A new model for co-creation of innovative measurement and analysis tools for translational health research

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Technical breakthroughs in brain and body measurement

- Optogenetics
- Electroencephalogram (EEG)
- Near-infrared spectroscopy
- Gesture recognition
- Video tracking
- Ultrasonic vocalizations
- Electroencephalogram
- Face reading
- Eye tracking
How to apply this new technology to battle societal challenges?

- **Drug discovery**: finding better medicines to cure neurological and psychiatric diseases
- **Eating behavior**: translational models for eating disorders and the prevention of obesity
- **Aging**: development of non-invasive tools for diagnosis and health monitoring
- **Ambient assisted living**: supporting independent living of elderly people
- **Product usability**: improved accessibility and ease of use for all age groups
- **Precision livestock farming**: sustainable animal husbandry based on individual health monitoring
The Dutch way: Public-private partnership

Collaboration between academic institutes, industry and end-users on the intersection of ICT, brain research and cognitive sciences

History:
- 2004: National Council for ICT Research
- 2009: National Initiative Brain & Cognition → Basic research
- 2009: ICT Innovation Platform Brain & Cognition → Practical application, valorization
- 2012: Foundation “ICT for Brain, Body & Behavior” (i3B Foundation)
i3B Foundation

- May 2012: i3B Foundation established
- June 2012: i3B business plan published (available in request)
- Sep 2012: Opening of i3B Lab
- Oct 2013: First i3B symposium
The i3B Living Lab

**TECHNOLOGY PROVIDERS**
- SMEs developing
- Sensors
- Actuators
- Data acquisition systems
- Computer vision systems
- Data analysis software
- Test apparatus

*Role in i3B*
- Technical research
- Product development

**FIELD LABS**
- *Example domains*
  - Consumer lifestyle
  - Intelligent lighting
  - Eating behavior
  - Sports
  - Psychiatric disorders
  - Ambient assisted living
  - Security/forensics

*Role in i3B*
- Testing in real-life context
- Scientific validation
- Practical validation
- Clinical validation

**KNOWLEDGE PROVIDERS**
- Universities
- Research institutes

*Role in i3B*
- Scientific research
- Technical research

**END USERS**
- Consumers
- Patients
- Hospitals
- Universities
- Consulting firms
- Automotive industry
- Aerospace industry
- Pharma industry
- Food industry
- Plant breeding industry
- Animal production industry

*Role in i3B*
- Large-scale deployment
- Practical use
Objectives

- User-driven creation, design and development of novel products
- Collaboration between high-tech companies, knowledge institutes and end users
- Facilities for collaborative research and development (co-location)
- Facilities for collaborative product integration, testing and validation
- Facilities for joint usage of reference data
- Facilities for demonstration and training
- Joint development of education and training programs
Combining science and technology to tackle societal challenges

**Scientific disciplines**
- Cognitive psychology
- Experimental psychology
- Consumer science
- Marketing science
- Neuroscience
- Physiology
- Behavioral biology
- Ergonomics
- Computer science
- Electronic engineering
- Mechatronics
- Industrial design
- Mathematics
- Statistics
- Artificial intelligence
- Communication science

**Technologies**
- Acoustical signal processing
- Physiological sensing
- Video technology
- Computer vision
- Video tracking
- Behavior recognition
- Gesture tracking
- Eye tracking
- Facial expression analysis
- Sensor fusion
- Multimodal data integration
- Complex event recognition
- Virtual reality
- Stimulation
- Brain-computer interface

**Application domains**
- Healthcare
- Food & nutrition
- Consumer behavior
- Psychology
- Public safety
- Workplace ergonomics
- Biomedical research
- Automotive
- Aerospace
- Gaming
- Animal husbandry
- Wildlife management
- Pest control
Participants

[Logos of various organizations]
i3B activities

i3B Research & Development
- Joint research program
- System integration and validation
- Hosting of researchers
- Administrative support of collaboration projects

i3B Facilities & Services
- Design and management of i3B Lab facilities
- Facilitating user-centered product development
- Recruitment of test subjects
- Usability testing
- Assistance with product certification
- Assistance with product localization
- Facilitating business development

i3B Communications
- Website, newsletter, blogs, leaflets

i3B Events
- i3B Café, annual symposium, conferences, thematic workshops, joint tradeshow exhibits
- Science, technology and trade missions

i3B Academy
- Education: training of employees and customers, certification
- Outreach: training in emerging markets
- Publication of handbooks, protocols
Benefits for participants

SME companies
- Access to knowledge, experience and assistance from fellow entrepreneurs
- Access to interns and graduate students
- Exposure of novel products and prototypes to press contacts, prospects and customers
- Administrative and managerial support for grant proposals and projects

Knowledge institutes
- Access to innovative SMEs for technology transfer
- Opportunities for students to develop their entrepreneurial skills
- Joint contract research for industry and government

End users
- One-stop shopping for expertise on ICT related to brain, body and behavior
- Access to network of high-tech SMEs that can respond quickly to business needs
- Flexible partnership opportunities, from ad-hoc usage of i3B labs to long-term agreements
- Contract research, development and engineering
Projects

Examples of i3B projects:

- SenseWell: Sensor technology for automated assessment of health and wellbeing
- FOCOM: Food and cognition model systems

Common elements:
- Consortium of public and private partners
- 50% funding from government, 50% from partners
Collaboration project

Automated Assessment of Health and Wellbeing

Integrating Sensor Technology with Brain and Cognition Research

2010-2014
Project objectives

- **Laboratory rat**: Animal model for diseases with social component (e.g. depression, schizophrenia, autism)

- **Goal**: Development of system for automated assessment of social behavior, communication and wellbeing

- **Needed**: Integrated measurement of behavior and physiology
  - Behavior: movement, body posture, cognition, social interaction
  - Acoustics: ultrasonic vocalizations
  - Physiology: body temperature
  - Multidimensional analysis
Project consortium

- **Utrecht University**: animal behavior, neuroscience, animal welfare
- **Wageningen University**: bioinformatics, statistics
- **Delft University of Technology**: sensor technology
- **Noldus Information Technology**: computer vision, software development, system integration
- **TeleMetronics Biomedical**: biotelemetry
- **Metris**: acoustics
- **Delta Phenomics**: in-vivo experiments, system validation
Measure – interpret – act

**Interpretation – Step 1**
- Behavior recognition
- USV classification
- Physiological event detection

**Feature extraction**
- Body position, shape, interaction
- Sonogram features
- Physiological signal features

**Preprocessing**
- Image processing
- Acoustical analysis
- Physiological signal analysis

**Interpretation – Step 2**
- Data fusion
- Pattern recognition
- Health / wellbeing assessment
- Incident detection

**Output**
- Alerts
  - Facility manager
- Stimulations
  - Animals
- Reports
  - Researcher

**Measurement**
- Accelerometer
- Video camera

**Modality**
- Food reward
- Sound
- Light
- Access to shelter

**Rats in home cage**
Video tracking
Automated behavior recognition

Image acquisition

Video tracking

Behavior classification

Feature extraction

shape

motion
Behavior + acoustics + physiology

Sonotrack controller
PhysioLinq controller
EthoVision
Sonotrack ultrasonic microphone
Video camera
Telemetry sensor
PhysioLinq base plate
Collaboration project

FOCOM

Food and Cognition Model Systems
2012-2015
Health trends
Objectives

Determining, understanding, predicting:

- Liking
- Choice
- Reward
- Eating behavior
- Cognition
- Wanting
- Aging
- Cognitive decline
- Health
Brain → Food

How does the brain influence our eating behavior?

How can we make the healthy choice the preferred choice?
Food → Brain

How does food influence our brain?

How can food ingredients improve brain functioning?
Ambitions

- Sensory attributes
- Marketing, communication
- Nutrition facts

Brain measurements

- Reward, liking
- Choice
- Mental health

Validation

- Traditional method: surveys, interviews, focus groups
- Drawback: highly subjective, unreliable data
- Needed: objective, quantitative research instruments
Project consortium

- **Radboud University**: brain and cognition
- **Wageningen University**: human nutrition, consumer behavior
- **University of Twente**: packaging design
- **Noldus Information Technology**: software development, eye tracking, system integration
- **Artinis Medical Systems**: near-infrared spectroscopy
- **TMSi**: electrophysiology
- **Green Dino**: virtual reality
- **Heinz**: consumer perception, new product development
- **Nizo Food Research**: sensory studies
- **Essensor**: consumer studies
Product 1: Food Experience Simulator
→ Testing of new, healthy food products
Universities
- fMRI studies: Can the brain distinguish between sugars and sweeteners?
- What happens in the brain if a person *thinks* that a product contains more or fewer calories?

Technology companies
- Translate fMRI findings into cost-effective measurement and analysis system, using EEG and fNIRS

Food companies
- Validation of new measurement systems in consumer tests
- Development of new food products
Which factors can we measure in the brain and where?
**fMRI findings**

**Design**
- **cued (expected) drink**
  - neutral
  - low-caloric
  - high-caloric

- **delivered drink**
  - demiwater
  - same drink (lemonade)

**fMRI results: cue (expectation) effect**
- high-caloric > low-caloric

Activates primary taste cortex, independent of wanting or liking measures

*Can these fMRI findings be replicated in the Food Experience Simulator?*
Food Experience Simulator design

- Translation of fMRI findings to stimulus delivery and response measurement system (Food Experience Simulator)
- Stimuli: visual, tactile, gustatory, olfactory
- Measurements: EEG, NIRS, ECG, GSR, gaze direction, facial expression
System architecture

Challenges

- Accurate synchronization of stimulus delivery
- Accurate synchronization of response measurement
- Event-related response interpretation
FOCOM product 2

Brain measurements
- Sensory attributes
- Marketing, communication
- Nutrition facts

Validation
- Reward, liking
- Choice
- Mental health

Product 2: Food Choice Simulator
Virtual supermarket for testing of new packaging design and product placement
Food Choice Simulator

- **Stimuli**: virtual supermarket with customizable shop layout and product placement and design
- **Measurements**: EEG, NIRS, ECG, GSR, gaze direction, navigation
Food Choice Simulator: Findings

**Experiment**
- 100 subjects
- Three conditions: real supermarket, virtual supermarket, pictorial display

**First results**
- Tendency to buy more products in lab conditions than in actual store
- More variety seeking in virtual environment
- Behavior in physical store was more closely resembled in virtual environment than in pictorial display

**Conclusion**
- Virtual store can be used to study a variety of relevant research questions and provide insightful information on consumer behavior
Wrapping up

- Innovation through multidisciplinary public-private cooperation: fruitful combination of science, engineering and domain expertise
- Public-private partnership enhances knowledge transfer from university to industry
- Integration of sensor technology, brain science and ICT leads to innovative new products for industry and health care
Thank you for your attention

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