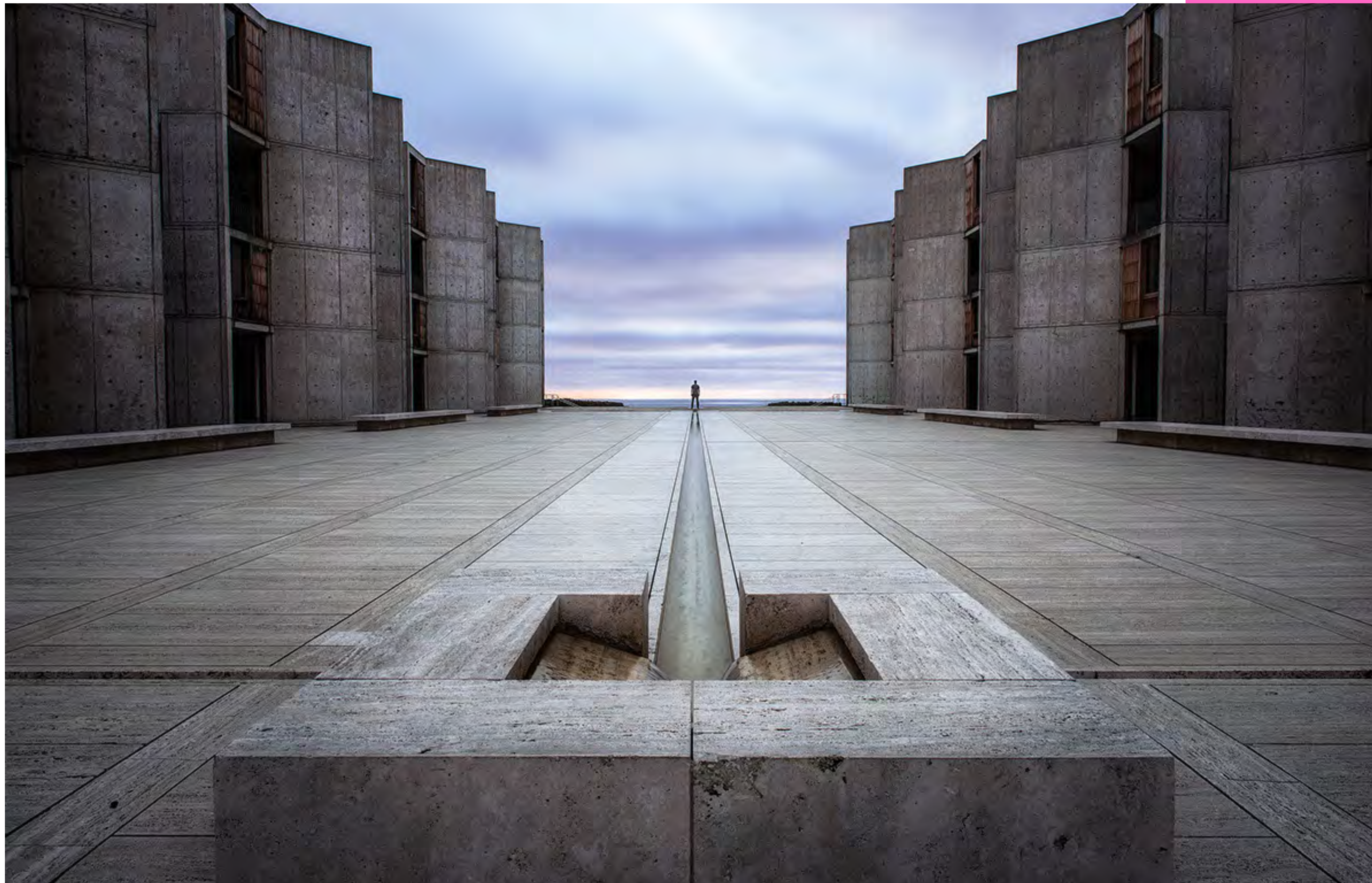


THE ACADEMY OF NEUROSCIENCE FOR ARCHITECTURE  
**20TH ANNIVERSARY CONFERENCE  
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**ANFA**  
Academy of  
Neuroscience for  
Architecture



# Imagination and digital tools in the architecture design process

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## Abstract

The process that leads to the prefiguration, and possibly to the materialization, of architectural space is a complex one. It involves various professionals, knowledge in multiple fields, and has always been developed through the reliance on some kind of tool. Digital technology for architectural design, nowadays, is equipped with ever greater potential, and has a direct impact, from the early stages, on the design process.

Taking into account the studies descending from the "extended mind" theory [1, 2] it seems inevitable to investigate the architectural design process through the lens of the tools used: body, brain, and "active externality" constitute a network of inseparable interactions, by which the brain undergoes continuous reconfiguration. Research on the cognitive implications of digital media for architecture seldom addresses the relationship with mental imagery, which we argue should be considered a modeling tool for architectural design [3].

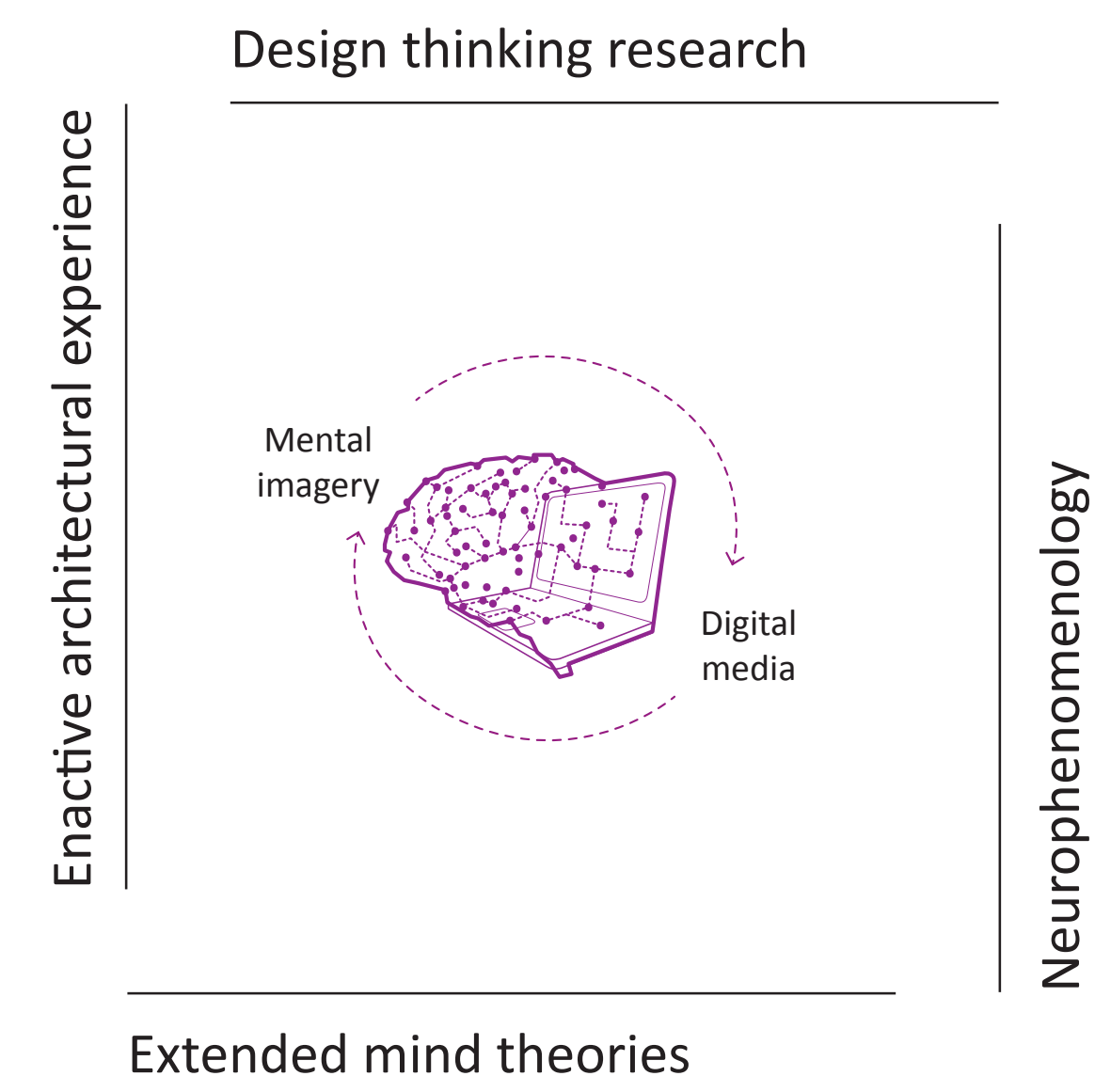
Considering the perception of the environment as an embodied experience of atmosphere [4], we argue that imagination in the form of multimodal mental imagery is the cognitive process that best can convey those experiential contents into the project. As demonstrated by many years of behavioral and neuroscientific research, mental imagery represents a form of perception without the corresponding sensory stimulus [5], can expand and bias perception [6], is closely related to memory constructs [7], preserve spatial properties and thus allow inspection and transformation [8]. Moreover, through imagination, the architect can stand in an emphatic relation with the imagined architectural experience [9].

Since the boundary between the designer's mind and the instrumental apparatus at their disposal is increasingly blurred, in this poster we will present a theoretical framework for the investigation of the interaction between digital tools and mental imagery through a philosophical and cognitive approach, and two experimental studies that stemmed from it.

With the aim of demonstrating the impact of the tools used on the design process, we asked a group of undergraduates of architecture to perform a simplified design task under two different conditions, namely using "2D-3D CAD software" vs. using "only imagery" (within-subjects design) and evaluated the effects through self-report questionnaires. The results obtained suggest that the process of architectural design is sensitive to the tools used, at least in terms of the subjective experience reported by participants.

In the second study, whose data analysis is still ongoing, we aim to understand if architects with different visual cognitive styles, "object" or "spatial" [10], show differences in their cerebral activity during a task that simulate a design process that relies on BIM software. Experimental research on the topic is only at its beginnings and we believe its future developments and results could have an impact on architectural education, on professionals' awareness of their own creative process, and on the Human-Computer Interaction adaptability.

## Context and Aim

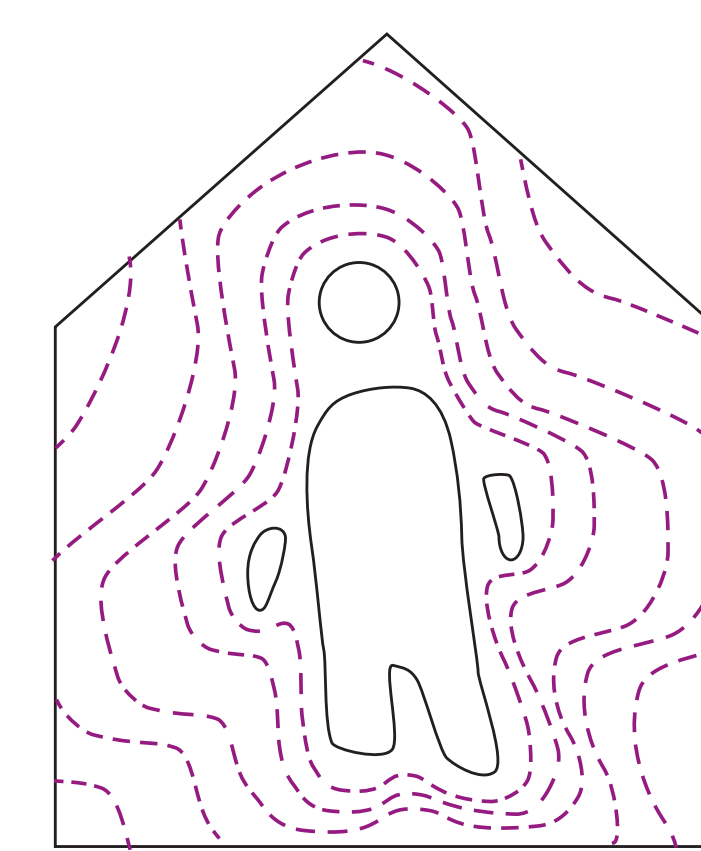


## Theoretical framework

### Introduction

#### EXPERIENCE

Experience of architectural space is an active process of multisensory engagement with an atmosphere.



- Embodied
- Enactive
- Precognitive
- Atmospheric

#### PROCESS

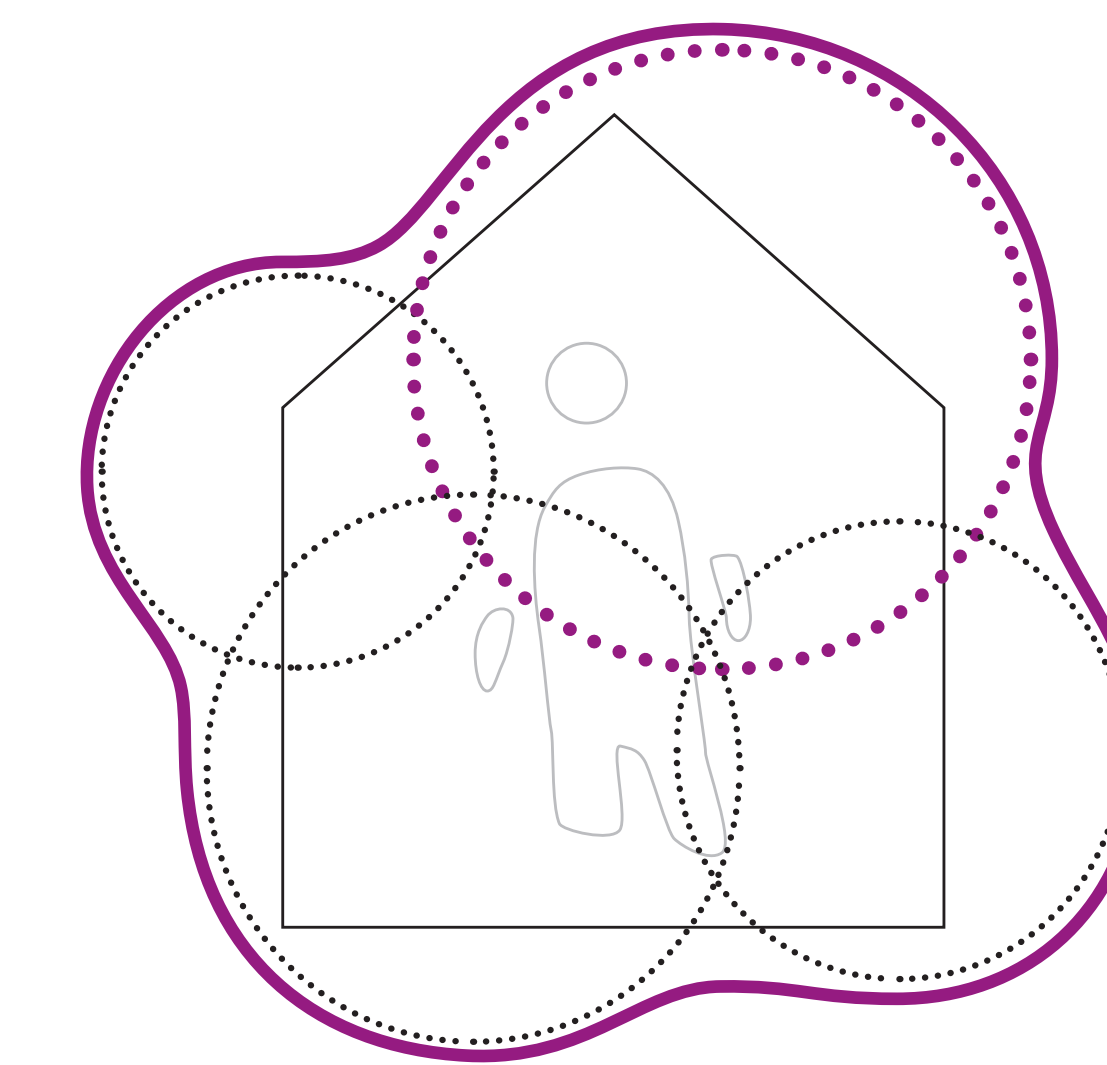
Classification of cognitive processes involved in the architecture design process.

- Executive functions  
Planning, monitoring, selecting
- Long term memory  
Storing representations
- Semantic processing  
Interpreting, and associating representations
- Visual perception  
Perceiving and attending to representations
- Mental Imagery  
Producing and modifying representations
- Creative output production  
Producing and combining concepts

#### MODELS

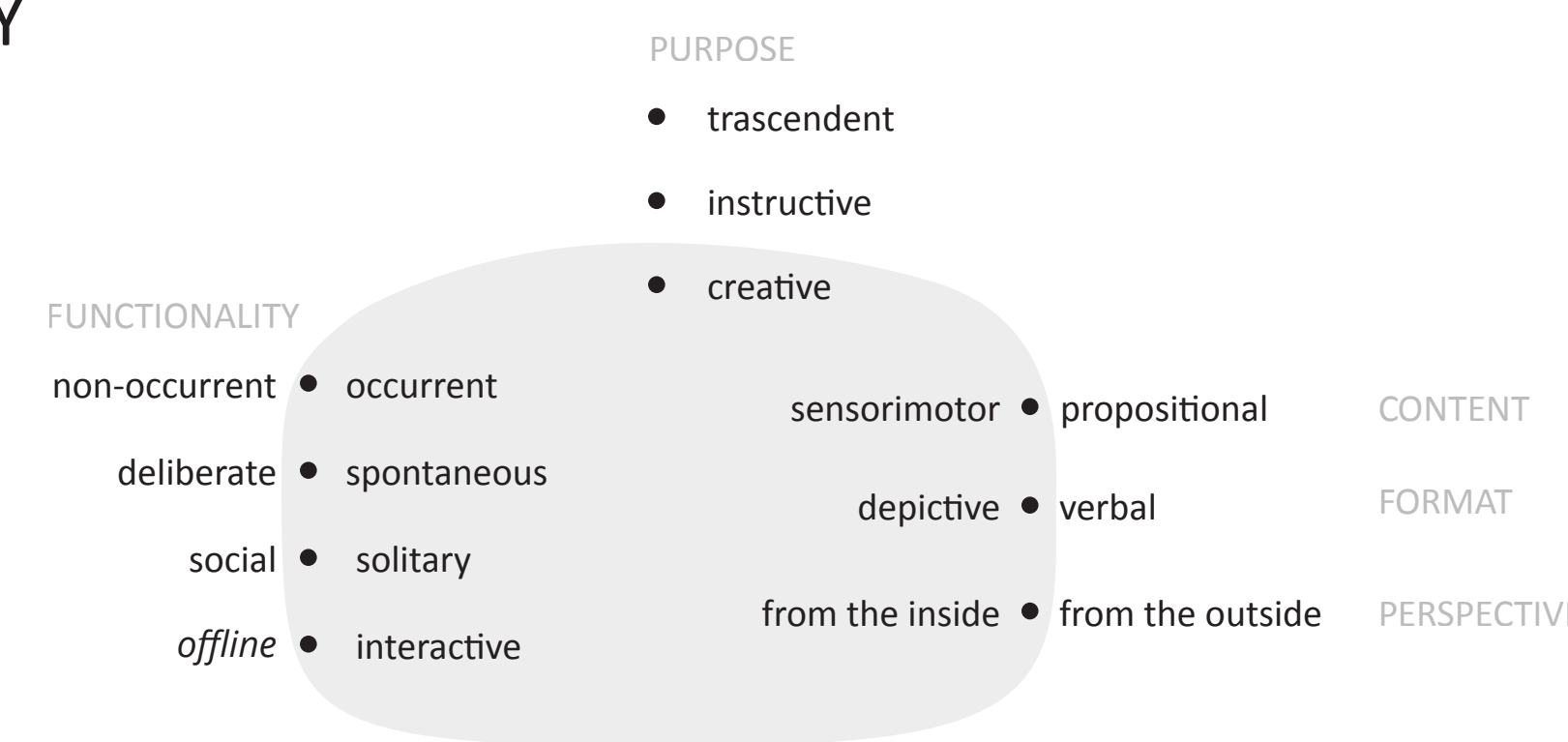
The architecture design process always involves the use of tools. Nowadays there is a preponderance of digital tools over others.

- Maquette  
Plastic features
- Digital technical drawing  
Dimensional information
- Verbal description  
Semantic values
- Sketch  
Potential forms

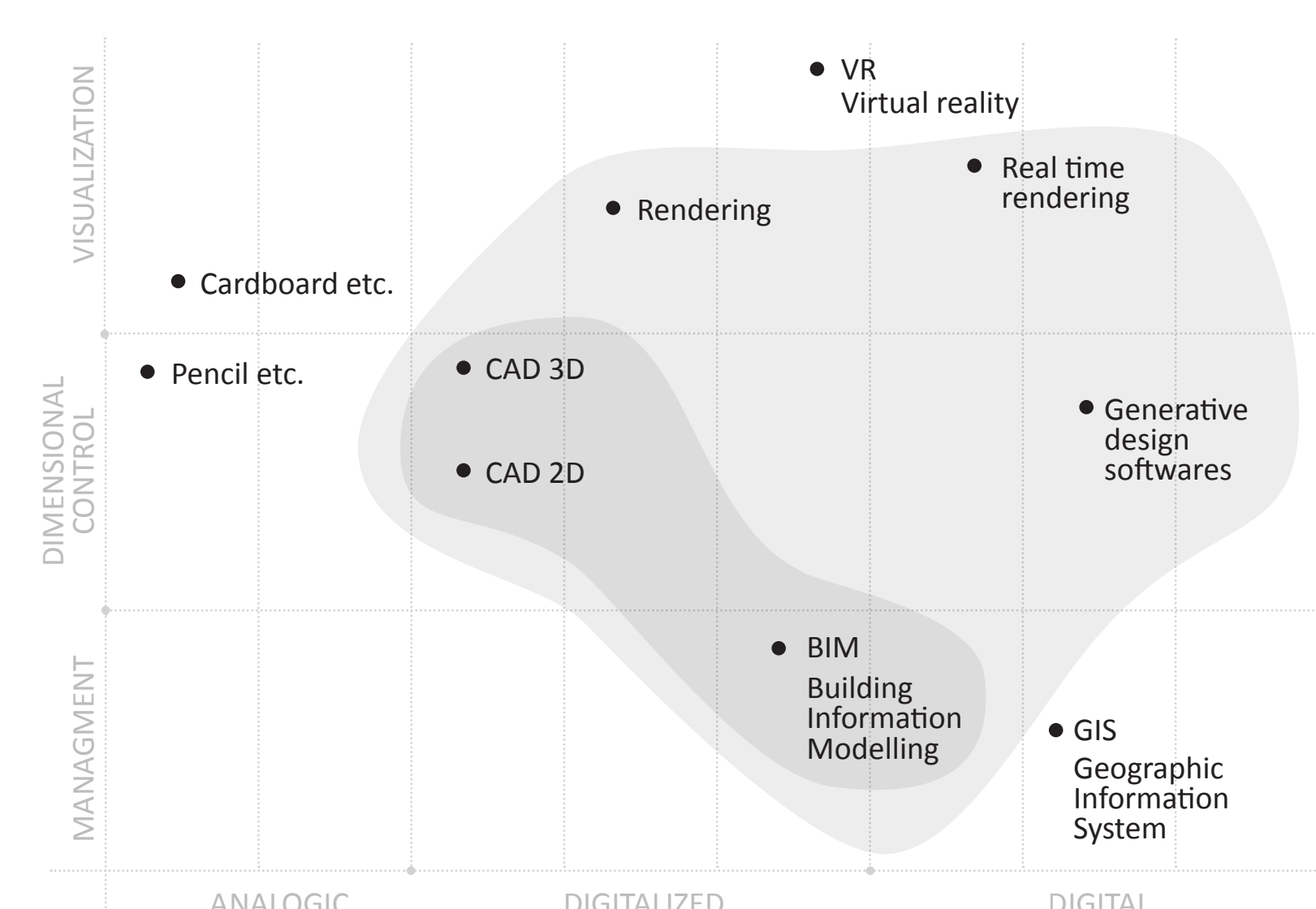


### Borders

#### MENTAL IMAGERY



#### DIGITAL TOOLS



### Critic

#### Simulation

Mental imagery is the perceptual processing not triggered by the corresponding sensory stimulation. This allows architects to simulate sensorimotor experience of the space yet to be built.

#### Expansion

Through mental imagery, sensory-triggered perception can be expanded toward content beyond the immediate present. While the architect is involved in the visual perception process given by a drawing, they can perceive what is beyond it, in the same sense modality or not.

#### Retrieval

Mental imagery retrieves from long-term memory fragments deriving from the embodied experience, which is per se a construction actively operated by the subject. Memories can be digitalized.

#### Abstraction

Digital tools demand inputs corresponding to some aspects, abstracted from the wholeness of the architectural object; this could remove from the architects' attention the more concrete aspects of the space to be designed.

#### Hyper-precision

Digital tools are primarily aimed to control the quantitative-dimensional aspects the more accurately as possible. The apparent fineness, and the illusion of realism, could be misleading and distract from the hypothesizing of better solutions.

#### Segmentation

Management methodologies like BIM rely on families of elements to create a model. This can induce a process reliant on additive procedures that could inhibit holistic and material thought about the architectural space.

#### Mirroring

Experimental studies demonstrated that mental images maintain the spatial properties of the represented object. Thus, the architect can use mental images to perform inspections and transformations of spatial elements.

#### Involvement

Mental imagery is the only representation system for architecture that allows the architect to be in a first-person perspective towards the space represented.

#### Interaction

Mental imagery is strongly rooted in technical knowledge both in terms of technic embedded in the represented object and in the technical tools used while imagining. This on the main distinctions between mental imagery and fantasy.

#### Scaleless

The digital realm, in certain conditions, lacks dimensional relativity; this could induce the architect to establish proportions related to the digital drawing and not necessarily appropriate for the body-space interaction.

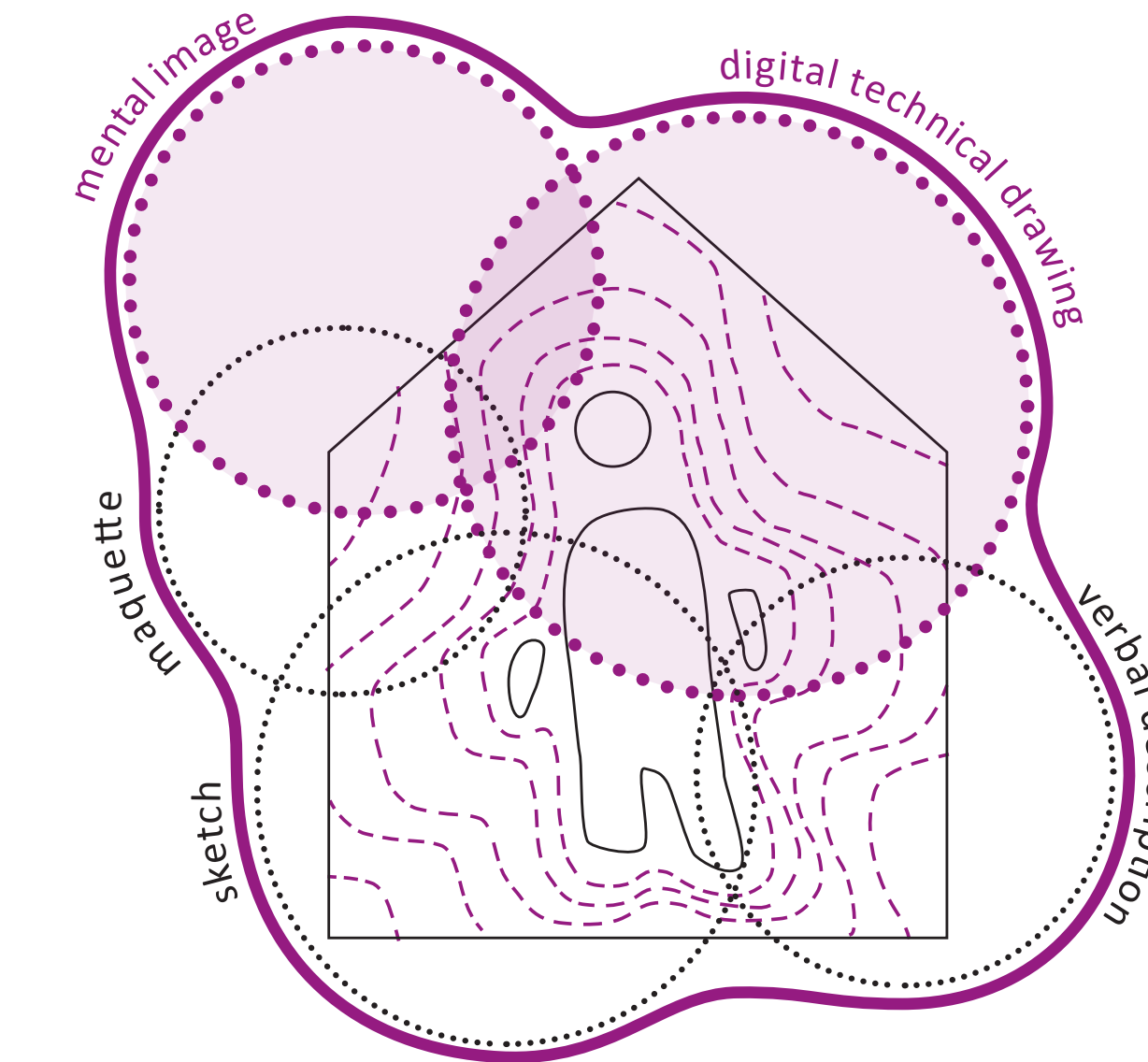
#### Disembodiment

The architect, being absorbed by the interaction with the symbols in the digital interface, could lose contact with their own corporality and with the bodily experiences that could be used as design guidance.

#### Big data

Softwares for generative design intervene not just in the content of the representation but also in the design process itself. They represent a shift from "form designing" to "form-finding" and could impact the architects' creative capacity.

### Conclusions



In order to simulate as precisely as possible the conditions generated by the project, in their absence, architects use models that themselves produce and modify recursively throughout the design process. Models are examples that, according to some aspects, represent the final architectural object, in order to speculate on them. Depending on what information is necessary to control or communicate, the model is selected with respect to the totality of the object it represents. These clusters of information, partially isolated within each model, only make sense if they dynamically interact with other models. To create the various partial models that architects, some information is abstracted from the object represented and entrusted to a tool with its own rules to manage them. The model that virtually represents the architectural object as it will be built is the fictional set of all the models produced; this macro-model is the one that dynamically conveys the most possible information characterizing the space.

Mental images can be considered one of the models through which architectural space can be represented. They are in fact representations containing information from the perceptual processing retrieved from long-term memory and retain the spatial properties of the object represented. Moreover, mental images are the only model that can allow the point of view in first person with respect to the object represented. Certainly, to be maintained, and specified, mental images require the support of other models, which must be informed by the mental image itself and vice versa. It is precisely the bounce of information from digital models toward mental images that is the specific interest of this research. We argue that this represents a critical issue in design thinking research that should be tackled with the contribution of neuroscience.

## Experimental studies

### Study 1

**AIM**  
 Verify if the tools used affect the design process and understand what is the impact on cognitive and emotional dimensions.

#### MATERIALS AND METHOD

90 bachelor students

SESSION	February	April	May
DESIGN ASSIGNMENT	Canopy and seats	Meditation space	
CONDITION	MI DIG	MI DIG	
GROUPS	A B	B A	
QUESTIONNAIRES	- Ad hoc questionnaire - PANAS	- Ad hoc questionnaire - PANAS	
GROUPS	A+B	A+B	A+B

2 aleatory groups

2 conditions:

MI Modeling tool: Mental Imagery

DIG Modeling tool: 2D-3D CAD

Assessment of individual differences

#### RESULTS

More concrete interactions with the objects of design

Satisfaction with the result

Too many ideas

More memories of previous similar experiences

Too much time

Difficulty focusing on the task

Unsatisfaction with the result

Sense of constraint

Lack of ideas

Lack of time

Focus on the task

### Study 2

**AIM**  
 Understand if architects with different visual cognitive styles, "object" or "spatial", show differences in their cerebral activity during a task that simulate a design process that relies on BIM software.

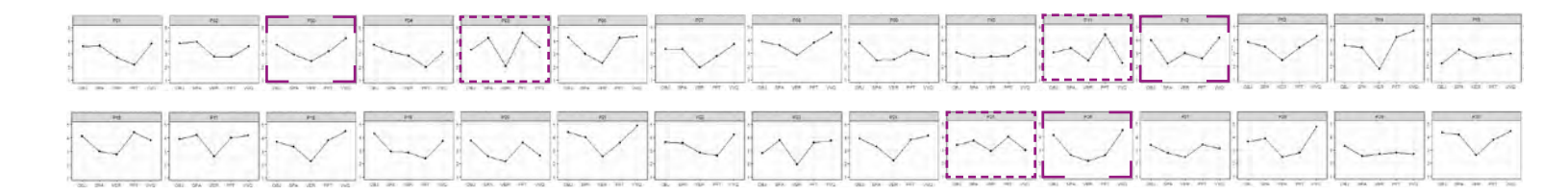
#### MATERIALS AND METHOD

30 Architects

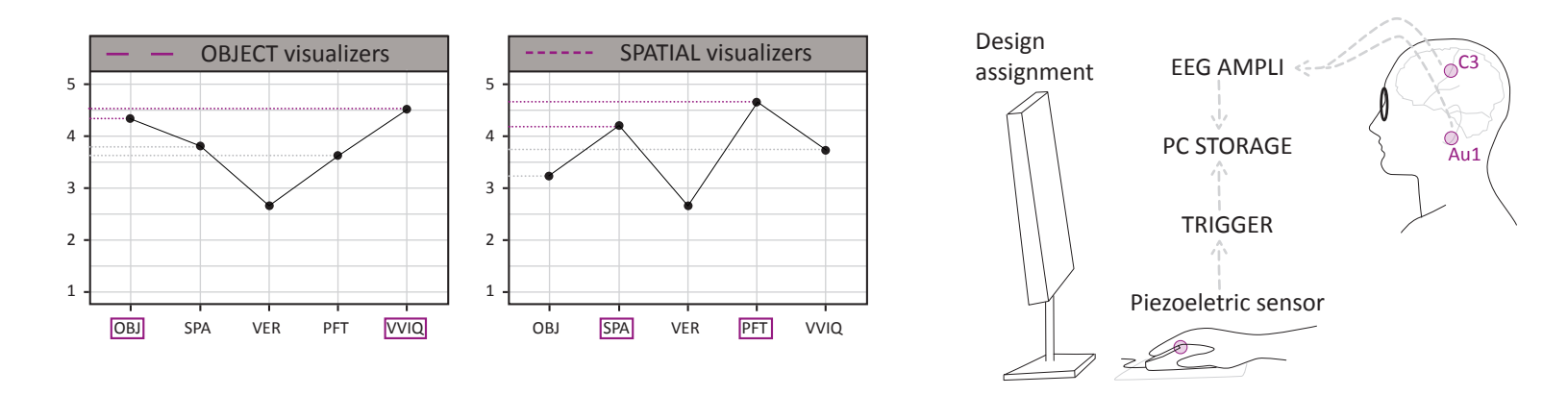
OSIVQ Object-Spatial Imagery and Verbal Questionnaire

PFT Paper Folding Test

VVIQ Vividness of Visual Imagery Questionnaire



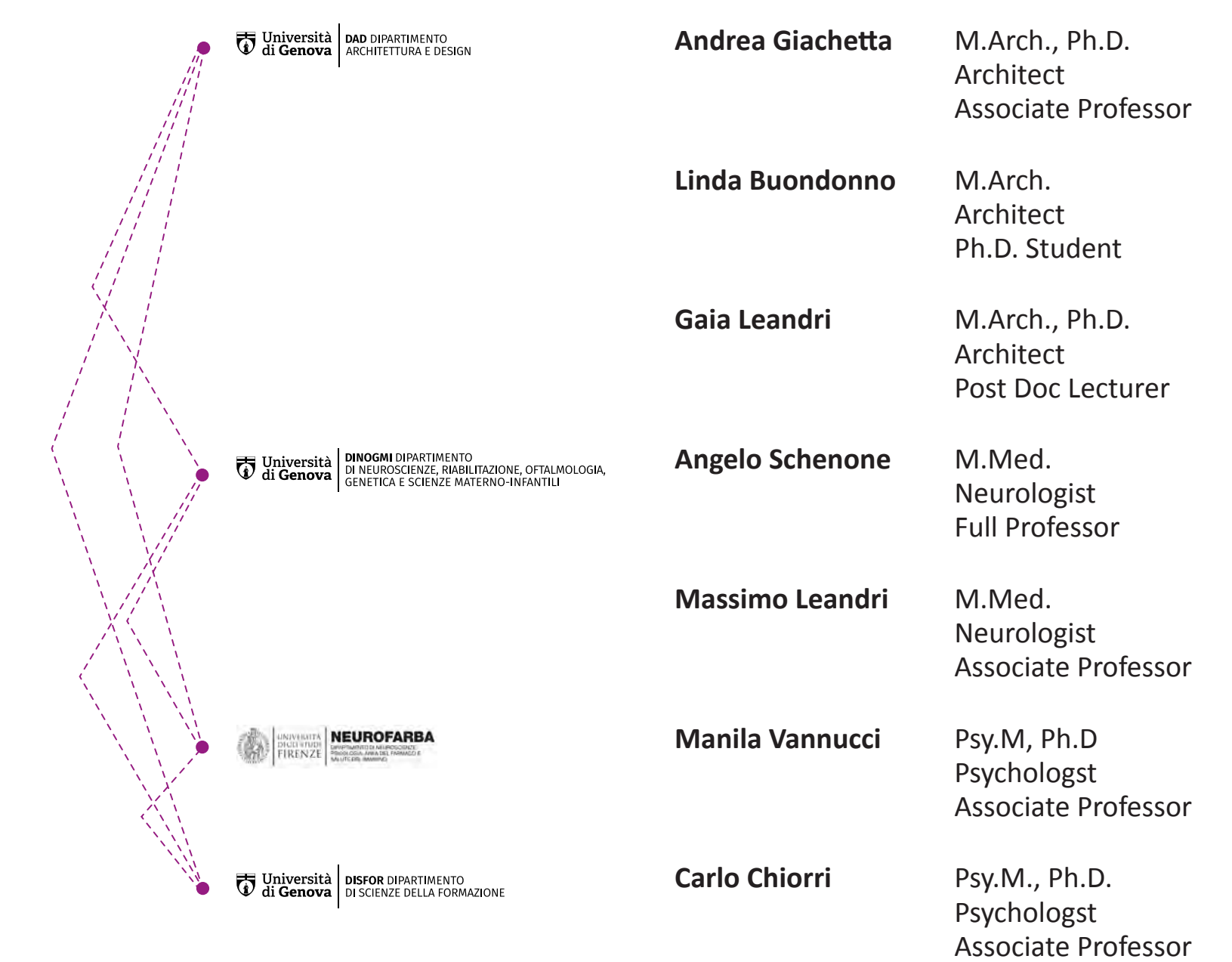
#### 2. Electroencephalographic assessment



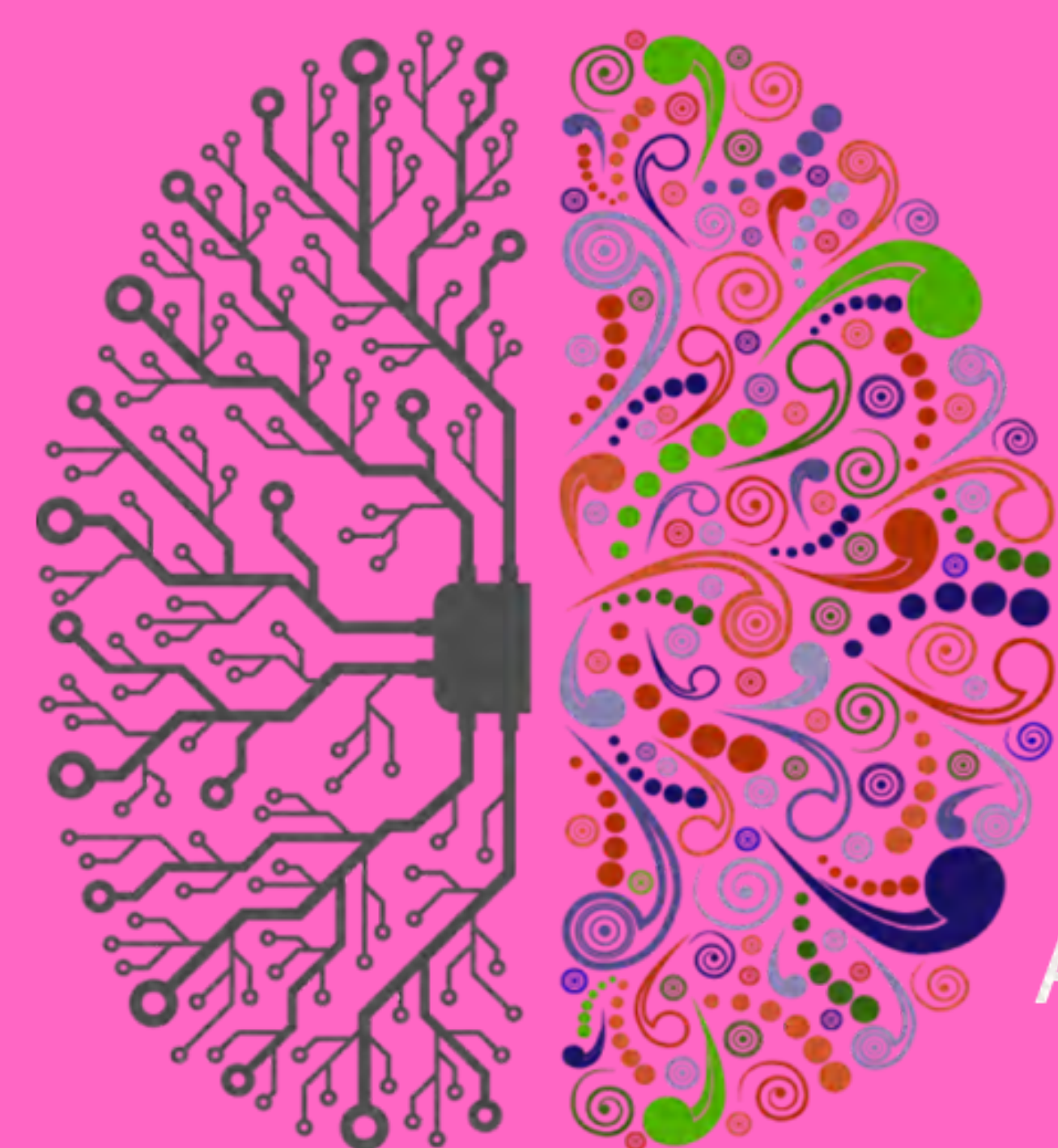
**RESULTS**

Work in progress...

## Collaborations







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