The Tactile Working Memory Scale:
on the interplay between assessing and providing strategies to support tactile cognition and communication

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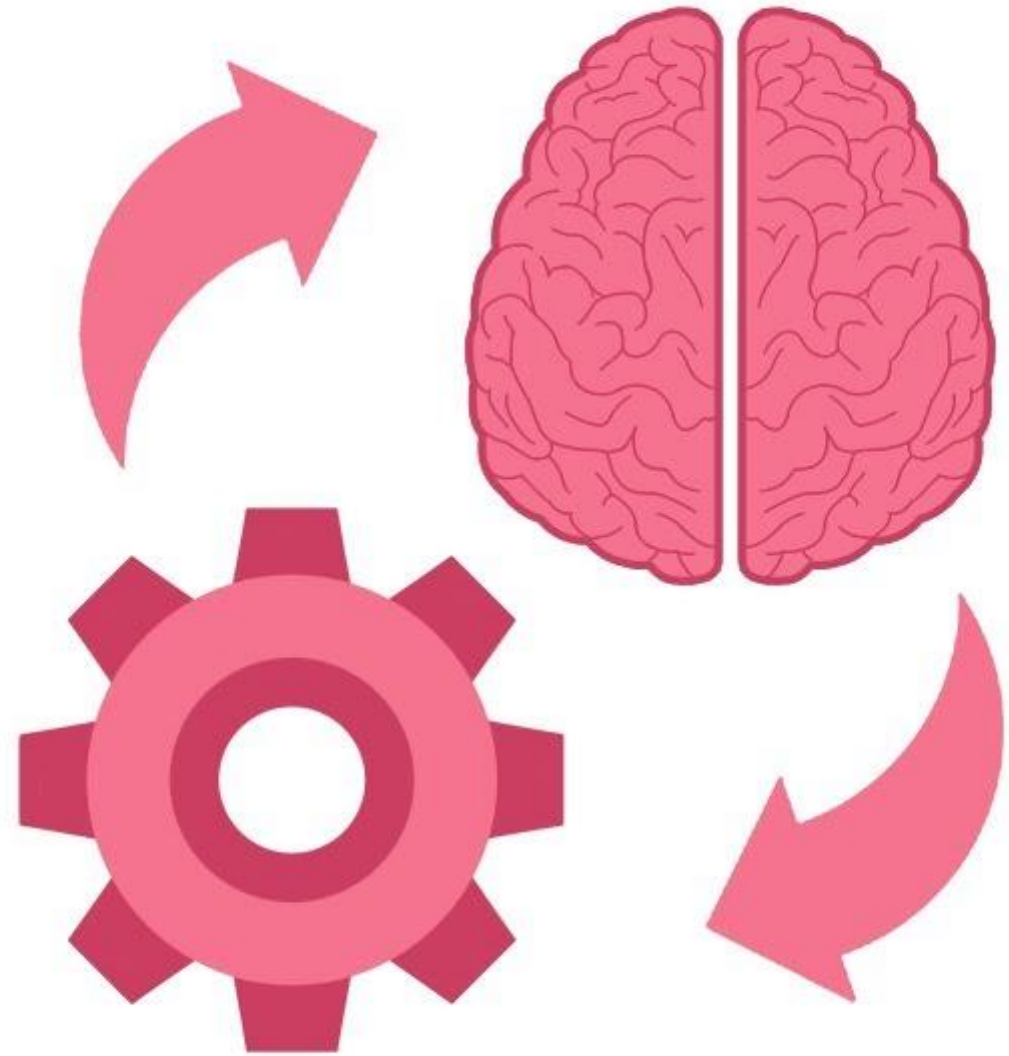
Outline

a) About working memory
b) TWMS: Theoretical framework
c) TWMS: Assessment principles
d) TWMS: Assessment scale
e) TWMS: Learning strategies
f) Brief summary

WHAT IS WORKING MEMORY



Working memory allows us to hold information in mind without losing track of what we're doing

Retaining information by engaging memory, attention, resistance to distraction & goal direction	Retaining social information for further social interactions

Working memory through the tactile sense

The importance of the tactile sense for people with deafblindness

- **When hearing and vision are both affected, there is a high likelihood that the processing of information will be fragmented.**

PEOPLE WITH DEAFBLINDNESS MAY BE FINER EQUIPPED AT PERCEIVING AND MAKING MEANING OF THE WORLD FROM A BODILY- TACTILE PERSPECTIVE

We could view deafblindness

…as a **positive state** in which active touch, body movements, postures, touch patterns and hand gestures, are the **pre-eminent source of information**

Thus, it may be important to support the cognitive development of a person with DB in the tactile modality

Working memory in the tactile sense: Assessment using the TWMS

- to i**dentify** Tactile Working Memory potentials
- to **promote** Learning strategies in the bodily-tactile modality
- **Aim**: improve communicative and learning competencies of a child or adult with deafblindness

NOT A DEFICIT BASED IDENTIFICATION; BUT AN ASSET BASED INTERVENTION

a) About working memory

b) TWMS: Theoretical framework

c) TWMS: Assessment principles

d) TWMS: Aseesment scale

e) TWMS: learning strategies

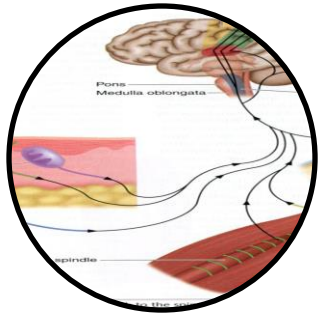
f) Brief summary

- Active touch is part of a purposive and information-seeking sensory system (i.e., bodily-tactile system/somatosensory system)

Philippe Mercier; The Sense of Touch; Circa 1744-1747

- The bodily-tactile system processes bodily-tactile information in a three-level system:

BODILY –TACTILE (SOMATOSENSORY) INFORMATION PROCESSING SYSTEM

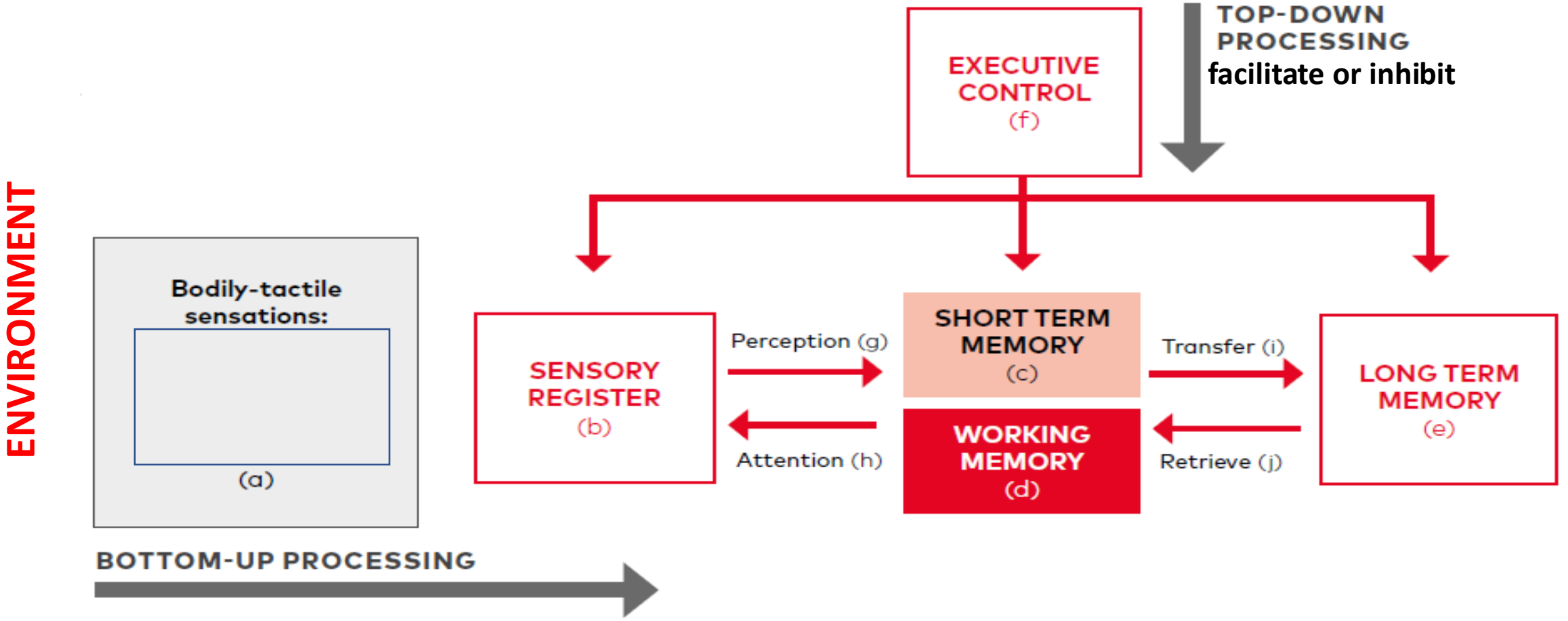


Bodily-tactile sensation

Bodily-tactile perception

Bodily-tactile cognition

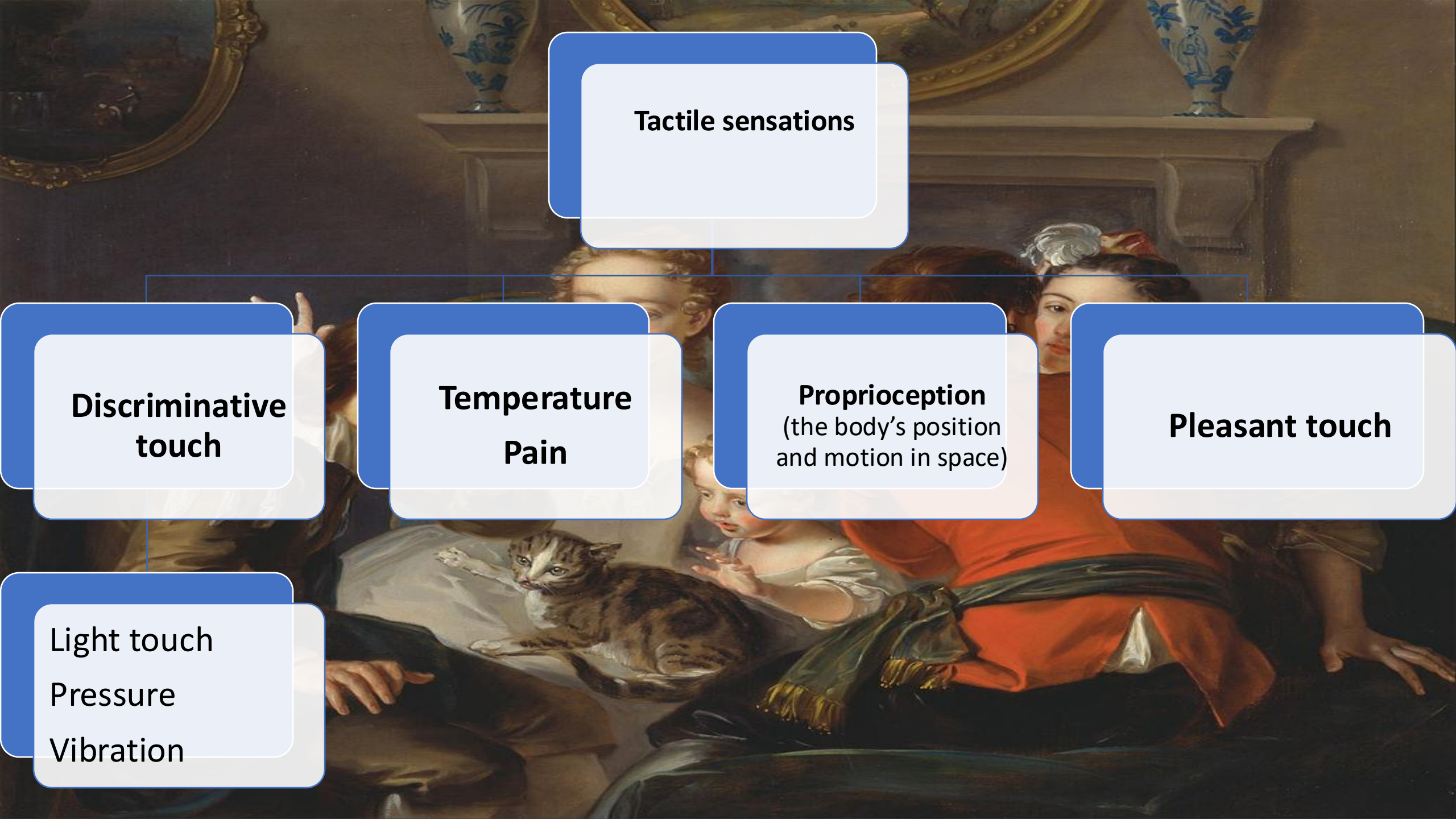
According to this model information processing starts by actively seeking out and focusing on the bodily-tactile available information from the surrounding environment where information flows through and perceived and interpreted in one or more neural processing units.
(Nicholas, Johannessen & van Nunen, 2019; Gallace & Spence, 2009)

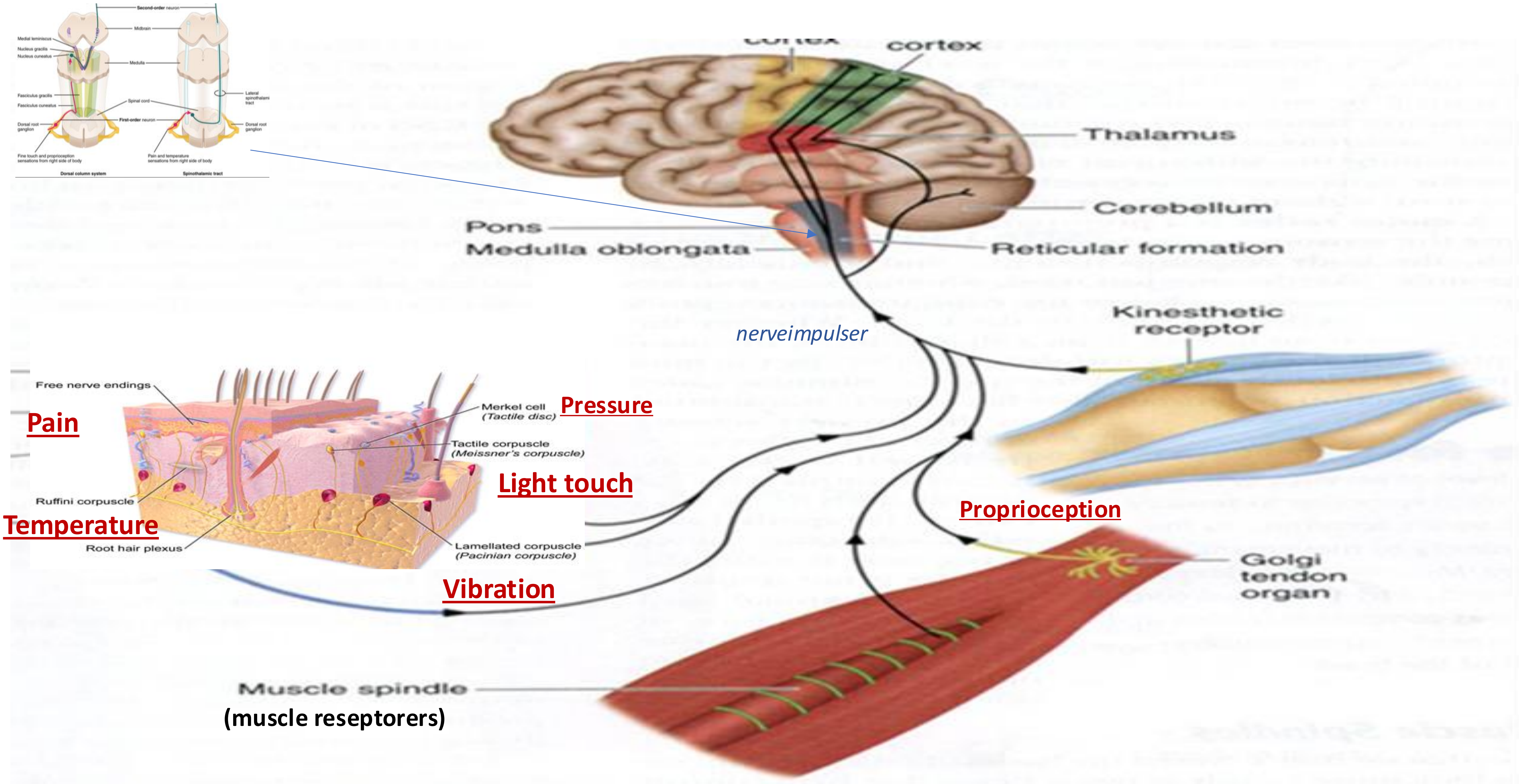


SENSATION **PERCEPTION** **COGNITION**

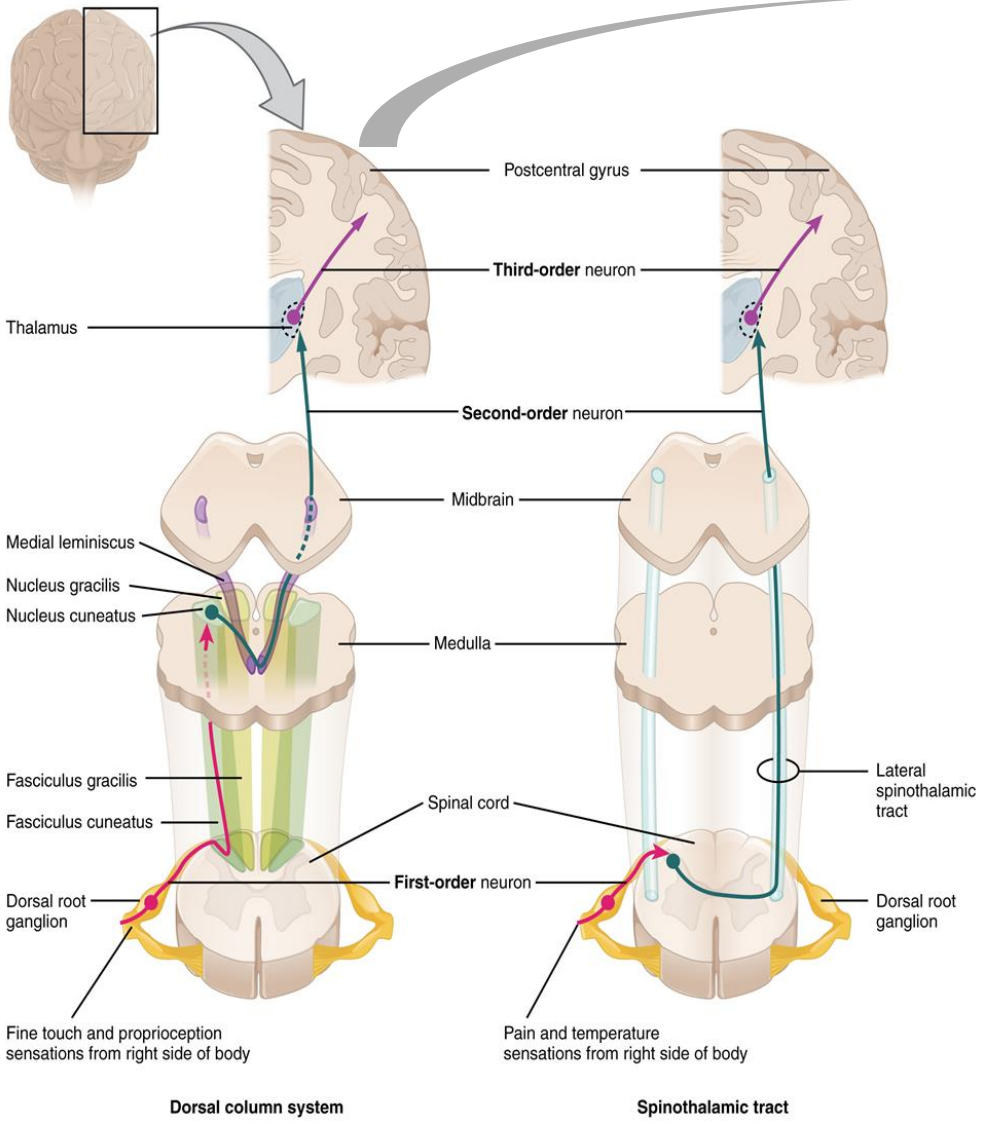
Bodily-tactile sensations

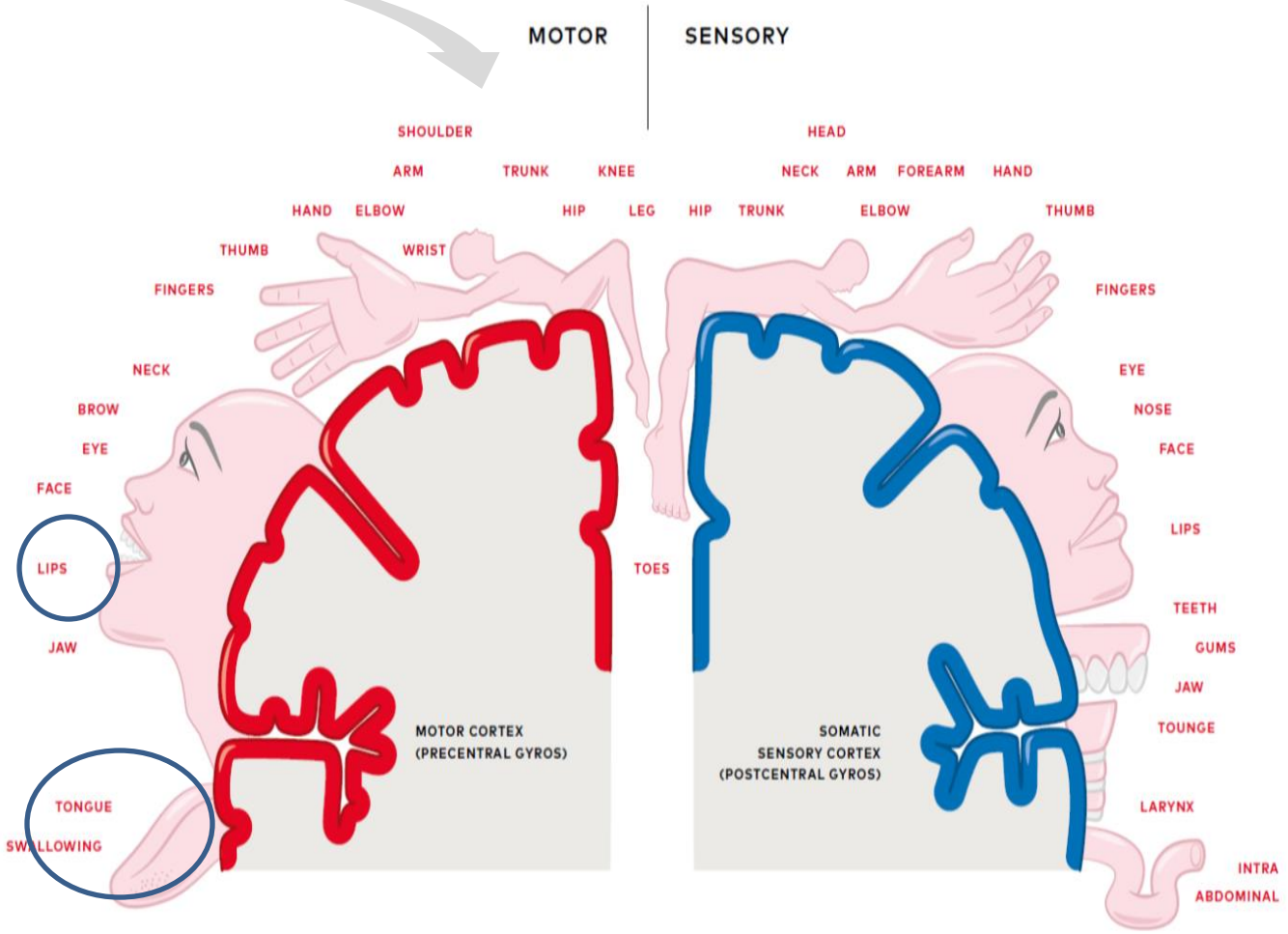
physical sensations of touch and movement received from the surface or inside the body


Tactile sensations
Discriminative touch
Light touch
Pressure
Vibration
Temperature
Pain
Proprioception
(the body's position and motion in space)
Pleasant touch



For most of these bodily-tactilesensations that are received from the skin, muscles and joints the primary destination in the brain is the parietal/somatosensory cortex.

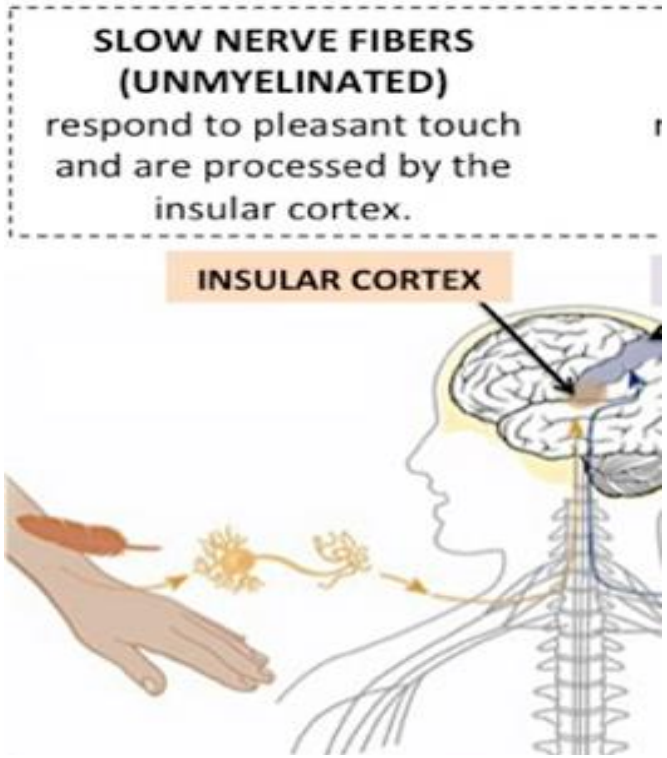


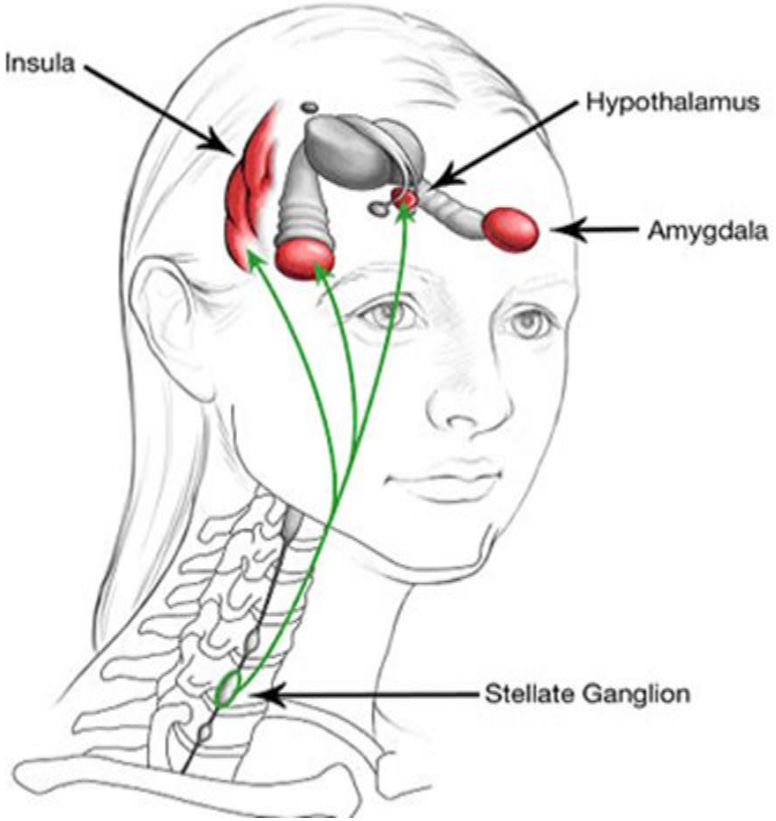


The information from the skin, tendons, muscles, and joints are carried up the spinal cord to the somatosensory brain area so a person can feel the different bodily sensations.

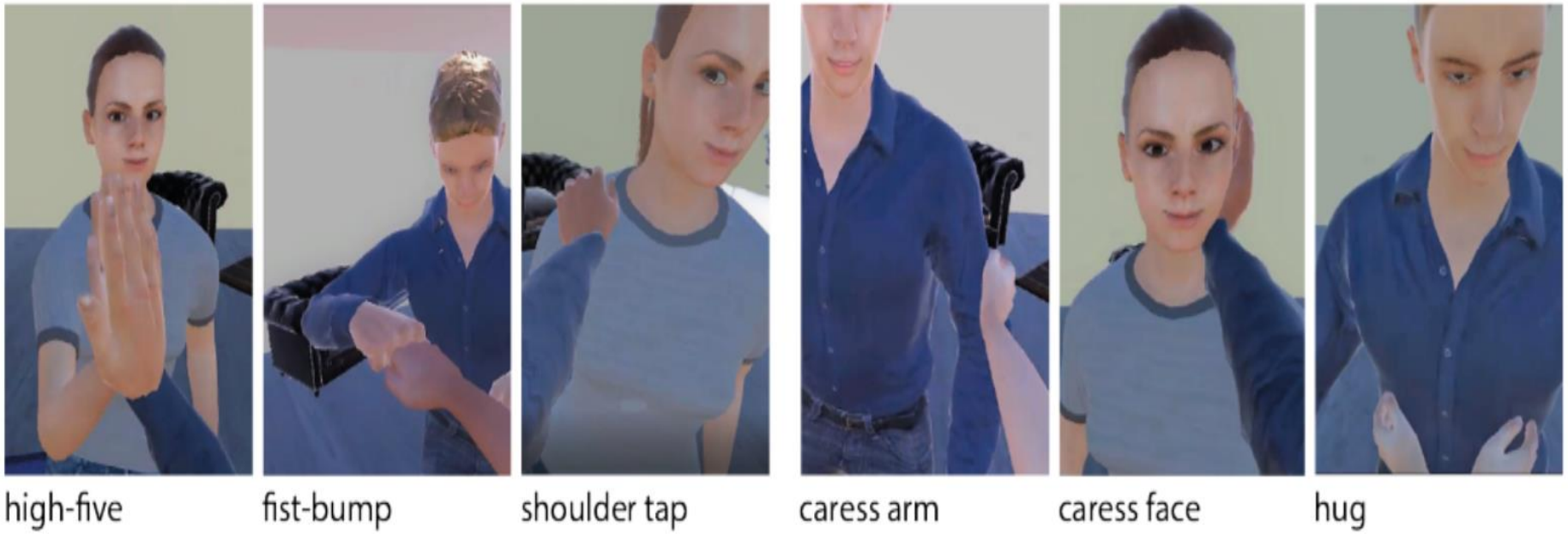
The somatosensory cortex is organized to reflect the way the body is laid out (body map). The body map isn't scaled to body size but reflects sensitivity: the hands, face, lip and tongue are relatively small physically, but because they are highly sensitive to touch, the parts of the somatosensory cortex that represent them are disproportionately large.

Pleasant touch is referred to as an emotional form of touch that transmits socially relevant information and relies on bodily contact and targets the insula brain (Insula links body sensations with emotions)





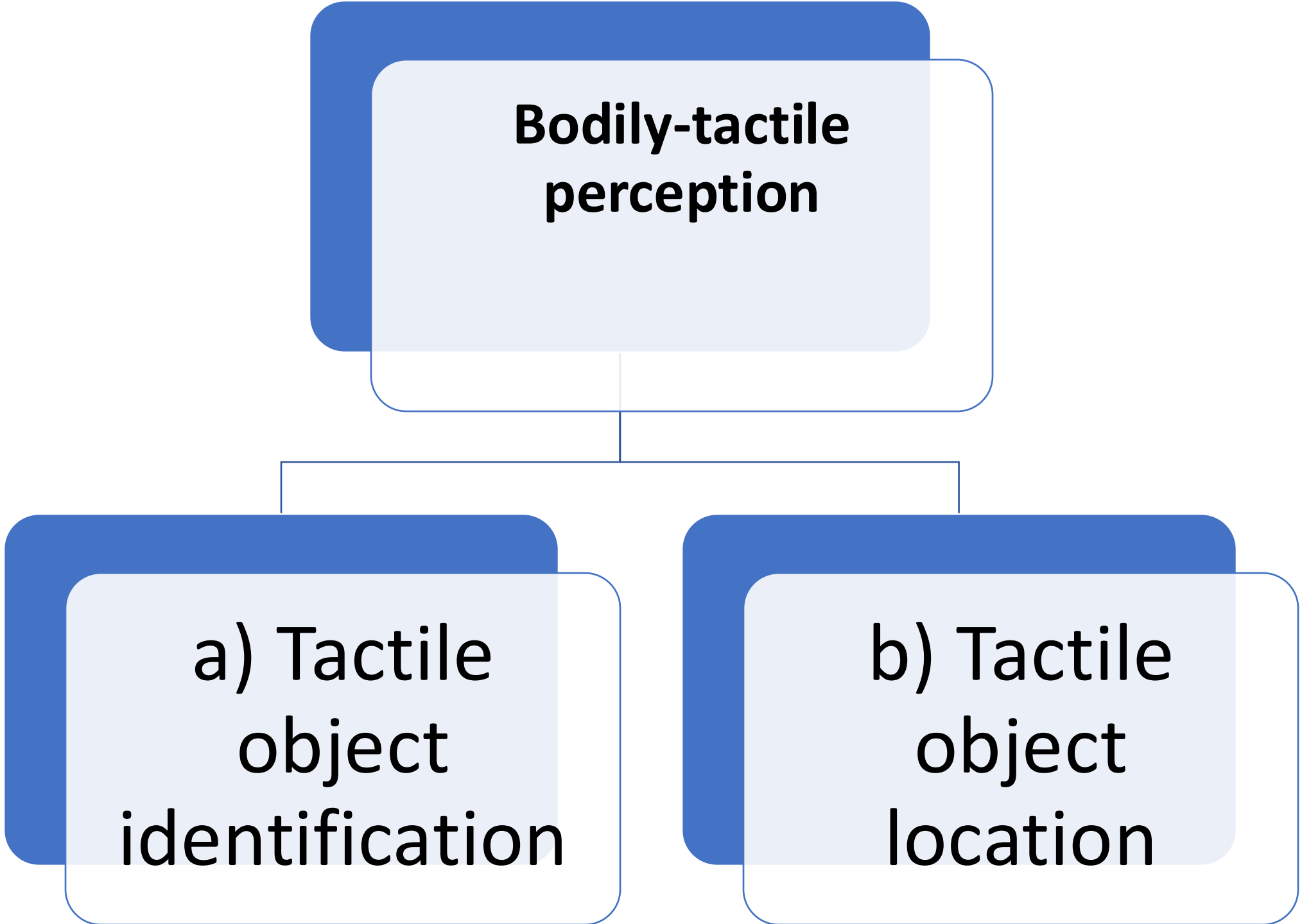
Pleasant touch & light touch are key aspects of social communication



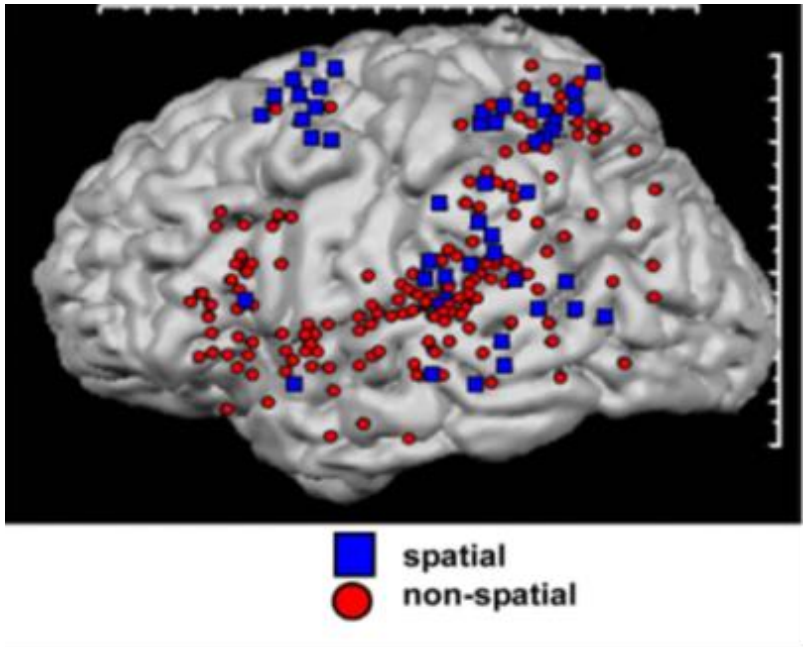
Shapes social perceptions in various ways

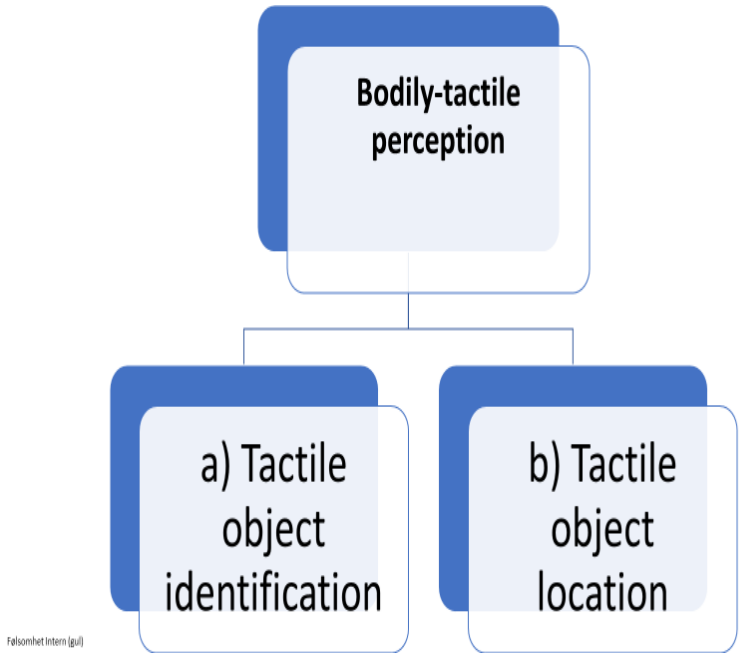
Bodily-tactile perception:

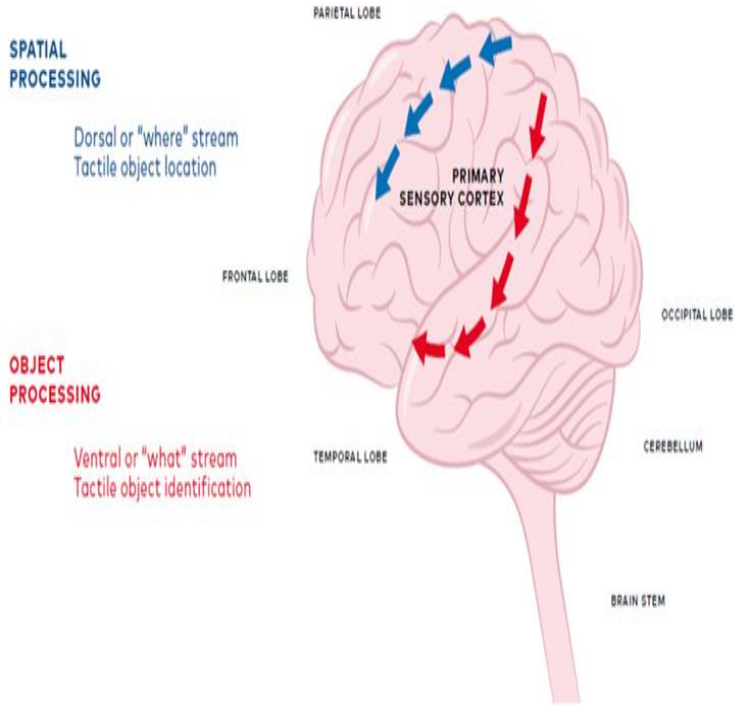
judge or perceive bodily-tactile sensations when physically exploring the tactual properties of objects



A dual neural pathway system: “what” pathway & “where” pathway



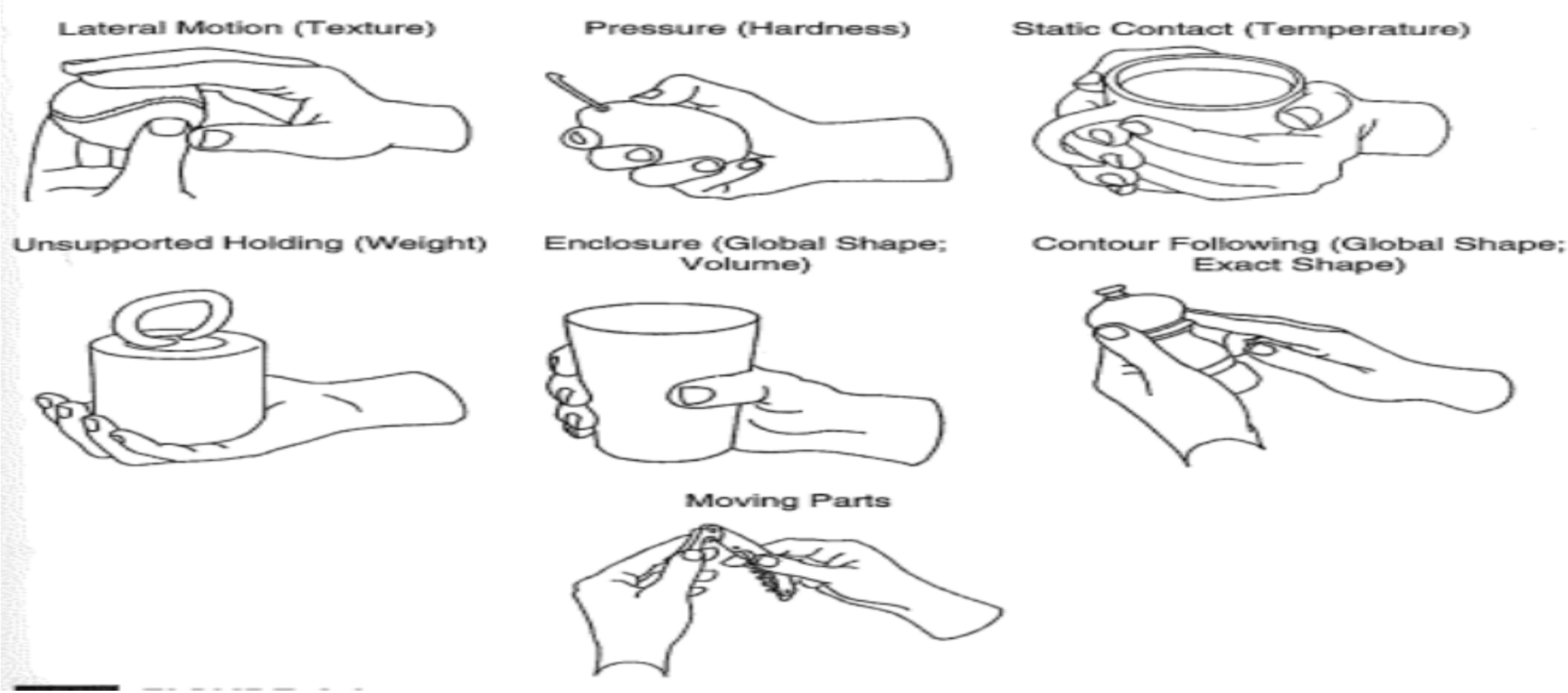




a) Tactile object identification what is the object?

- Gathering information about the **surface properties of objects** (smooth/ rough, hardness/softness)
- Gathering information about the **physical dimensions of objects** (weight, shape, size)
- Identifying **similarities or differences** among objects
- **Categorizing or grouping** objects

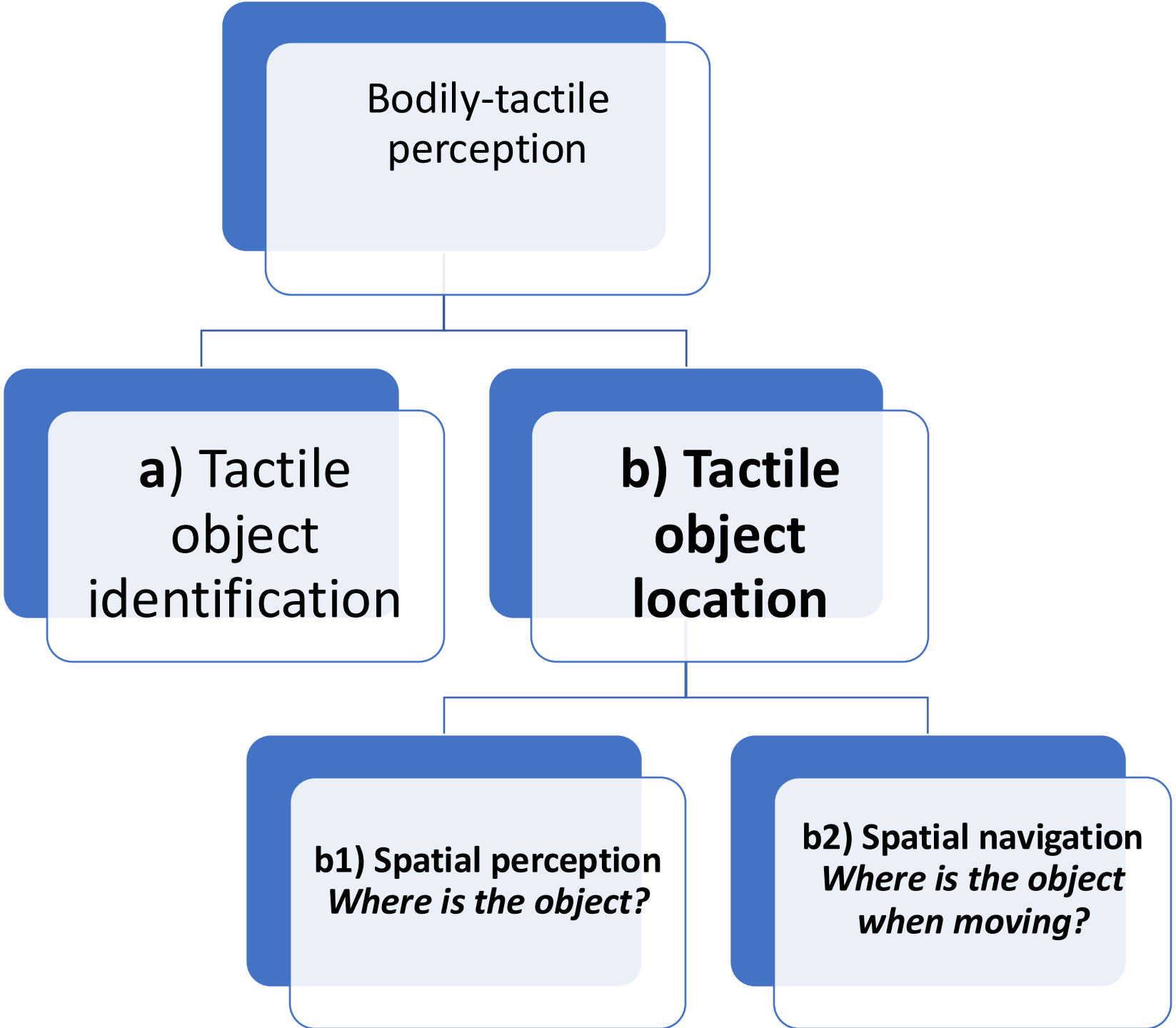
Using specific exploratory procedures for identifying the surface properties (i.e., hardness) or physical dimensions (i.e., weight) of an object



(Lederman and Klatzky, 1987; Nicholas, Johannessen & van Nunen, 2019)

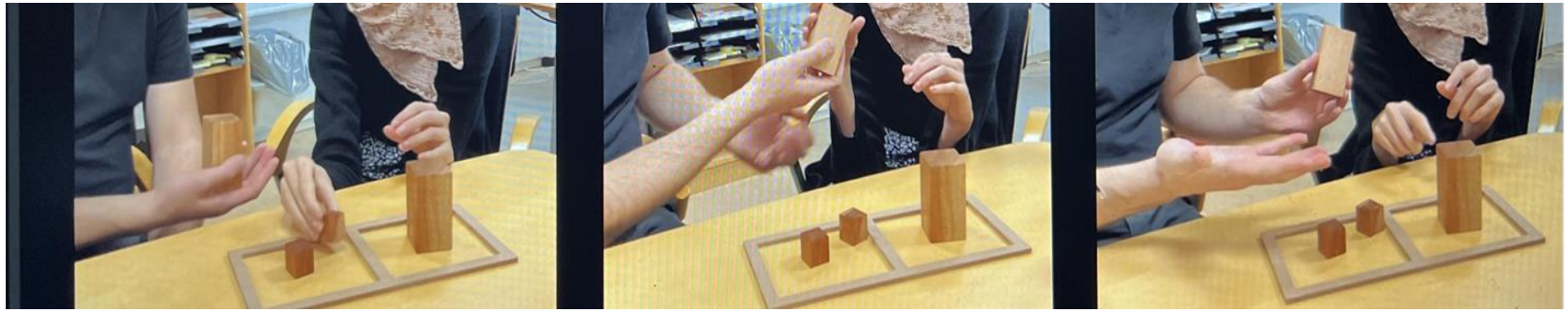
Exploratory procedures follow a developmental progression

- Grabbing and grasping in infants are considered precursors for exploratory procedures (Klatzky, et. al., 2005)
- These exploratory procedures or tactual scanning stratagies have to be learned (Davidson, 1985).
- The importance of training blind children in exploratory procedures at an early age (Vinter, et.al., 2012)



b) Where is the object?
Object-spatial location

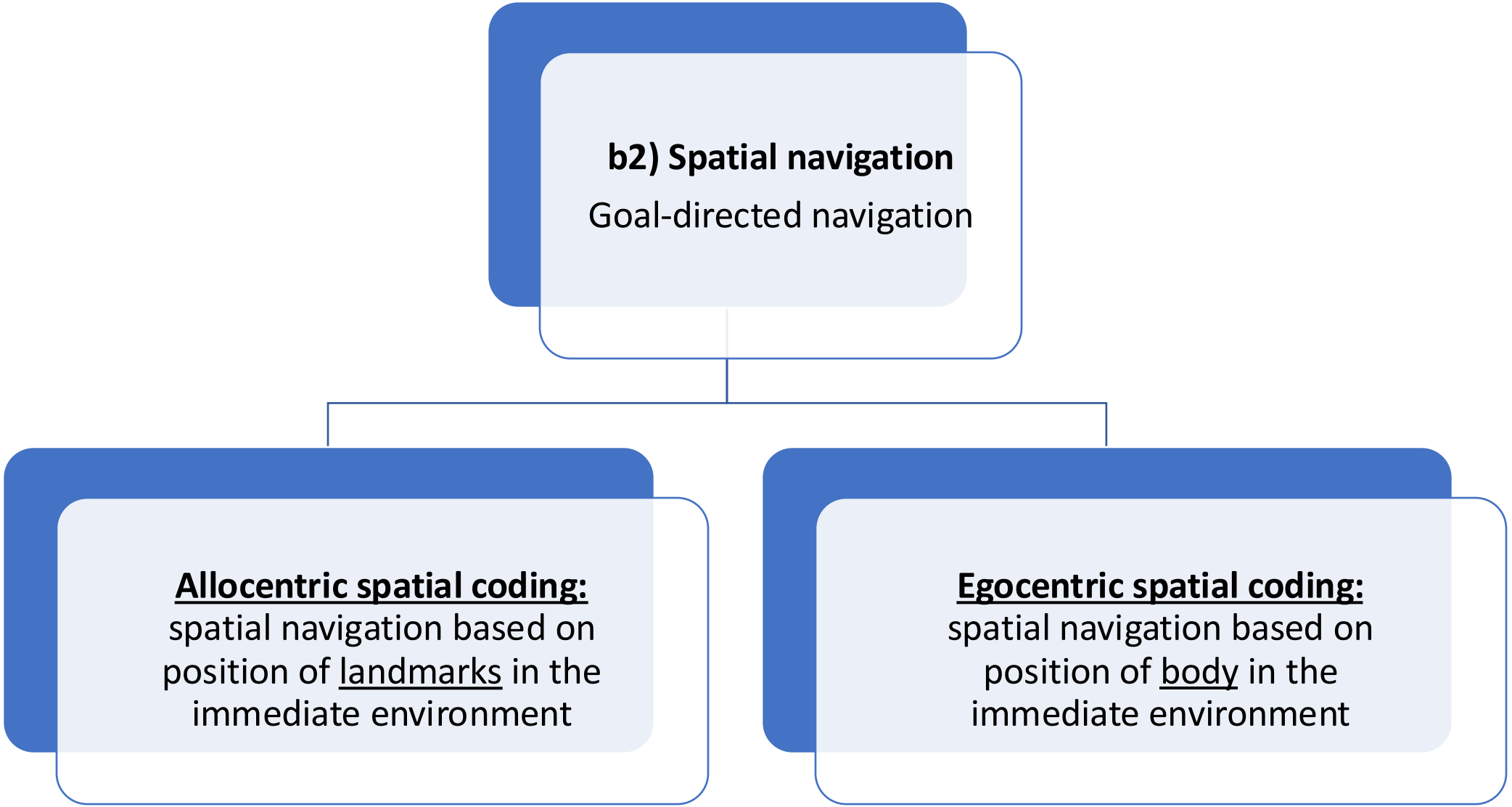
Identifying the spatial placement or distance between two objects



Where is the object when moving? Spatial navigation

Navigating and gathering information about location

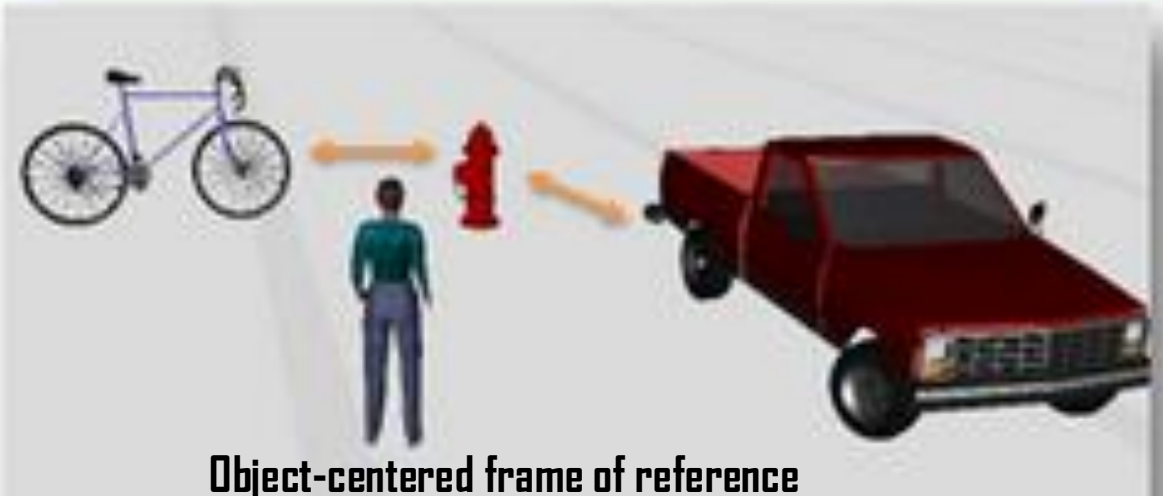
Tactually tracing an accessible pathway and navigating through novel paths



Spatial Coding Systems

Allocentric (object-to-object)

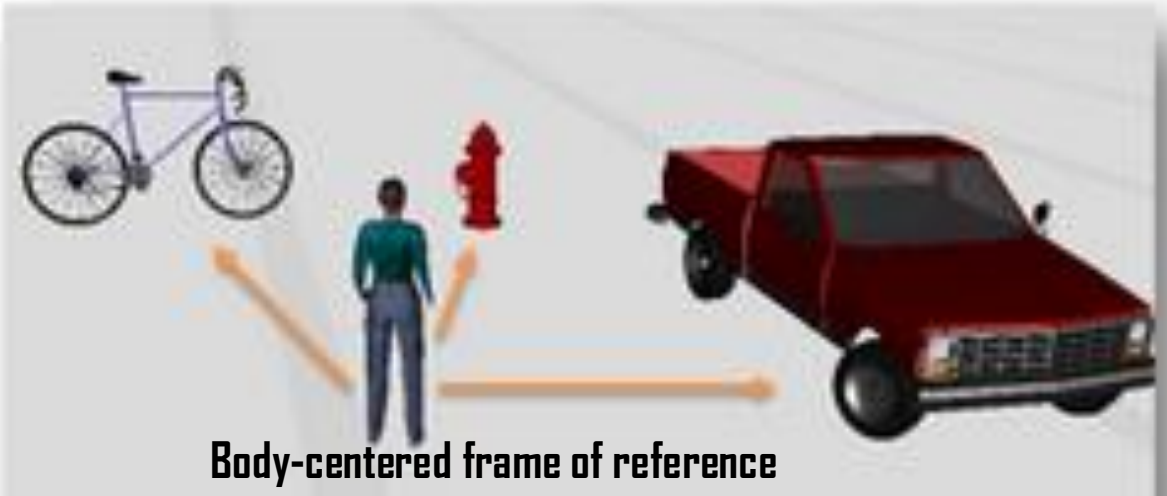
Encodes information about the location of one object or its parts with respect to other objects. The location of one object is defined relative to the location of other objects.



Object-centered frame of reference

Egocentric (self-to-object)

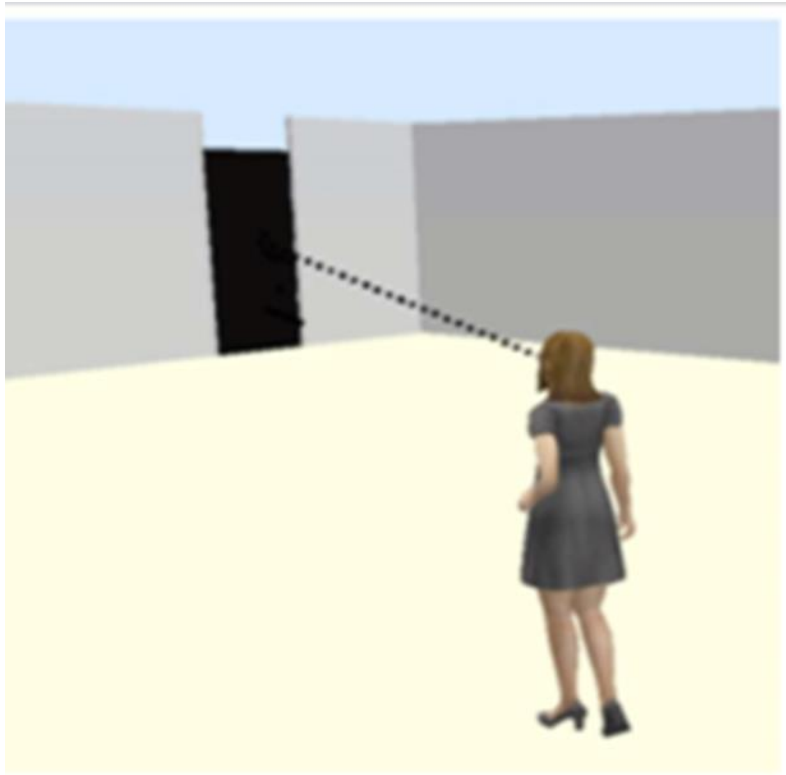
Represents the location of objects in space relative to the body axes of the self (left-right, front-back, up-down).



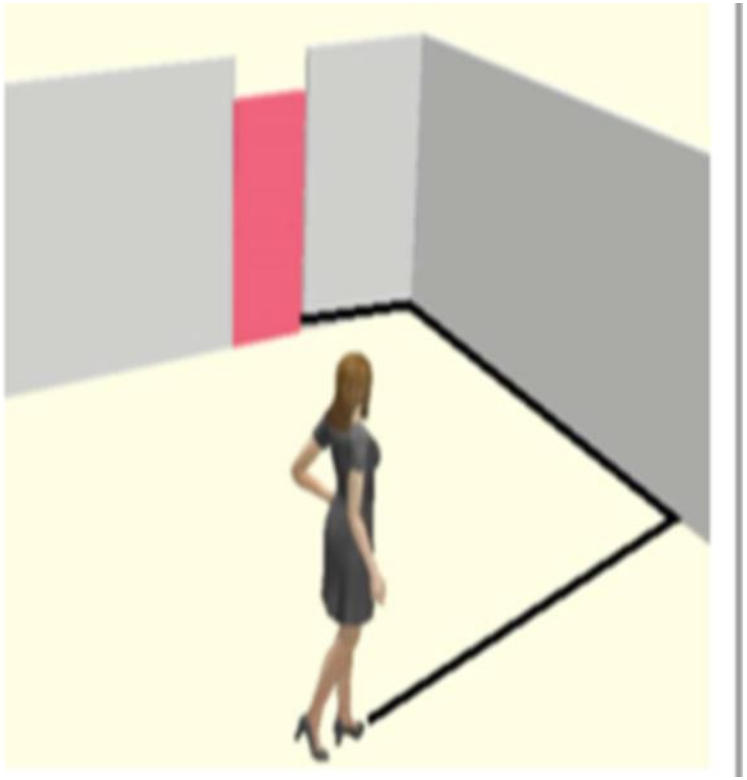
Body-centered frame of reference

Sighted individuals typically employ a spatial coding strategy based on the combination of allocentric and egocentric knowledge, during spatial navigation

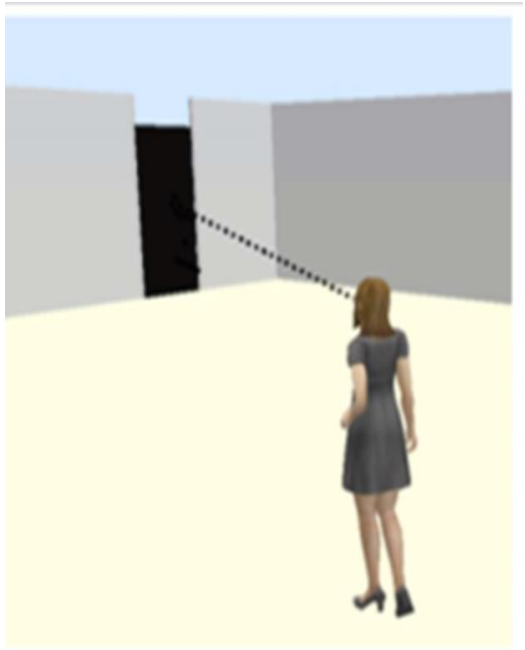
<u>Allocentric knowledge</u>:
recognizing environmental landmarks
the black door is located between the two gray walls



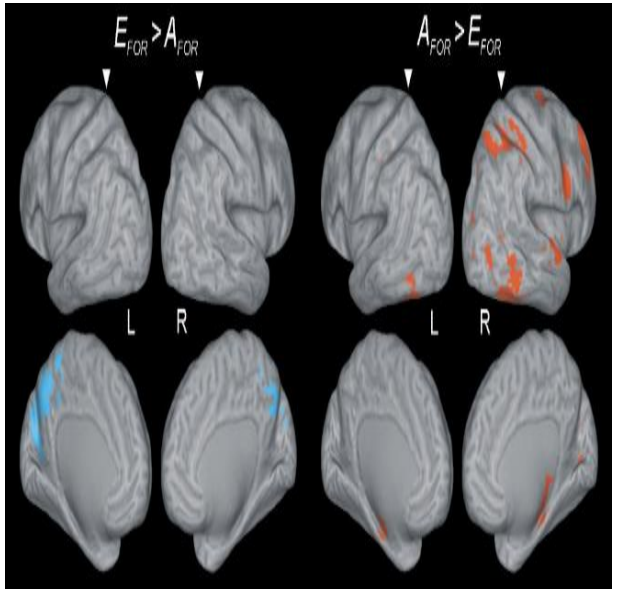
<u>Egocentric knowledge</u>:
depends on our body own position
the pink door is located at the right side of the wall



Allocentric:
object to object coding
Allocentric knowledge (i.e., map learning)



Differential brain activation observed for the comparison between allocentric and egocentric coding in space



Stronger involvement of the bilateral <u>hippocampi</u> during allocentric spatial processing (Zaehle, et. al., 2007)

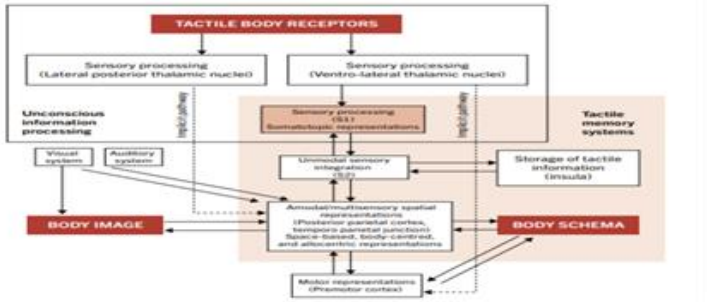
Egocentric:
body to object coding
Egocentric knowledge (i.e., route learning)

- Which spatial frame of reference would a person with congenital deafblindness use when navigating in the environment?

- A person with congenital deaf blindness often uses an egocentric spatial frame of reference (self to object) through the bodily-tactile modality to raise awareness of their body positioning in space and navigate through the environment

Due to the impact of Vision Loss on Spatial Coding, children with blindness may remain anchored to an egocentric reference frame during navigation (Martolini et. al., 2020)

Bodily-tactile perception



Body representations

Distinct brain regions supporting body schema and body (Gallace & Spence, 2010).

Body schema

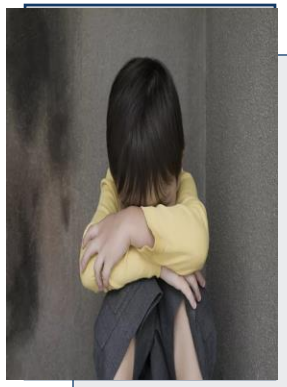
Being aware of one owns bodily-tactile acts and the sense of knowing the body`s relative position in space (proprioception)

Body image

conscious perception of one's appearance and it is closely related to the mental picture a person gets when they imagine what they look like.

Conditions associated with reduced body schema

Impairments of proprioception in patients with Parkinson's Disease



Reduced proprioception and bodily regulation in children with developmental trauma

Poor Proprioception and "atypical" body positioning in CHARGE syndrome

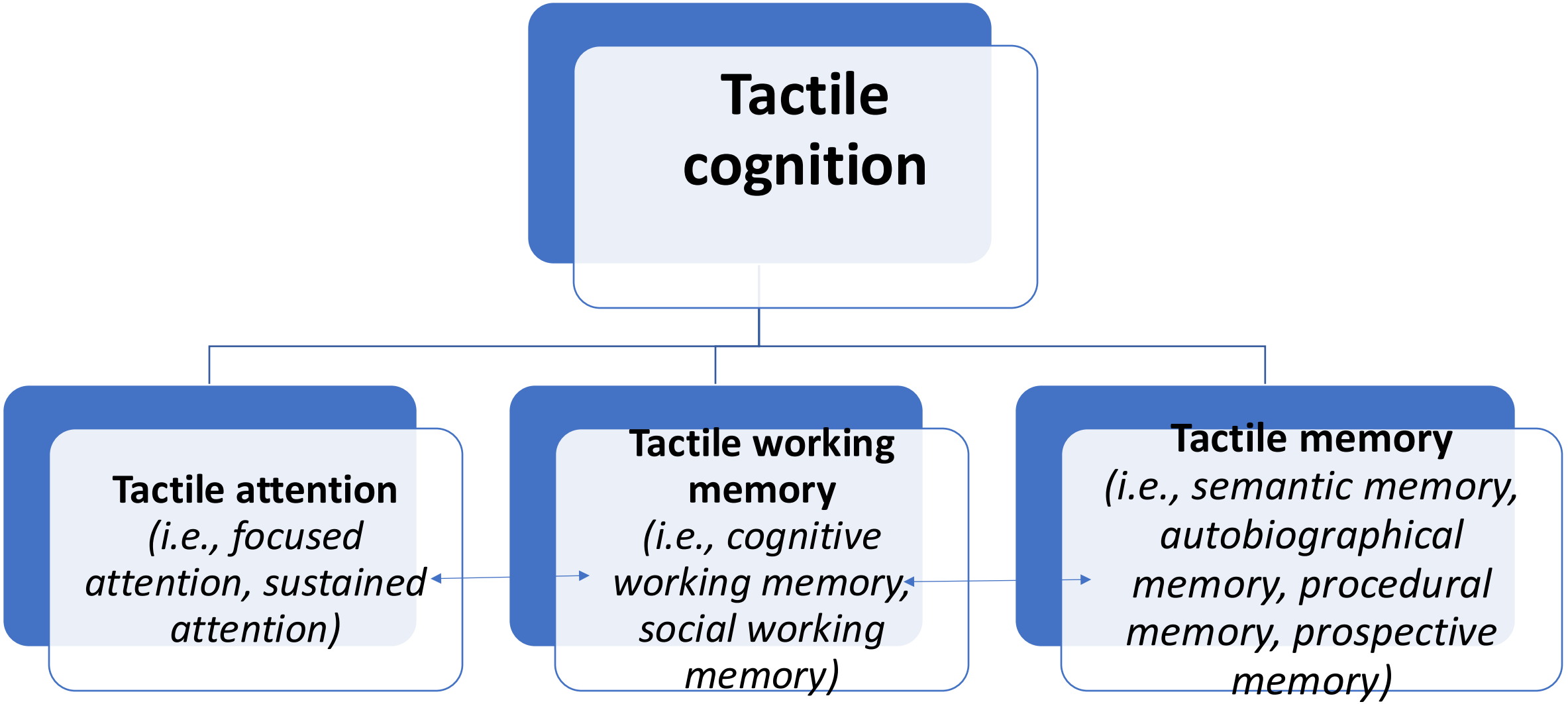
Poor awareness of proprioception n people with acquired deafblindness

Understanding Body Image change

- A distorted or negative body image affects Mental Health
(from poor self-esteem to risks for developing an anxiety disorder)

Bodily-tactile cognition

integration and interpretation of tactile sensory-perceptual information



Semantic memory: knowledge-based memory

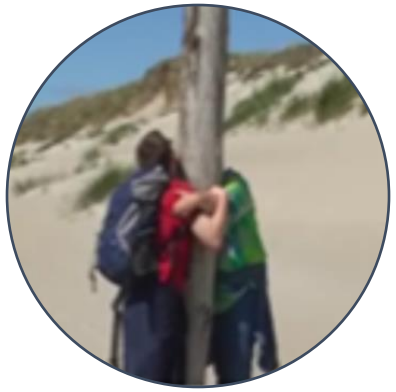
- The ability to recognize something by grasping it generates memories that are far more complex and long-lasting than previously thought (Hutmacher, 2019)

Association processes for forming semantic memory

168 Objects (10 s per Object)

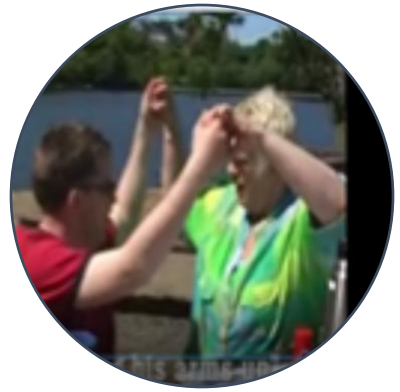
Participants could remember the correct objects (168 household objects) 94 percent of just after the study period and 85 percent a week later.

Autobiograghical memory: event-specific knowledge related to past personal experiences



Constructive process: memory representations formed by sensory-perceptual details (i.e., tactual details) to form narrative format

Co-constructive process: engaging in a memory conversation (i.e., bodily tactile modality) during and immediately after the event (autobiographical memory conversation)

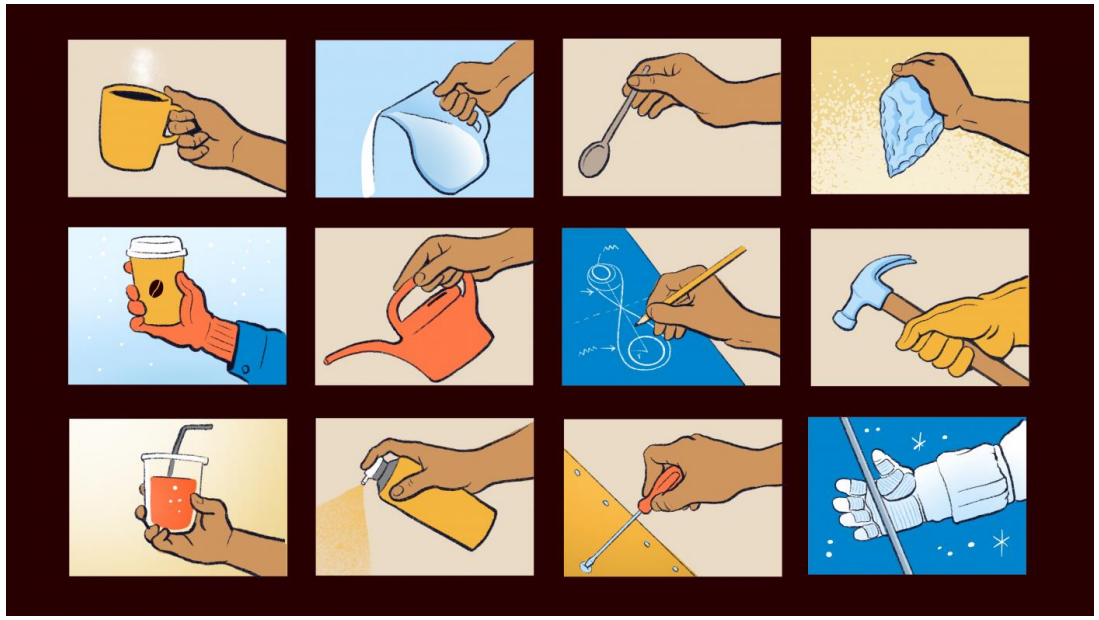


Reconstructive process: sharing the memory narratives of the event (i.e., bodily tactile modality) by joint reminiscing

Three cognitive -narrative processes for forming autobiographical memory

Procedural memory: movement memory

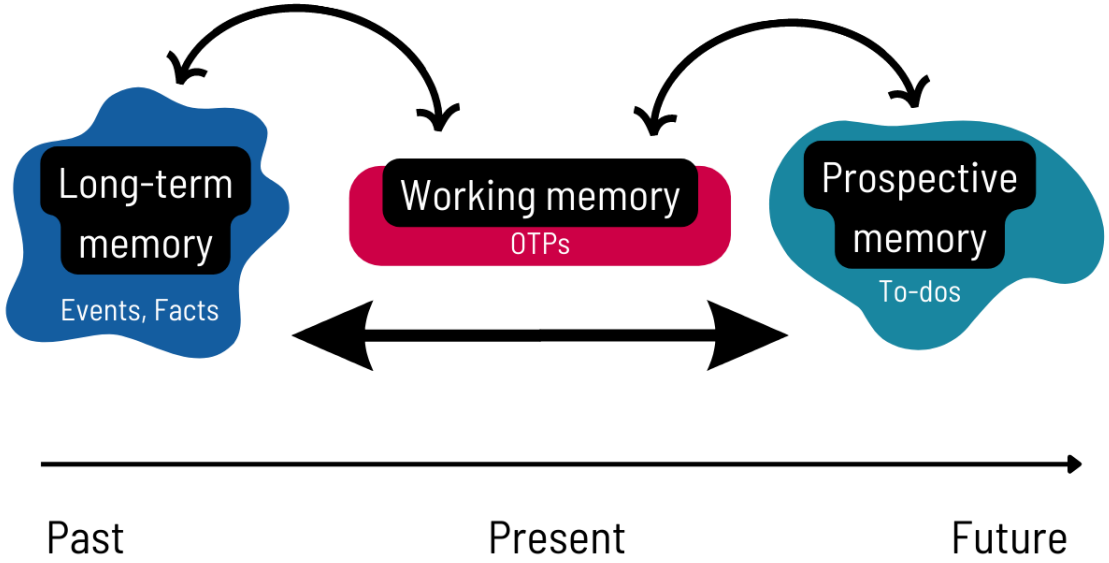
- The brain maintains a repertoire of motor memories, **each associated with the context in which it was created,** such as playing squash versus tennis.
- Even for a single swing of the racket, the brain can draw upon many memories, each in proportion to how much **the brain processes it is currently in the context in which that memory was created** (Heald, et. al., 2021); Bekke, et. al., 2022)



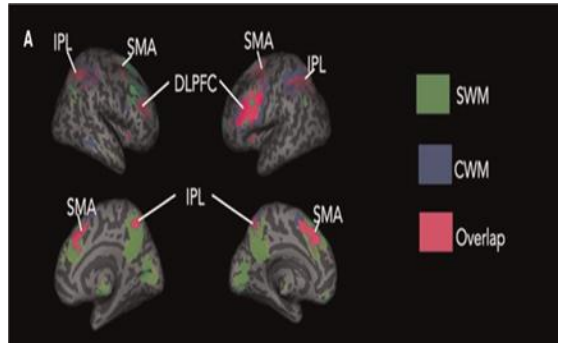
Context is key for learning and remembering motor skills

Prospective memory: memory for actions

- Remembering to perform a planned action at some future point in time is critical to everyday life.
- Prospective memory performance across childhood is strongly linked to Working Memory (Cottini, 2023).



Working Memory



Cognitive working memory:
keeping in mind and using task-relevant information during problem-solving: <u>involved in executive functions</u>

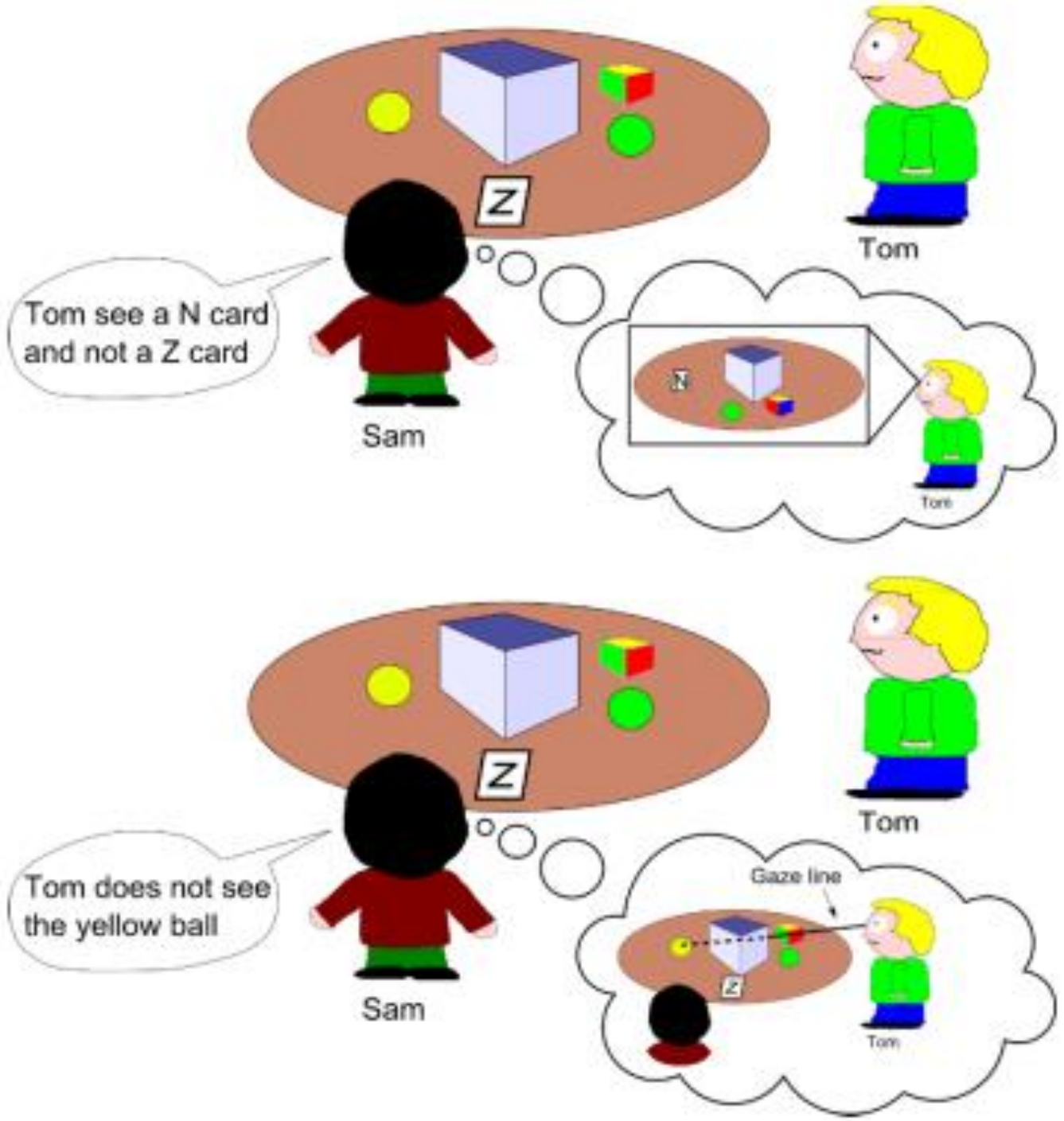
Social working memory:
keeping in mind what has occurred in the immediate past and then integrate this social information in order to achieve a cohesive understanding of the present: <u>involved in social cognitions</u>

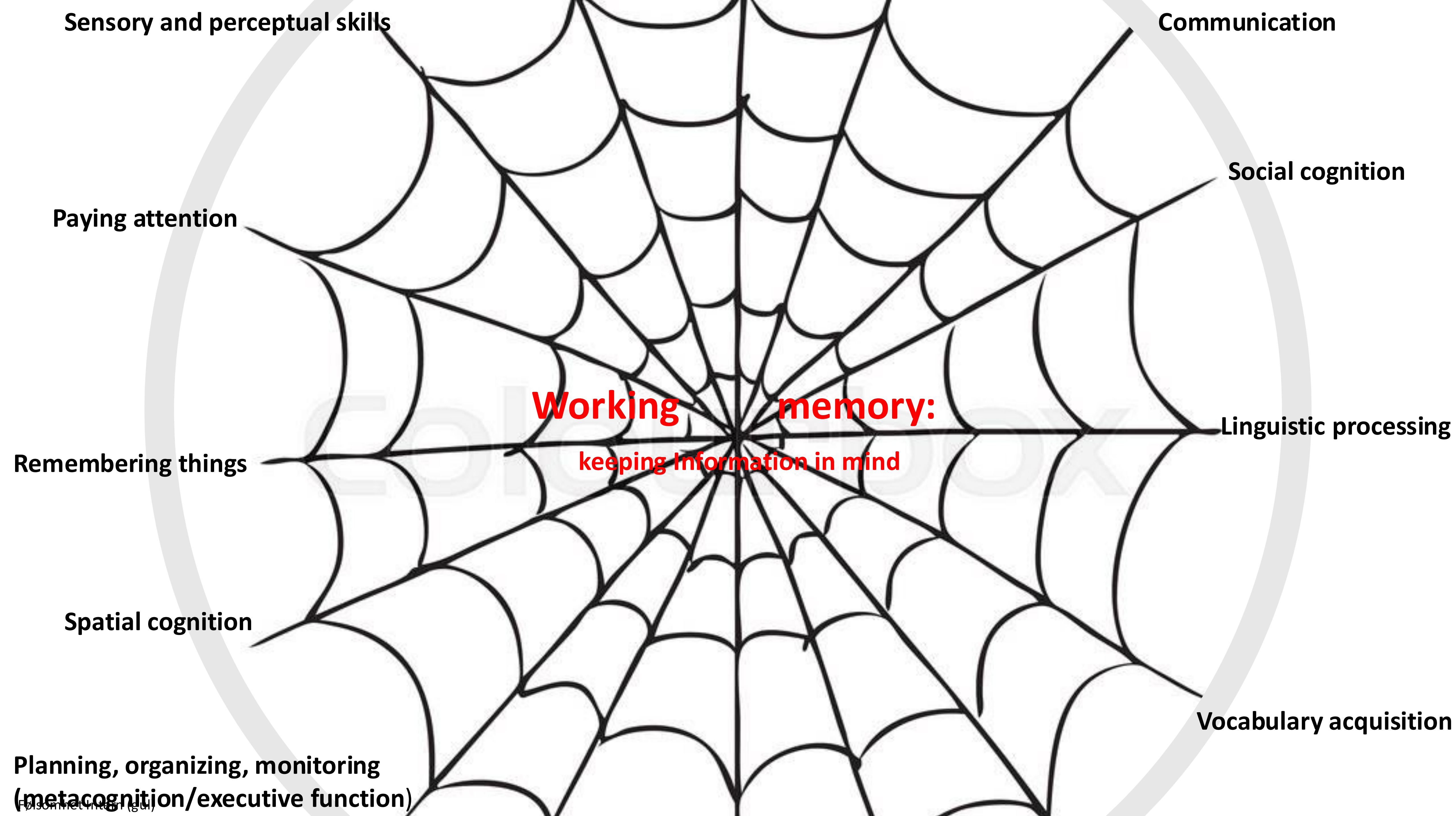
(Meyer, Taylor & Lieberman, 2015)

Social Working memory is involved in perspective taking

(understanding a situation from another person's point of view)

Social Working Memory Training Improves Perspective-Taking Accuracy (Meyer & Lieberman, 2016)





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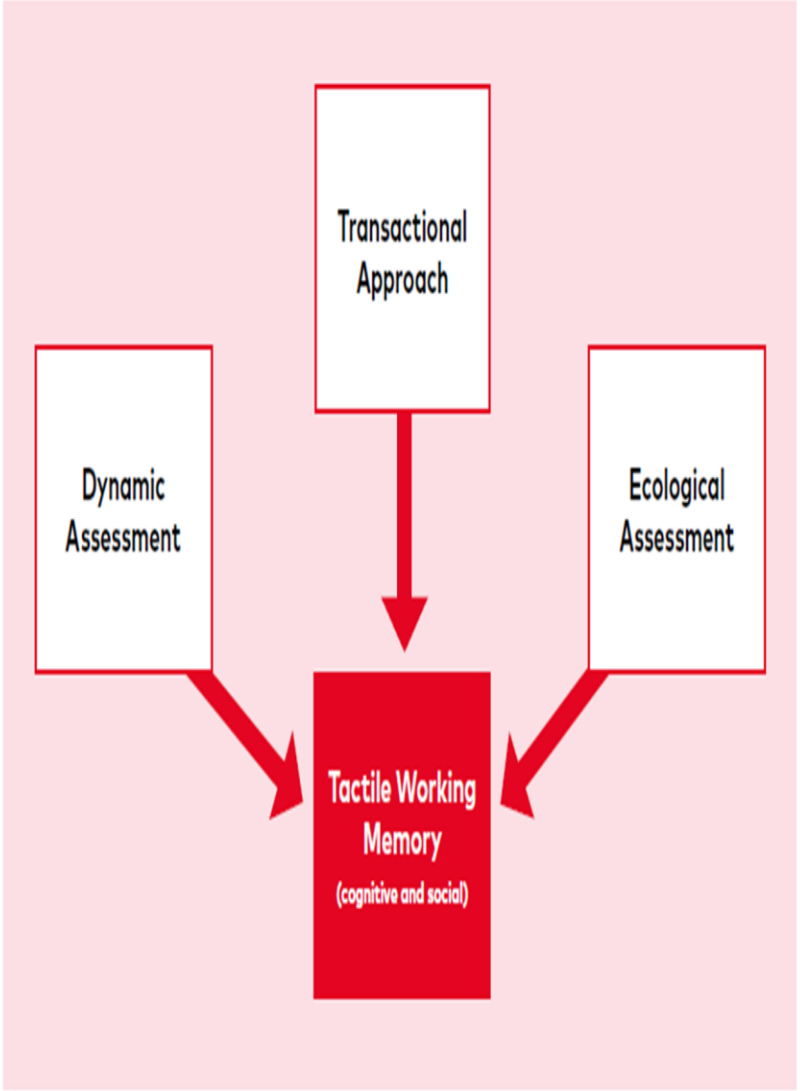
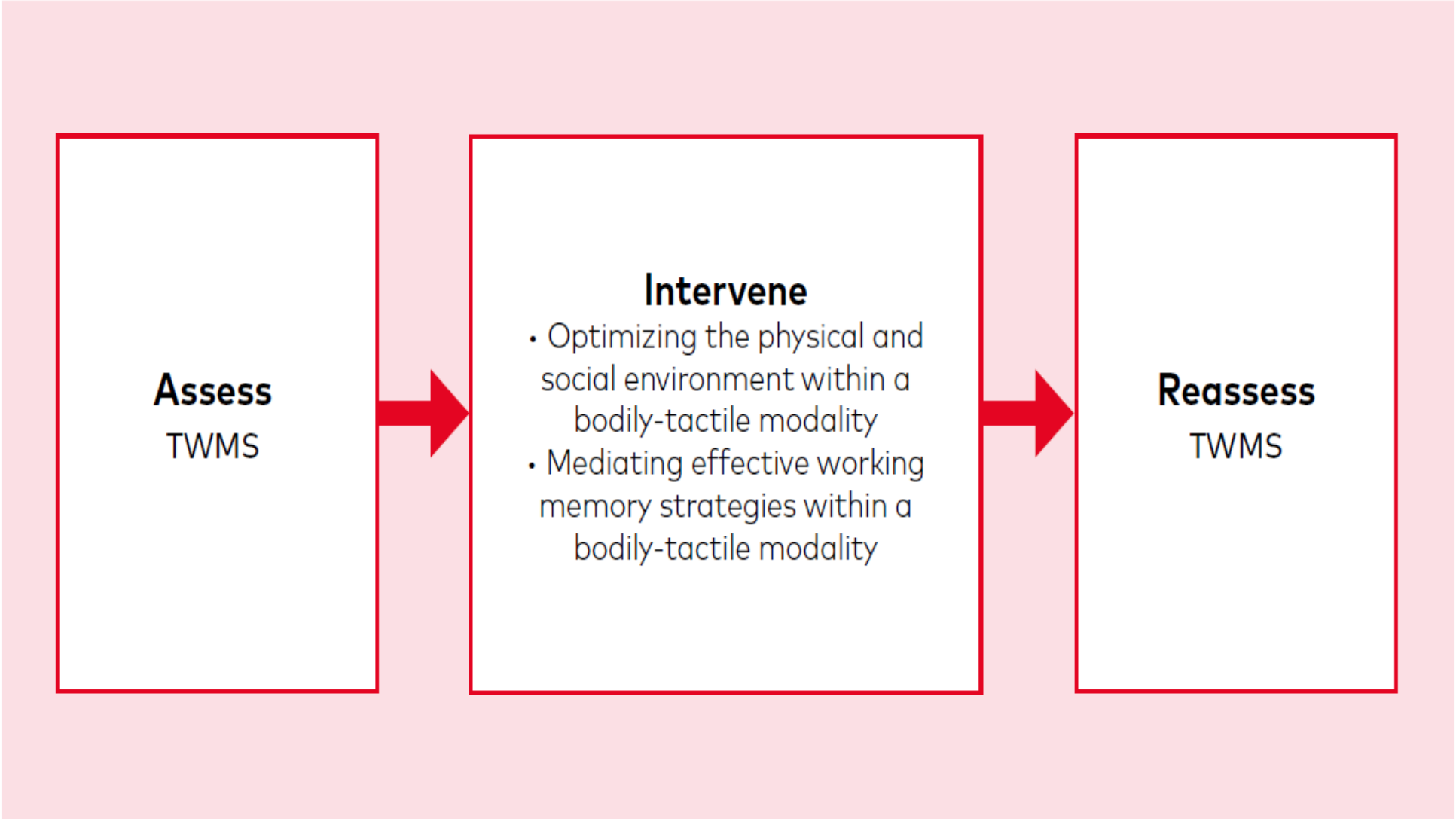
- Recognizing tactual environments and providing opportunities for tactile exploration **(ecological):** *repeated, real-time assessments of tactile working memory behaviors over a period of time in naturalistic settings (i.e., the competencies of person)*
- Focusing on the bidirectional and reciprocal exchanges between the person and interaction partner over time **(transactional):** *recognizing, affirming, and confirming the bodily-tactile expressions/acts of the person (i.e., the competencies of the partner)*
- Integrating intervention into assessment and to support the individual to successfully perform **(dynamic):** *strength/asset (not deficit)-based assessment (i.e., mediating appropriate tactile learning strategies on an individual basis)*

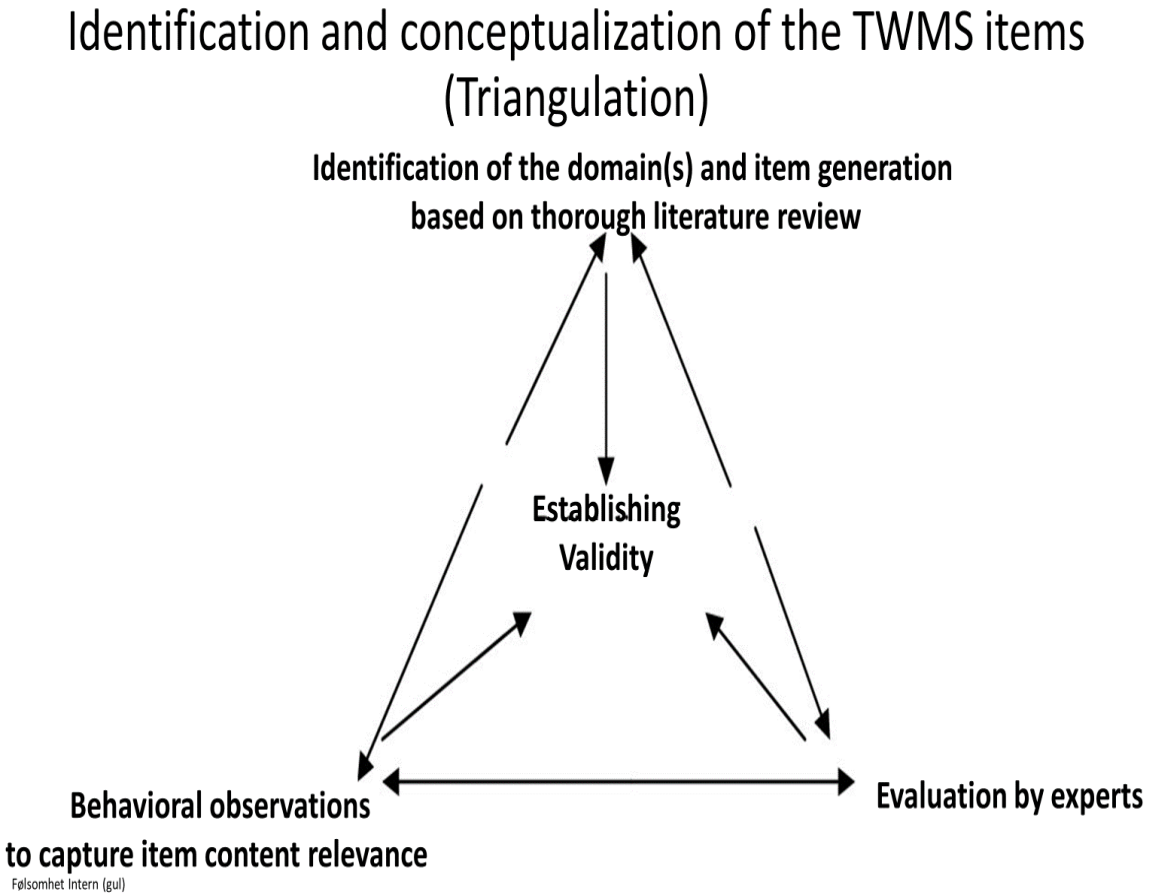




Integrating intervention into assessment for the purpose to identify working memory potentials

Methodology

- Initially, the TWMS was validated through a triangulation method, and currently an ongoing research study is aiming to further improve the reliability and accuracy of the tool: n= 25 (Smits, et. al., ongoing research project)



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Tactile Working Memory Scale (TWMS)

A behavioral observation scale for identifying bodily-tactile working memory in everyday occurrences and during social interaction.

Jude T. Nicholas, Annika M. Johannessen and Trees van Nunen

Instructions

On the following pages is a list of 20 items with examples of behavioral cues that describe the processes of working memory in the bodily-tactile modality. Examples are provided for the items to add clarity. The given examples are illustrative and not exhaustive.

The TWMS professional manual also illustrates descriptions of the 20 items and demonstrates several examples of perceptual, cognitive, and social cognitive strategies that may enhance bodily-tactile working memory. Please read **Tactile Working Memory Scale - A Professional Manual** manual before using the scale.

The items within the scale could be rated through direct or video observation. The TWMS must be administered by an examiner who has good observational skills and a knowledge of the person's repertoire of behaviors. Most valid results are obtained if several individuals who have close contact with the person (teachers, support teachers, parents, specialists) evaluate the person on a collaborative basis. The examiner may use the space provided under "comments" for observational notes.

Read each item carefully and draw a circle around your response for each example.

Draw a circle around:

P **Present** – when you can clearly observe the behavioral cues relevant to the item.

E **Emergent** – when you can to a certain degree observe the behavioral cues relevant to the item: partially present.

A **Absent** – when you cannot observe any of the behavioral cues relevant to the item.

N/A **Not Applicable** – when an item doesn't apply in the current assessment context, due to relevant individual factors such as severe motor or physical limitation or other situational factors.

Before you begin rating the items, please fill in the information regarding general data.

General data

DATE OF ASSESSMENT: _____

NAME: _____

AGE: _____ GENDER: _____

Visual loss: ☐ None ☐ Mild ☐ Moderate ☐ Severe

Visual aid/optical devices/other _____

Hearing loss: ☐ None ☐ Mild ☐ Moderate ☐ Severe

Hearing aid/cochlear implant/other _____

Displays signs of tactile defensiveness ☐ Yes ☐ No
(Negative reaction to touch: objects to being touched by others; avoids using hands; avoids touching objects)

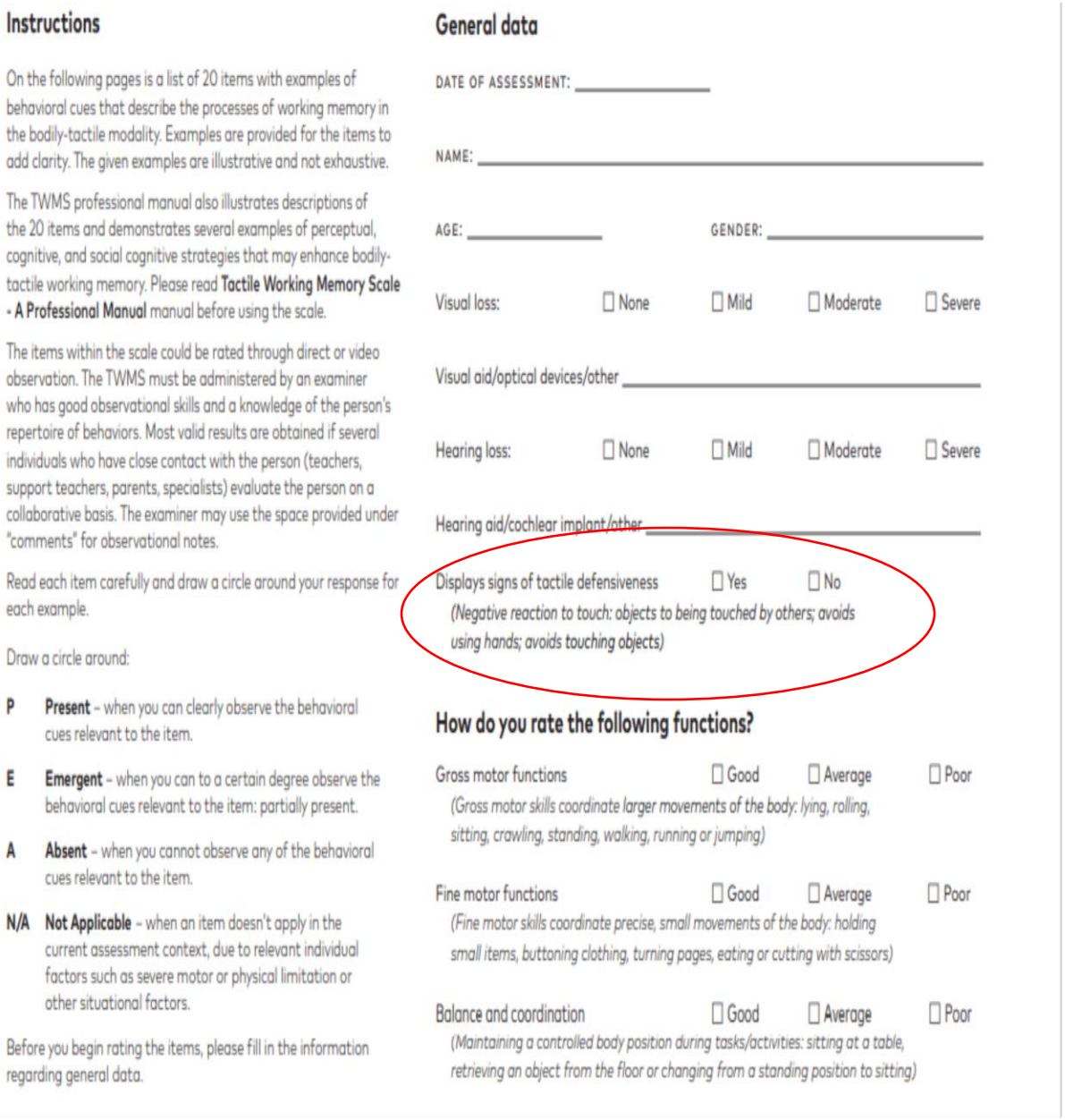
How do you rate the following functions?

Gross motor functions ☐ Good ☐ Average ☐ Poor
(Gross motor skills coordinate larger movements of the body: lying, rolling, sitting, crawling, standing, walking, running or jumping)

Fine motor functions ☐ Good ☐ Average ☐ Poor
(Fine motor skills coordinate precise, small movements of the body: holding small items, buttoning clothing, turning pages, eating or cutting with scissors)

Balance and coordination ☐ Good ☐ Average ☐ Poor
(Maintaining a controlled body position during tasks/activities: sitting at a table, retrieving an object from the floor or changing from a standing position to sitting)

Response choices	Response choices
Present (P)	when you can clearly observe the behavioral cues relevant to the item
Emergent (E)	when you can to a certain degree observe the behavioral cues relevant to the item: partially present
Absent (A)	when you cannot observe any of the behavioral cues relevant to the item
Not Applicable (N/A)	when an item doesn't apply in the current situation, due to relevant individual factors such as severe motor or physical limitation or other situational factors



Instructions

On the following pages is a list of 20 items with examples of behavioral cues that describe the processes of working memory in the bodily-tactile modality. Examples are provided for the items to add clarity. The given examples are illustrative and not exhaustive.

The TWMS professional manual also illustrates descriptions of the 20 items and demonstrates several examples of perceptual, cognitive, and social cognitive strategies that may enhance bodily-tactile working memory. Please read **Tactile Working Memory Scale - A Professional Manual** manual before using the scale.

The items within the scale could be rated through direct or video observation. The TWMS must be administered by an examiner who has good observational skills and a knowledge of the person's repertoire of behaviors. Most valid results are obtained if several individuals who have close contact with the person (teachers, support teachers, parents, specialists) evaluate the person on a collaborative basis. The examiner may use the space provided under "comments" for observational notes.

Read each item carefully and draw a circle around your response for each example.

Draw a circle around:

P **Present** – when you can clearly observe the behavioral cues relevant to the item.

E **Emergent** – when you can to a certain degree observe the behavioral cues relevant to the item: partially present.

A **Absent** – when you cannot observe any of the behavioral cues relevant to the item.

N/A **Not Applicable** – when an item doesn't apply in the current assessment context, due to relevant individual factors such as severe motor or physical limitation or other situational factors.

Before you begin rating the items, please fill in the information regarding general data.

General data

DATE OF ASSESSMENT: _____

NAME: _____

AGE: _____ GENDER: _____

Visual loss: ☐ None ☐ Mild ☐ Moderate ☐ Severe

Visual aid/optical devices/other _____

Hearing loss: ☐ None ☐ Mild ☐ Moderate ☐ Severe

Hearing aid/cochlear implant/other _____

Displays signs of tactile defensiveness ☐ Yes ☐ No
(Negative reaction to touch: objects to being touched by others; avoids using hands; avoids touching objects)

How do you rate the following functions?

Gross motor functions ☐ Good ☐ Average ☐ Poor
(Gross motor skills coordinate larger movements of the body: lying, rolling, sitting, crawling, standing, walking, running or jumping)

Fine motor functions ☐ Good ☐ Average ☐ Poor
(Fine motor skills coordinate precise, small movements of the body: holding small items, buttoning clothing, turning pages, eating or cutting with scissors)

Balance and coordination ☐ Good ☐ Average ☐ Poor
(Maintaining a controlled body position during tasks/activities: sitting at a table, retrieving an object from the floor or changing from a standing position to sitting)

- **Tactile defensiveness** is term used to describe the reaction that occurs when someone is generally very sensitive to touch (i.e., negative reaction to touch, object of being touched by others)
- **Tactile selectiveness** is a term used to describe the reaction when someone has a decreased variety in their touch behavior (i.e., preferring or avoiding certain objects or substances)

20 items within 3 theoretically derived domains that measure the cognitive and social cognitive processes of tactile working memory, during tasks/activities & social interactions:

ENCODING

(detection and initial interpretation)

MAINTAINING

(temporarily retaining)

MANIPULATING

(actively controlling /retrieval of stored information)

- The 20 items of the scale are abstract and theoretical but have been observed in practice.

Fougnie, (2008)

DOMAINS	Encode						Maintain							Manipulate						
Present (P)																				
Emergent (E)																				
Absent (A)																				
N/A																				
Items	1	2	3	5	6	8	4	7	10	11	12	15	16	9	13	14	17	18	19	20
BEHAVIORAL DESCRIPTIONS	Tactile focused attention	Object manipulation (ventral stream function)	Tactile object identification (ventral stream function)	Tactile object location (dorsal stream function)	Spatial navigation (dorsal stream function)	Social Working Memory: person oriented	Tactile object recognition (ventral stream function)	Tactile spatial recognition (dorsal stream function)	Social Working Memory: mutual & joint attention	Social Working Memory: retaining social info	Tactile sustained attention	Sustained attention: interaction-time	Selective attention: interaction-novel condition	Social Working Memory: emotion-perception	Tactile selective attention	Attentional switching	Attentional switching: interaction-topic change	Attention manipulation: long-term working memory strate-gies	Attention manipulation: maintenance cognitive strategies	Attention manipulation: metacognitive strategies

Items	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Perceptual	*	*	*	*	*	*	*													
Social								*	*	*	*				*	*	*			
Cognitive												*	*	*				*	*	*
Dorsal stream					*	*	*													
Ventral stream		*	*	*																
Body awareness						*	*													
Prolonged time												*			*					

a) About working memory

b) TWMS: Theoretical framework

c) TWMS: Assessment principles

d) TWMS: Aseesment scale

e) **TWMS: learning strategies**

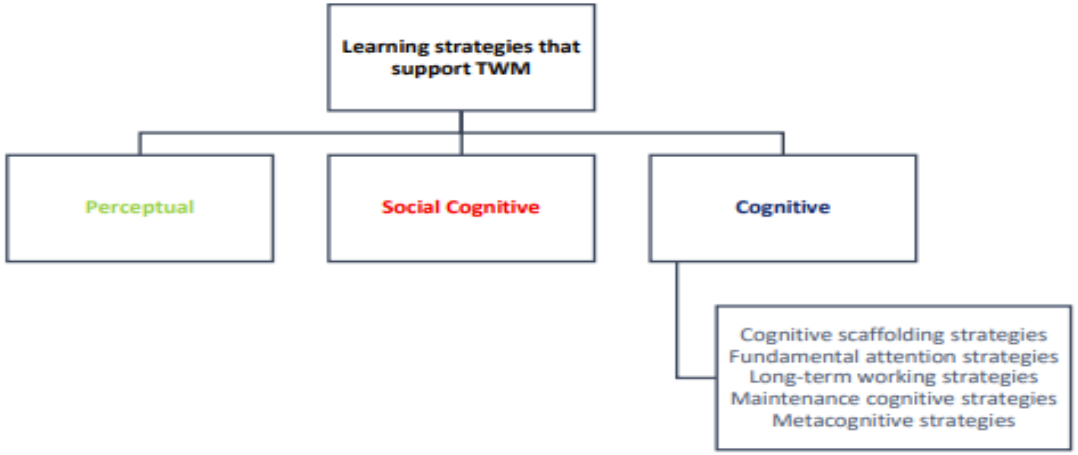
f) Brief summary

Learning Strategies in the TWMS assessment

- Learning strategies are targeted bodily-tactile processes which are first applied **intentionally** (i.e., mediated by the teacher/partner) and then gradually **internalized,** thus supporting the learner’s tactile working memory.

A checklist of learning strategies that support Tactile Working Memory (TWM)

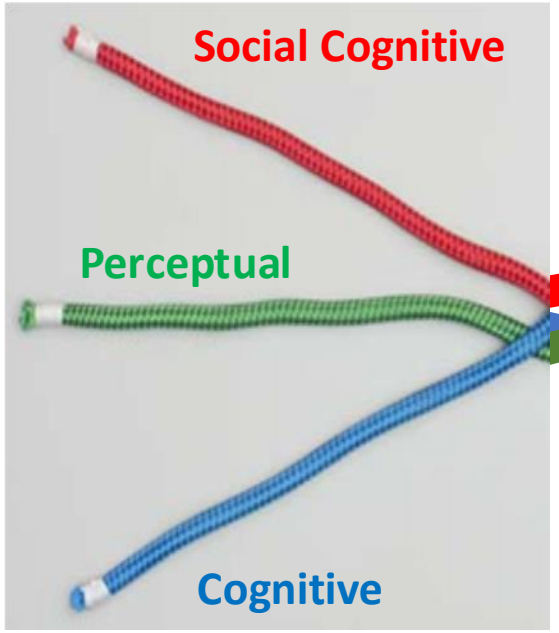
A checklist of the three major groups of learning strategies (perceptual, social cognitive, cognitive), including the distinct categories of the cognitive strategies (cognitive scaffolding strategies, fundamental attention strategies, long-term working strategies, maintenance cognitive strategies, metacognitive strategies). See figure below. The checklist is compiled by Nicholas, J (2022) and provides an overview of the different learning strategies with descriptions, and examples. The given examples are illustrative and not exhaustive.



The checklist also distinguishes between the different types of strategies namely, general strategies (G) and item specific strategies (I). General strategies are strategies that are necessary to optimize the physical and social environment within a bodily-tactile modality. Item specific strategies on the other hand, refer to TWMS item specific strategies that are mediated within a bodily-tactile modality.

Nicholas, J. T., (2022). Tactile working memory scale: a professional manual [Supplementary material 2, A checklist of learning strategies that support Tactile Working Memory] Sweden: Nordic Welfare Centre

The three major groups



General strategies (G)
Item specific strategies (I)

Increasingly internalized
(self-regulates)

Tactile
Working
Memory

Increasingly systematized
(transfers)

Near transfer
transfer of knowledge
between similar
learning contexts/situations

Far transfer
transfer of knowledge between
dissimilar, novel or complex
learning contexts/situations

Cognitive potential: transfers or generalizes to similar learning situations/contexts

Perceptual strategies:

sensory-perceptual strategies that enhance tactile perceptual learning (pp. 2-5)

- Adapting the learning environment within a bodily-tactile modality (G) p2
- Strategies to identify similarities or differences among objects (I 3) p3

I 3 Uses active touch and motion to identify similarities or differences among objects.
The interaction partner provides opportunities and supports the person to sequentially touch and compare things that are similar and contrast things that are different (tactual matching/differentiating)
• guiding the person to tactually match similar shaped or textured objects (i.e., sorting materials based on their tactual similarities) • guiding the person to tactually discriminate between different shaped or textured objects (i.e., sorting materials based on their tactual differences)

Social cognitive strategies:

strategies for managing demands to social cognition and improving social working memory skills pp 6-8

- Providing a social scaffolding format within the bodily-tactile modality (G) p6
- Supporting social forms of attention (i.e., mutual attention, joint attention) in a bodily-tactile manner (I 10) p8

I 10 Uses active touch and motion to explore an object together with the interaction partner while displaying behaviors of social attention
The interaction partner detects and follows the person`s social forms of attention in a bodily-tactile manner, during social interactions

- sharing attention to each other or to a shared activity in a bodily-tactile manner (i.e., touching the same thing at the same time)
- mirroring the movements and actions (goal-related intentional activity) of the person in a bodily-tactile and aligned manner
- drawing the person's attention towards the action of an another in a bodily-tactile manner (i.e., to what the partner is doing now/ partner's intentional activity)

Cognitive strategies:

mental strategies that involve attention, organization, retention, and deliberate manipulation of information to improve learning pp 9-14

- Cognitive scaffolding strategies (G) p 9
- Fundamental attention strategies that enhance attentional skills p 9

<u>Long-term working memory strategies:</u>

- Categorization strategy (1 18) p 10
- *Semantic Association strategy* (I 18) p 10
- *Sequential Chunking strategy* (I 18) p 10
- Retrieval cue strategy (1 18) p 10
- Narrative memory strategy (I 18) p 11
- Method of loci strategy (I 18) p 12

<u>Maintenance cognitive strategies:</u>

- *Tactile Spatial Rehearsal strategy* (I 19) p 13
- Cognitive weeding strategy/error handling strategy (I 19) p 13

<u>Metacognitive strategies:</u>

- Metacognitive conversation (I 20) p 14
- Prospective memory strategy (I 20) p 14

Sequential chunking strategy & Rehearsal strategy

- Introducing a **counting sequence** that helps the person to keep track with the “here and now” information and to relate to what comes next
- **ONE-TWO-THREE …PUSH the tree!**
- Guiding the person to systematically repeat the bodily-tactile counting sequence **(tactile-spatial rehearsal strategy)**
- Scaffolding the person with deafblindness to take initiatives to start the counting sequence himself

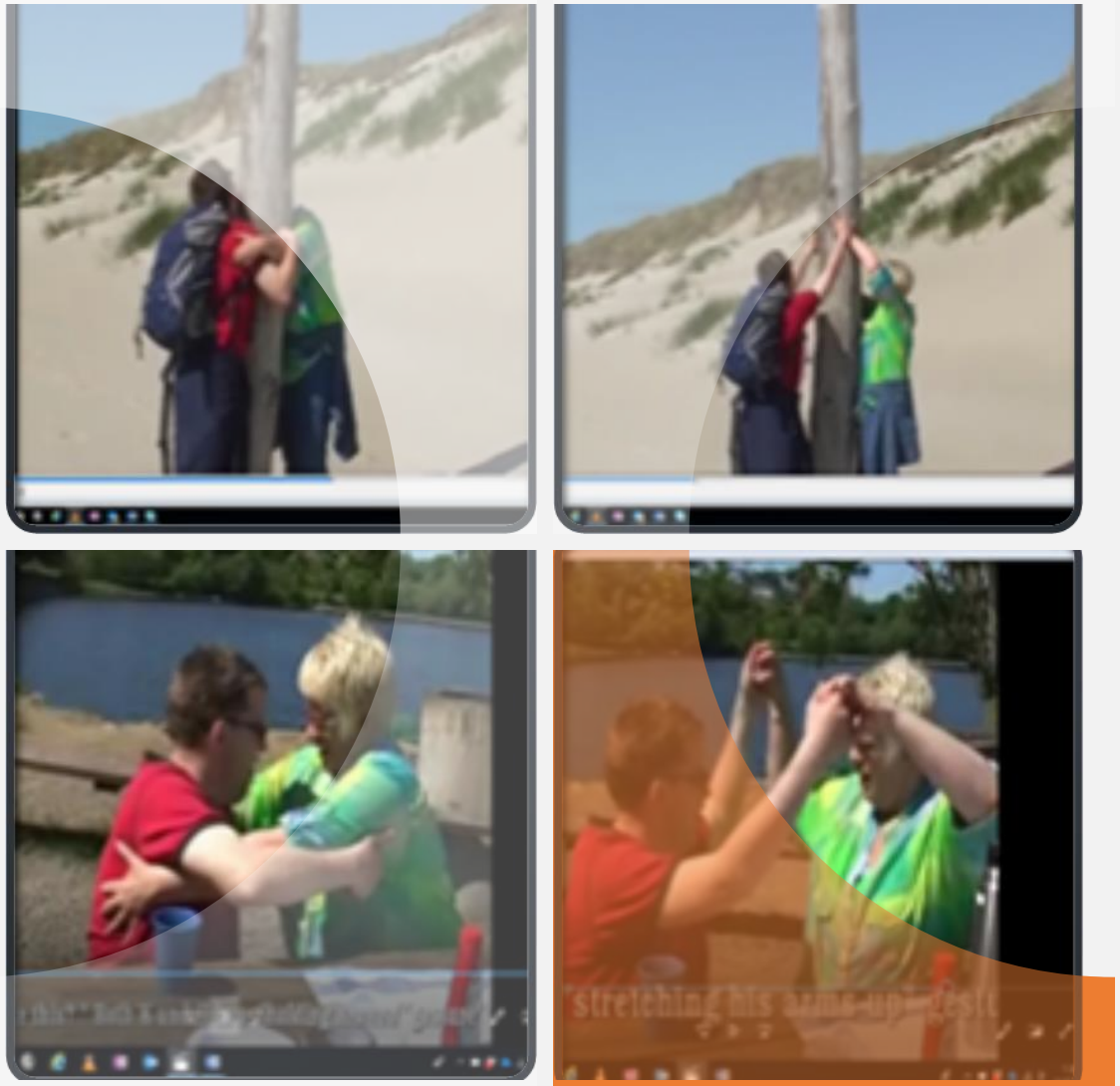
Two interaction partners are involved in a bodily-tactile activity with a person with deafblindness. The activity is about pushing and shaking a wet tree, while the rainwater falls on them.
The rainwater falls on the person with deafblindness making him feel wet and he is thrilled.

Narrative memory strategy

- helping formulate a personal memory of a shared event/activity in a narrative format, such as, **providing a thematic coherent script** (i.e., the story exploring a tree-trunk in bodily-tactile manner)

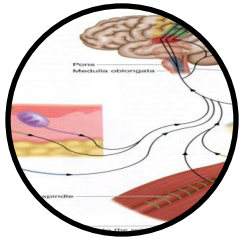
- engaging the person in a **memory dialogue** in **the bodily tactile modality,** during or immediately after the event/activity)

- providing opportunities for the person **to share the "personal narrative"** that provide material for conversation about a shared past event **(joint reminiscing)**



Exploring a tree-trunk in bodily-tactile manner

Helen Keller's awakening, when she made the connection between the word **Anne Sullivan** spelled into her hand **and** the tangible substance splashing from the water pump, flowing over one hand, **whispering** "wah-wah," **—her way of saying** "water."



Bodily-tactile sensation

Light touch
Pressure
Temperature
Pleasant touch

Bodily-tactile perception

Perception of wetness
Bodily Awareness

Bodily-tactile cognition

Word association
Semantic memory association
Procedural memory
Narrative memory

a) About working memory

b) TWMS: Theoretical framework

c) TWMS: Assessment principles

d) TWMS: Aseesment scale

e) TWMS: learning strategies

f) Brief summary

- Working memory in the bodily tactile modality is linked to various sensory-perceptual and cognitive functions and can be flexibly used to support a variety of tasks performed in daily life and in social contexts.
- Assessing TWM & Supporting TWM in people with deafblindness may help promote communication and language development, reveal cognitive potentials and improve social connection.