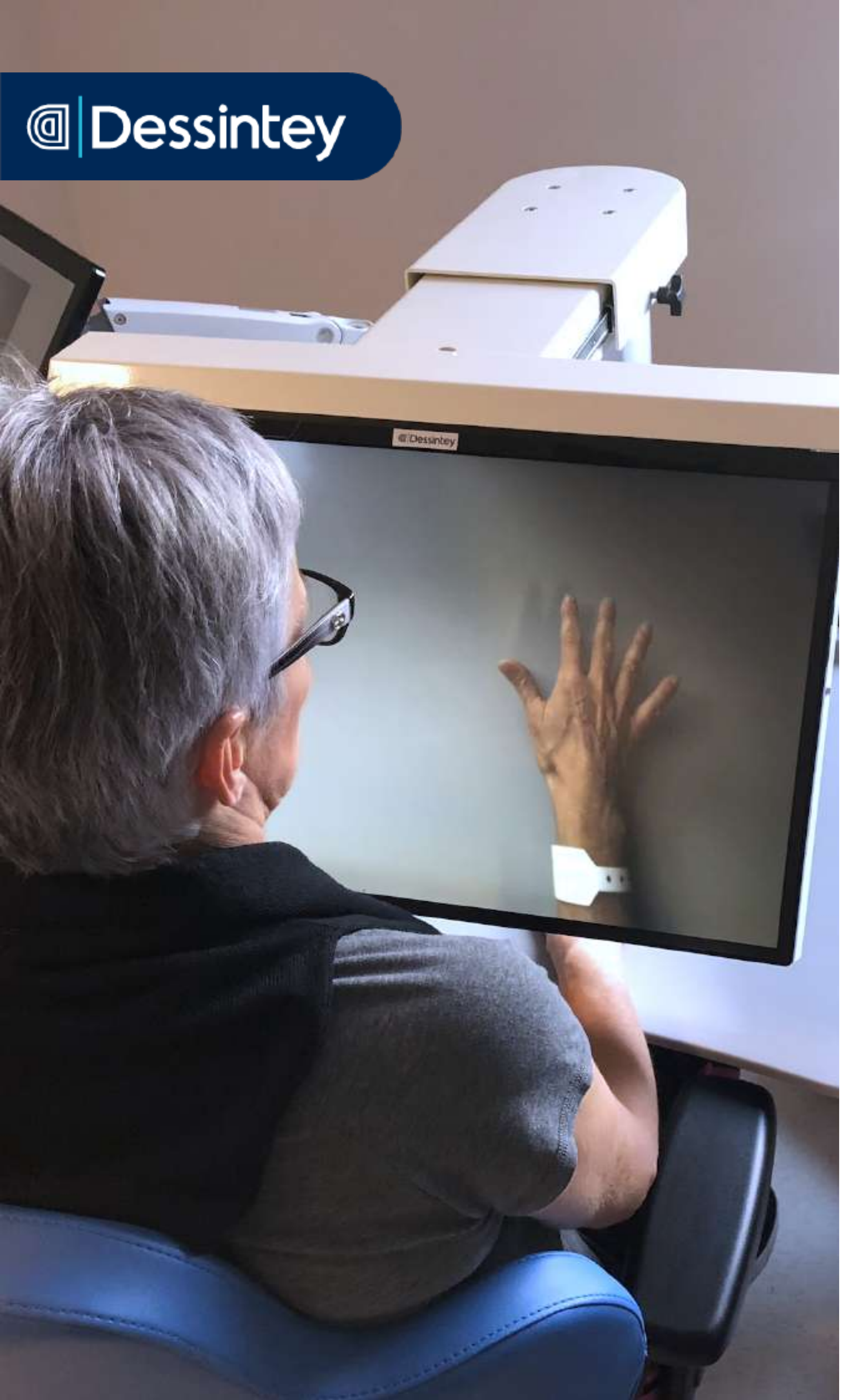

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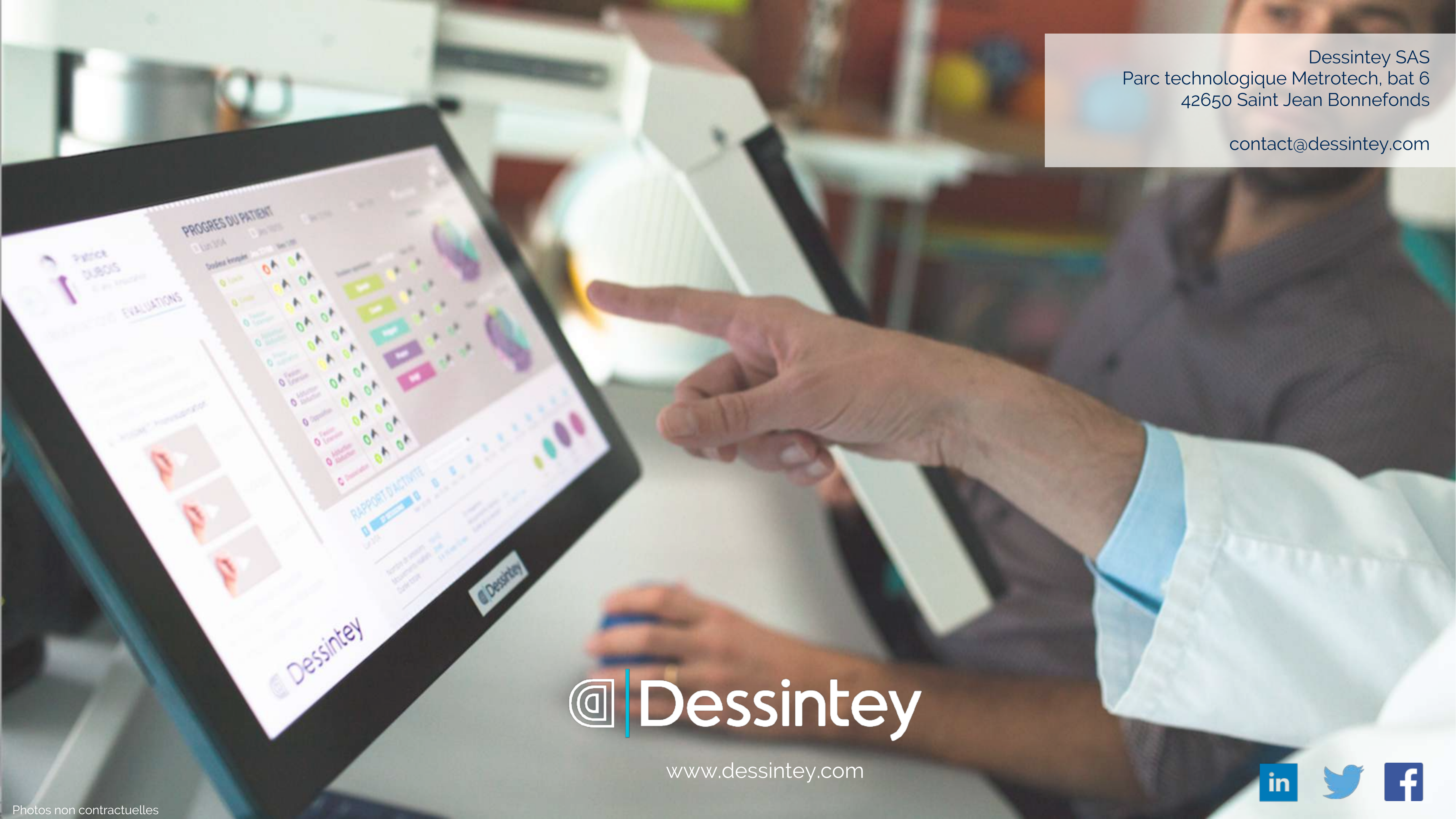

Dessintey SAS
Parc technologique Metrotech, bat 6
42650 Saint Jean Bonnefonds

contact@dessintey.com

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www.dessintey.com

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