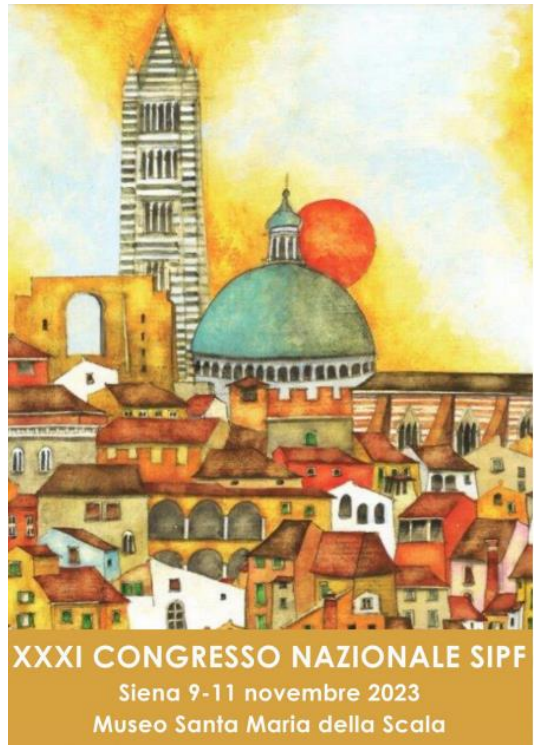
UNIVERSITÀ DI TORINO

MANIBUSLab

SIPF
Società Italiana di Psicofisiologia e Neuroscienze Cognitive

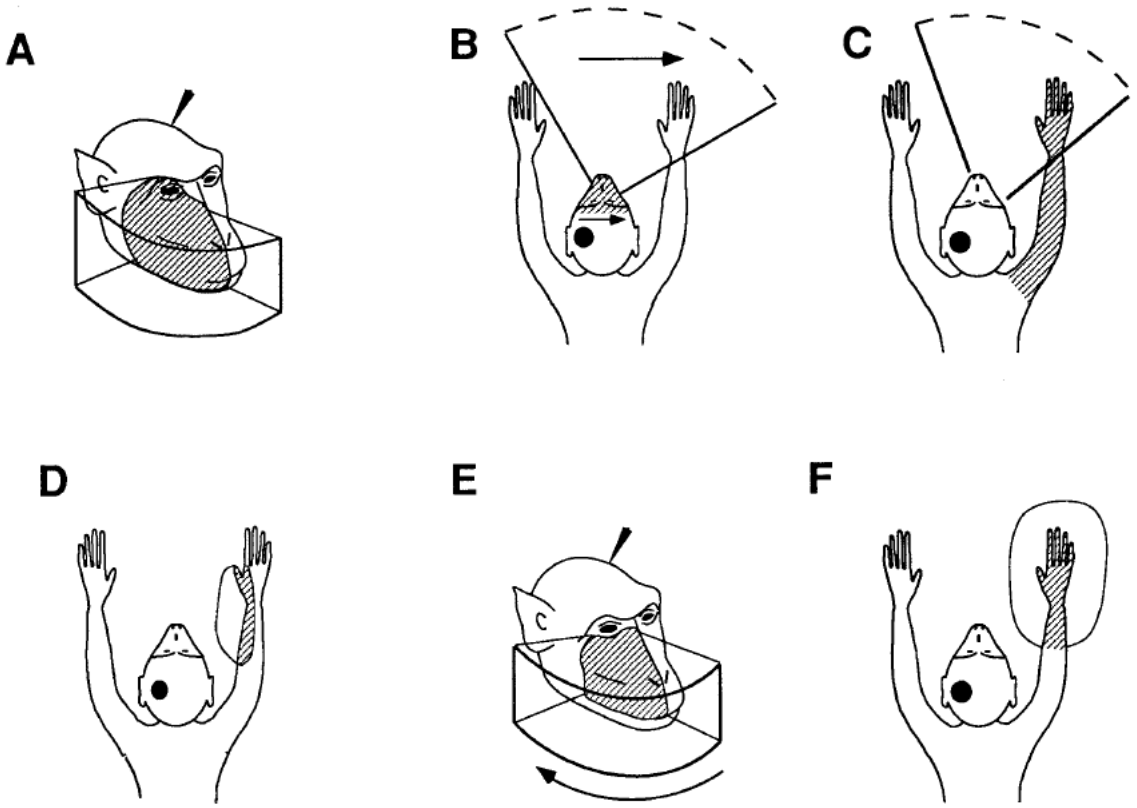
The role of motor context in multisensory integration development

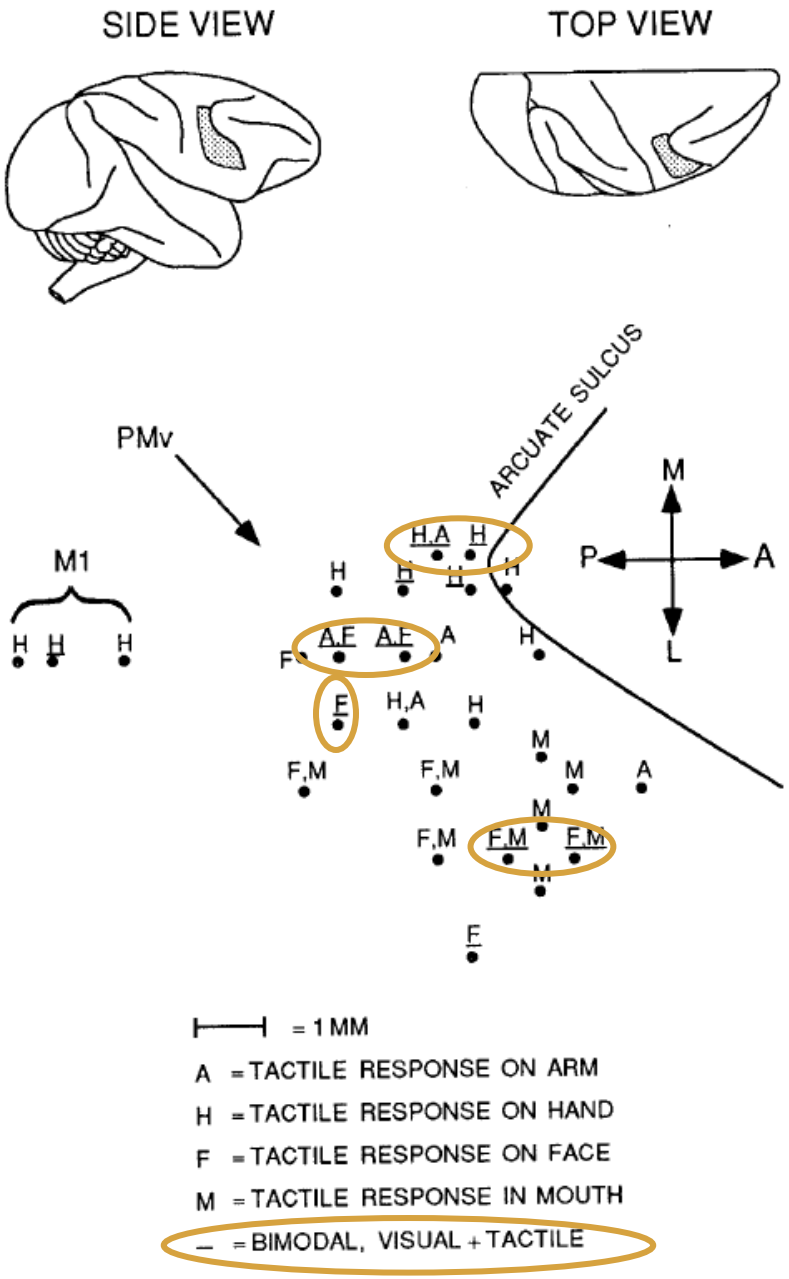
Valentina Bruno
valentina.bruno@unito.it



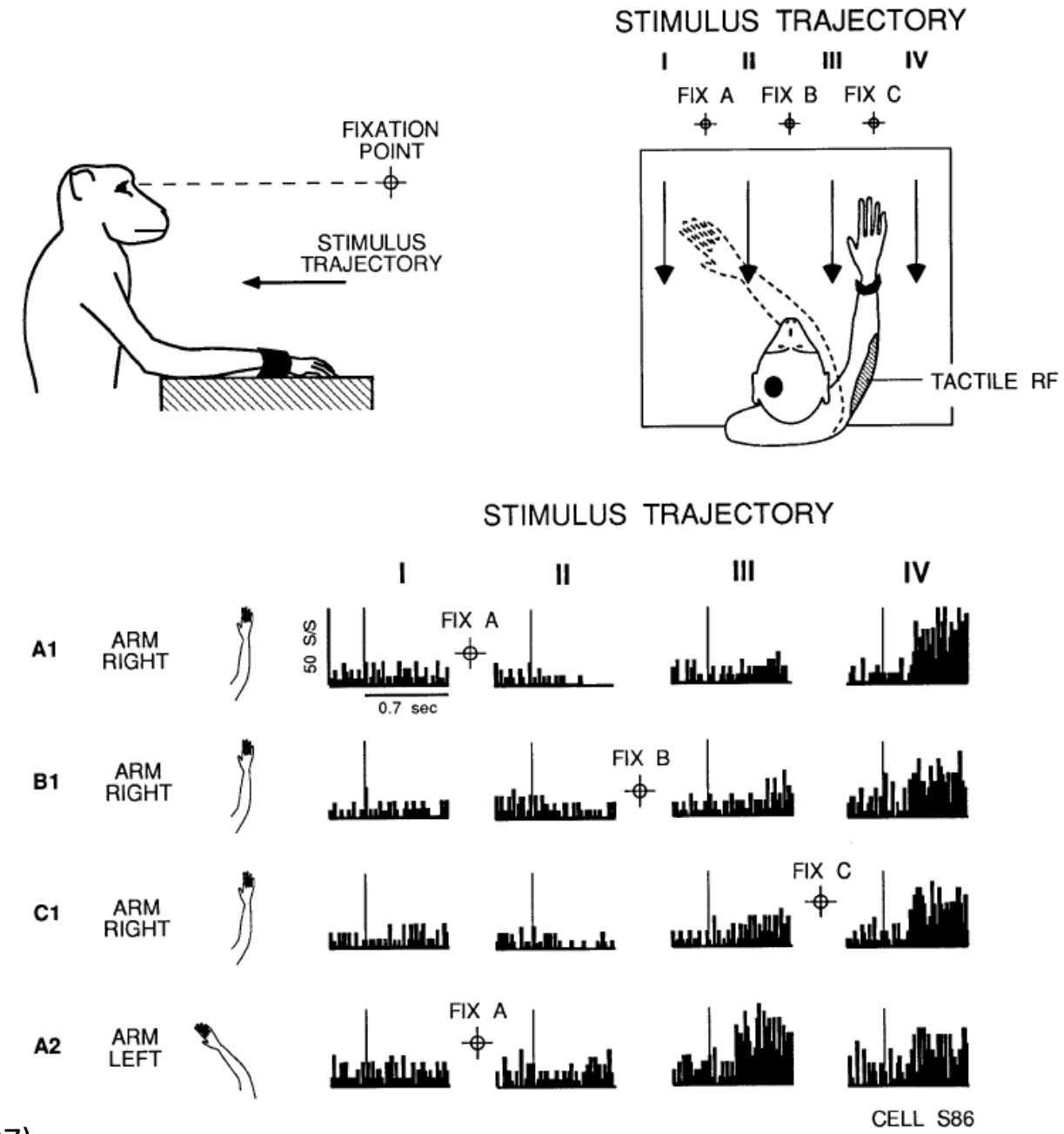
"Multisensory integration 40 years later: three outstanding topics on the table"
Symposium

Siena, 09/11/23





Graziano et al., *J. Neurophysiol. (*1997)
Fogassi et al. *J. Neurophysiol.* (1996)
Gentilucci et al. *Exp. Brain Res.* (1988)
Rizzolatti et al. *Behav. Brain Res.* (1981)



Bimodal neurons with a tactile response on the arm, the visual receptive field moved when the arm was moved

↓

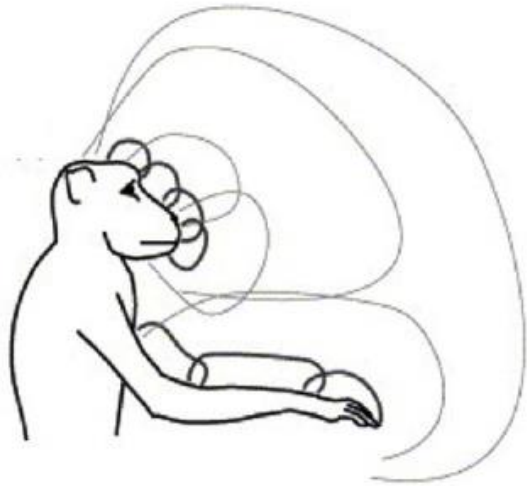
Visual receptive fields in vPMc **are anchored** to the **tactile** receptive field on the arm

↓

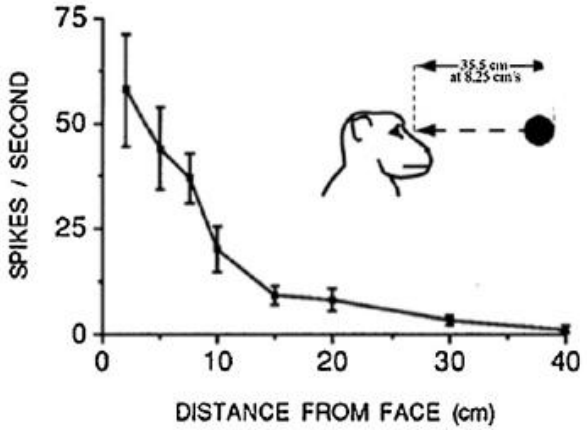
Upper-limb centred multisensory representation of space

Graziano et al., *J. Neurophysiol. (*1997)
Fogassi et al. *J. Neurophysiol.* (1996)

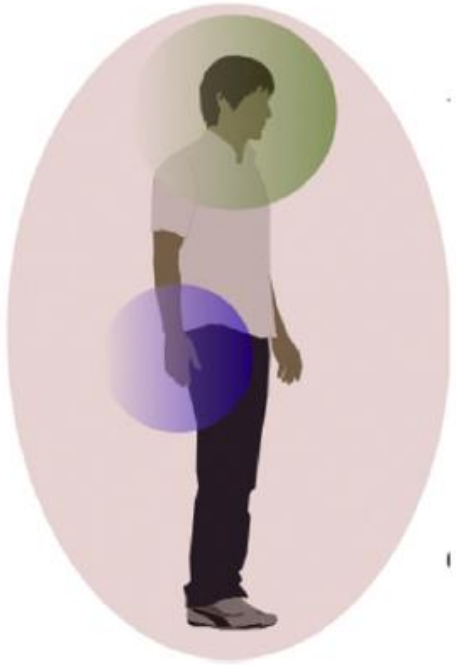
A



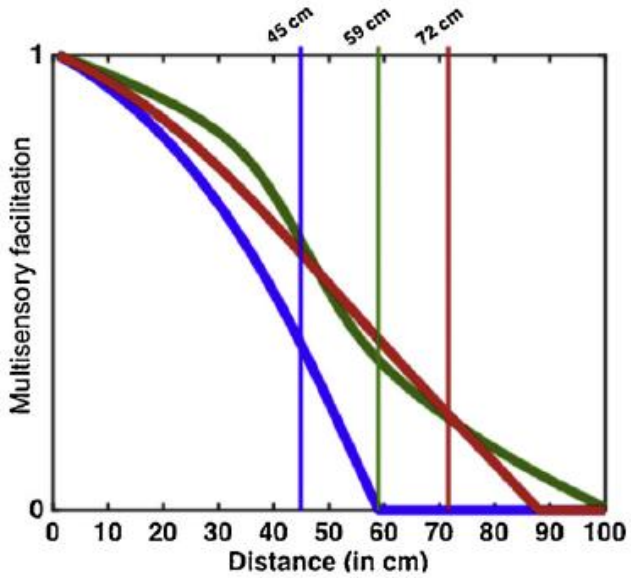
B



C



D



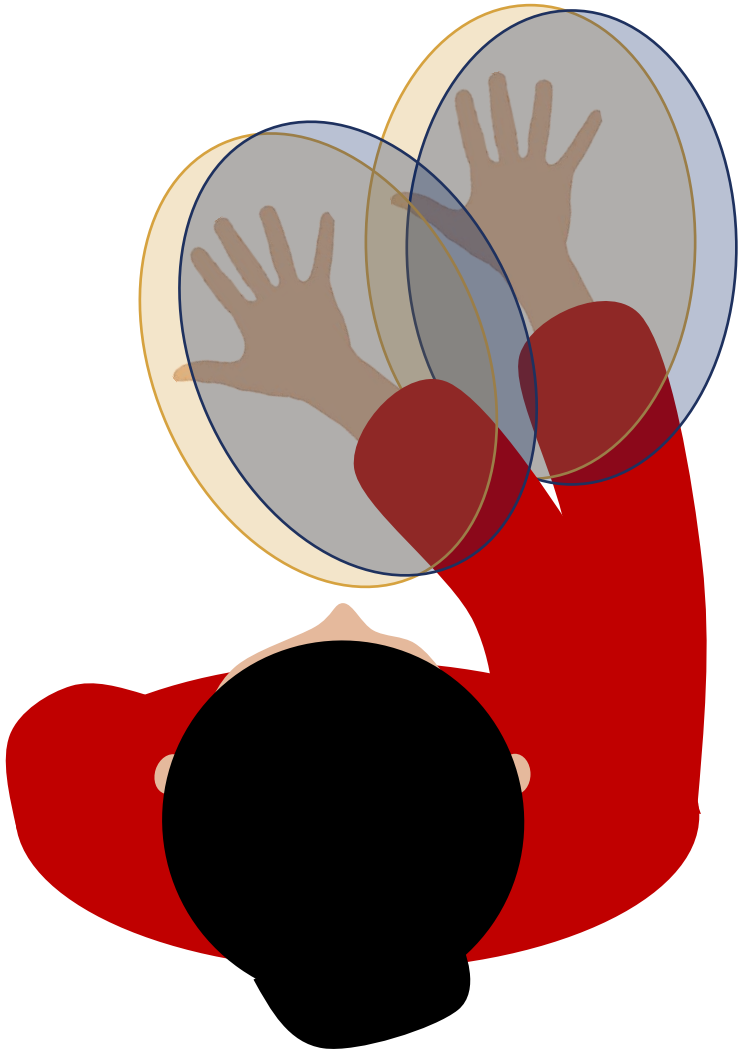
These neurons respond to and integrate only when information (visual or auditory) is located within a spatial range from the body

Peripersonal space (PPS)

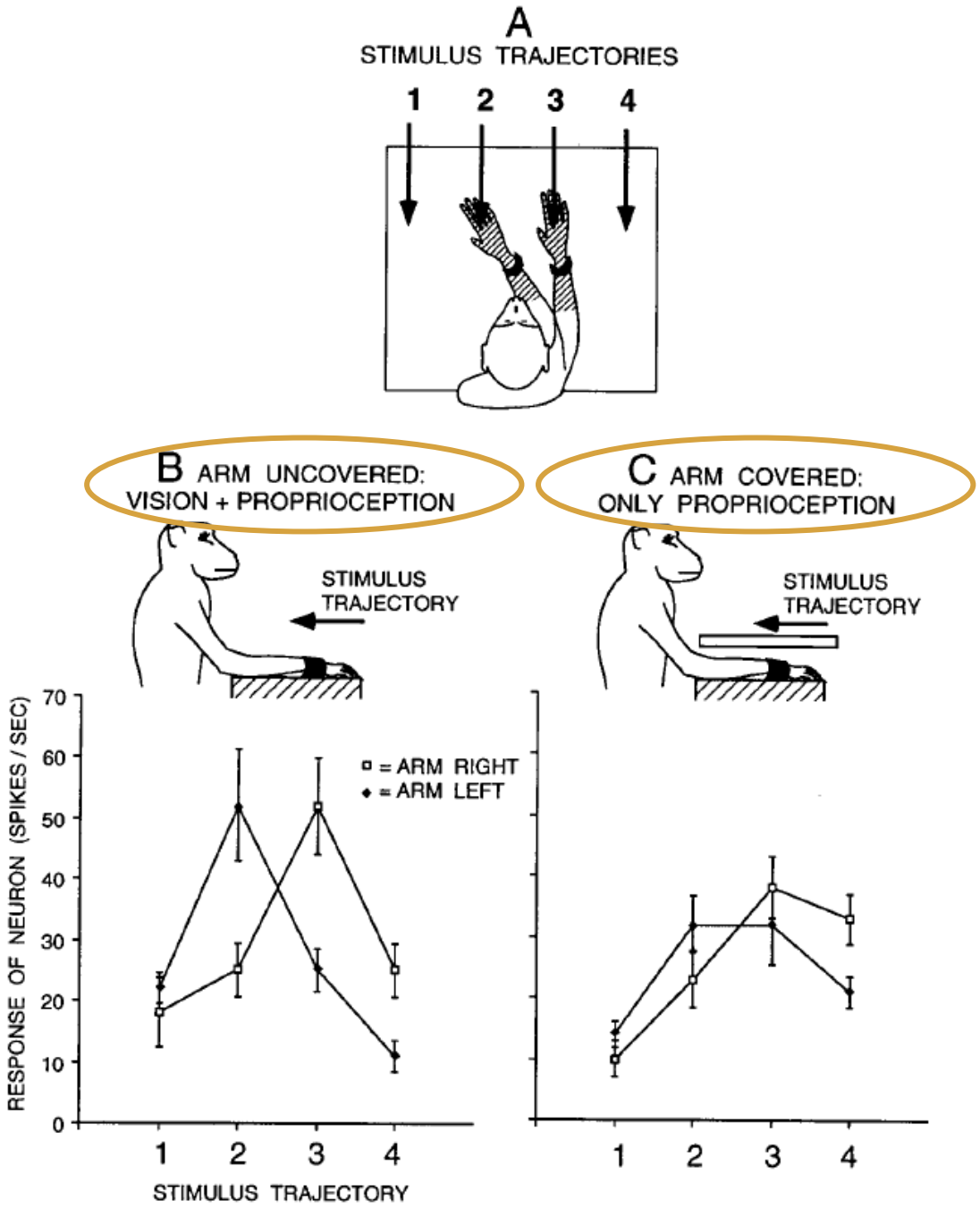
Graziano & Cooke, *Neuropsychologia* (2006)
Serino, *Neuroscience and Behavioral Review* (2019)

Tactile receptive field

Visual receptive field



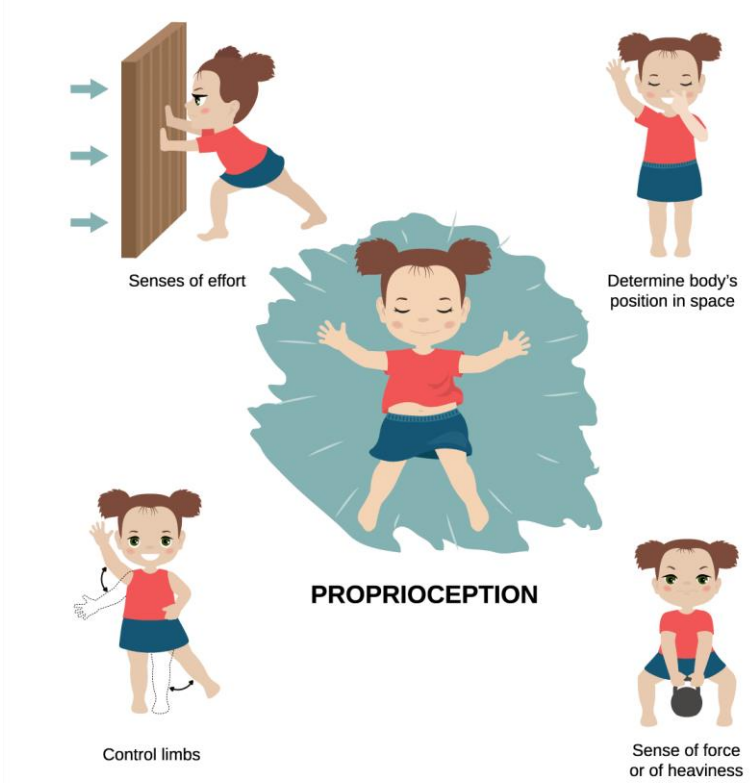
Proprioceptive information about the arm is critical for arm-centred PPS representation



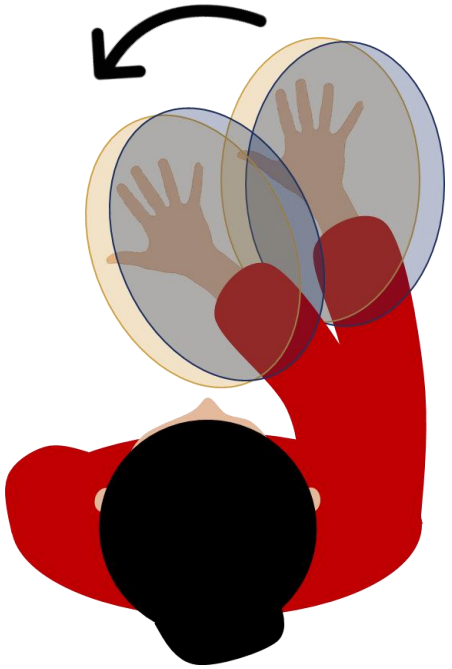
Proprioceptive information about the arm is critical for arm-centred PPS representation

Graziano, *PNAS* (1999)

Proprioception: position sense



Re-alignment of tactile and visual receptive fields into a unique reference frame



Developmental motor experiences

The **motor context,** crucial for the development of efficient proprioception, allows the construction of an **effective multisensory integration** to guide successful interactions with others and the environment

The **motor context,** crucial for the development of **efficient proprioception**, allows the construction of an **effective multisensory integration** to guide successful interactions with others and the environment

Pathology **Normal functioning**

The **motor context,** crucial for the development of **efficient proprioception**, allows the construction of an **effective multisensory integration** to guide successful interactions with others and the environment

Motor deprivation: Acquired *vs.* Congenital

Pathology

SIPF
Società Italiana di Psicofisiologia e Neuroscienze Cognitive

XXXII CONGRESSO NAZIONALE
SIPF 2024
Cesena-Bologna

?

The **motor context,** crucial for the development of **efficient proprioception**, allows the construction of an **effective multisensory integration** to guide successful interactions with others and the environment

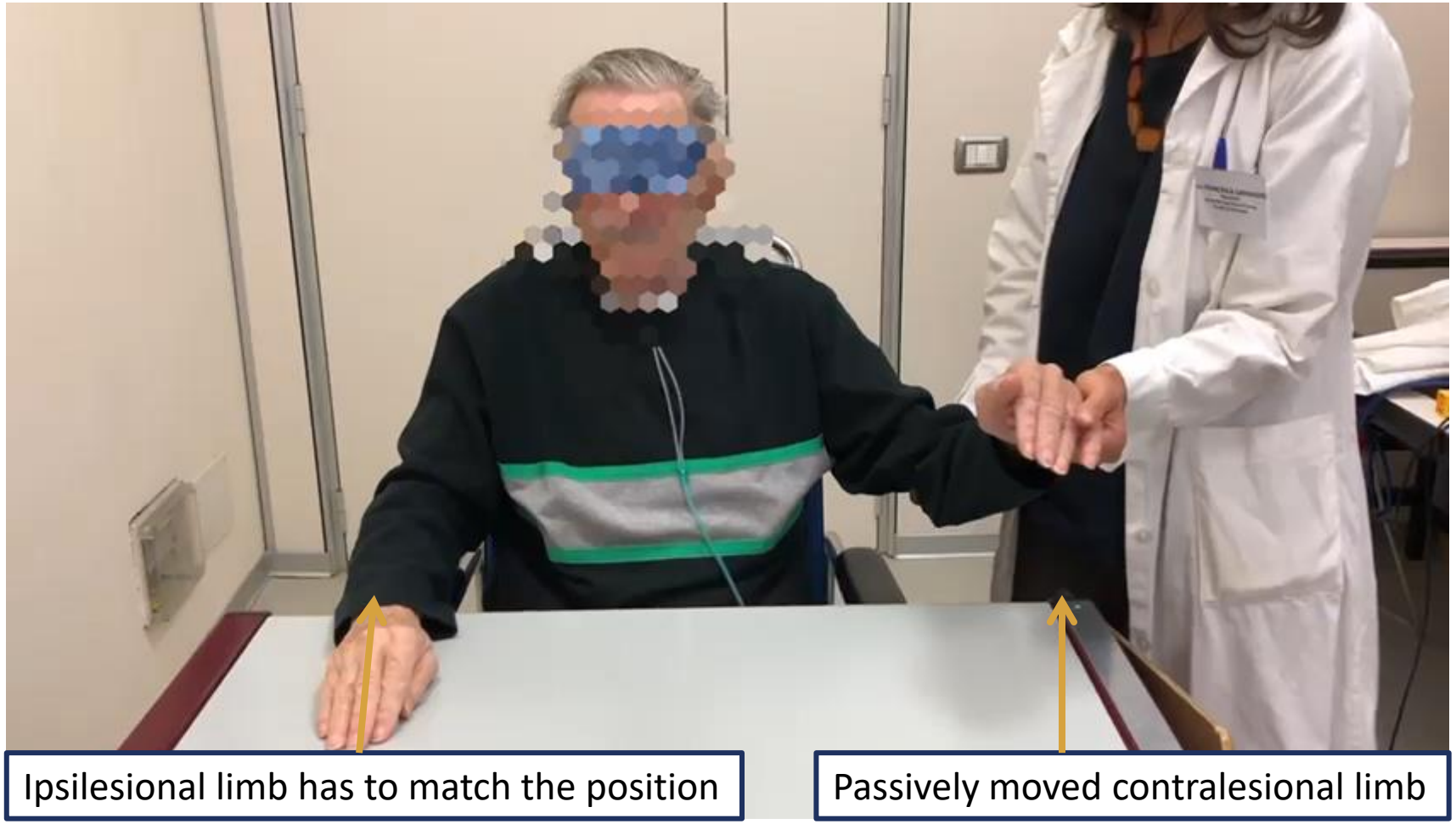
Proprioceptive information:

- Is it relevant "***online***" to process multisensory stimuli?

or

- is it relevant to "***have had***" proprioception to process multisensory stimuli?

	15 neurologically healthy subjs	9 patients with proprioception	4 patients without proprioception
			
Proprioception	✓	✓	✗
Somatosensory	✓	✓	✓


Ipsilesional limb has to match the position
Passively moved contralesional limb

LED

The limb is passively moved forward
Starting position
(arm rotated)

Postural manipulation
(for each hand)

Starting position

After each trial

Limb passively moved

Near condition
(to the LED)

Far condition
(from the LED)

UNIVERSITÀ DI TORINO

Techniques	Populations	Stimuli
RTs		
ERPs		
VR		

PNAS 2021 Vol. 118 No. 12 e2024548118 https://doi.org/10.1073/pnas.2024548118

Spatial tuning of electrophysiological responses to multisensory stimuli reveals a primitive coding of the body boundaries in newborns

Irene Ronga[a], Mattia Galigani[a], Valentina Bruno[a], Jean-Paul Noel[b], Andrea Gazzin[c], Cristina Perathoner[c], Andrea Serino[d], and Francesca Garbarini[a,1]

iScience

CellPress OPEN ACCESS

Article

Spatial proximity to others induces plastic changes in the neural representation of the peripersonal space

Carlotta Fossataro,[1] Mattia Galigani,[1] Alice Rossi Sebastiano,[1] Valentina Bruno,[1] Irene Ronga,[1] and Francesca Garbarini[1,2,3,*]

CORTEX 144 (2021) 133–150

Seeming confines: Electrophysiological evidence of peripersonal space remapping following tool-use in humans

Irene Ronga [a], Mattia Galigani [a], Valentina Bruno [a], Nicolò Castellani [a,c], Alice Rossi Sebastiano [a], Elia Valentini [b], Carlotta Fossataro [a], Marco Neppi-Modona [a] and Francesca Garbarini [a,*]

CORTEX 127 (2020) 94–107

The sense of body-ownership gates cross-modal improvement of tactile extinction in brain-damaged patients

C. Fossataro [a], V. Bruno [a], E. Bosso [a], V. Chiotti [b], P. Gindri [a,c], A. Farnè [d] and F. Garbarini [a,e,*]

Psychological Research (2021) 85:2107–2118
https://doi.org/10.1007/s00426-020-01365-6

ORIGINAL ARTICLE

Does musical interaction in a jazz duet modulate peripersonal space?

A. Dell'Anna[1,2] · M. Rosso[1,2] · V. Bruno[2] · F. Garbarini[2] · M. Leman[1] · A. Berti[2]

Neuropsychologia 146 (2020) 107540

Contents lists available at ScienceDirect

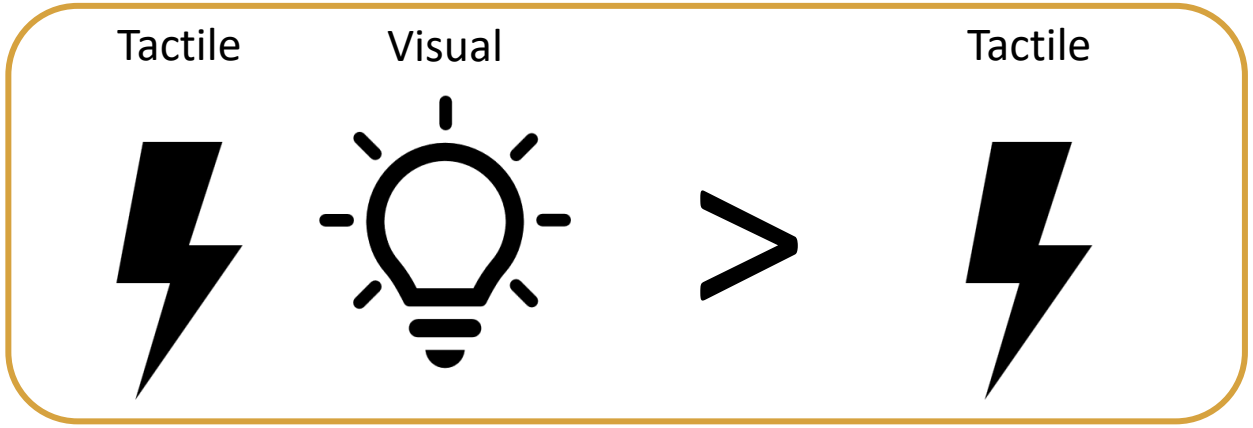
Neuropsychologia

journal homepage: http://www.elsevier.com/locate/neuropsychologia

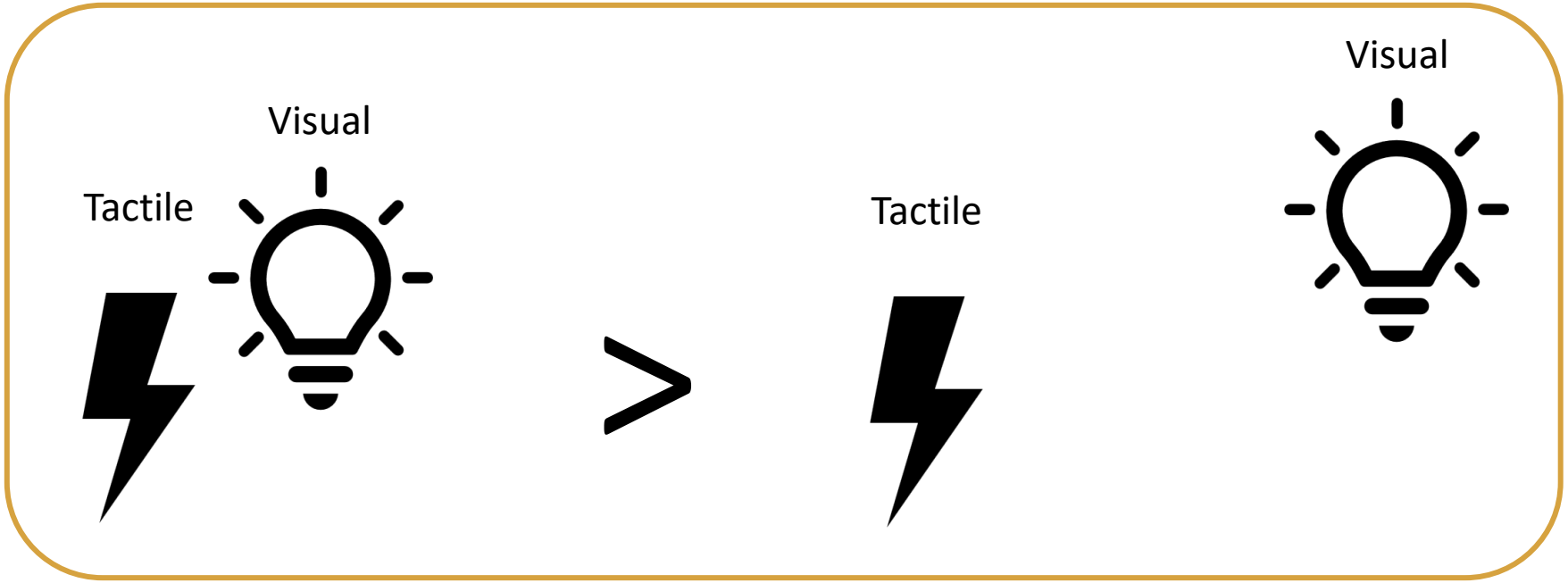
Immersive virtual reality reveals that visuo-proprioceptive discrepancy enlarges the hand-centred peripersonal space

C. Fossataro [a,b], A. Rossi Sebastiano [a], G. Tieri [c,d], K. Poles [a], M. Galigani [a], M. Pyasik [b,e], V. Bruno [a,b], T. Bertoni [f], F. Garbarini [a,g,*]

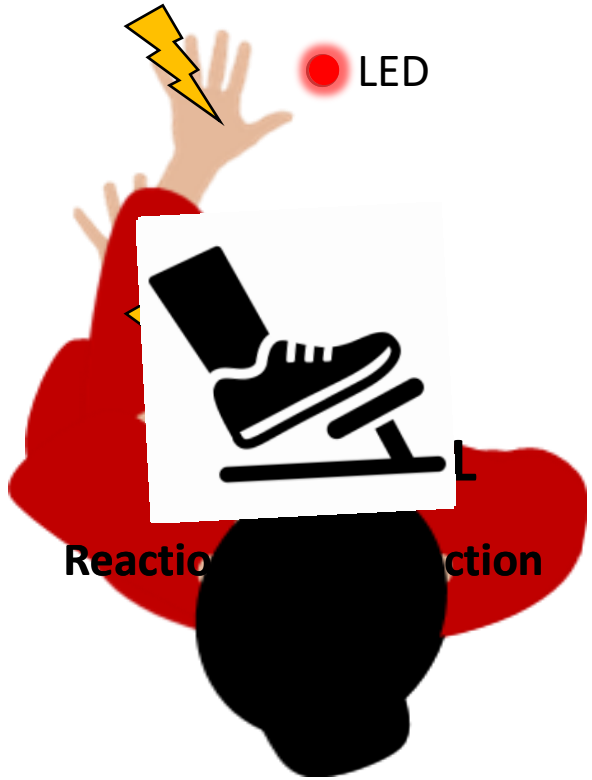
Multisensory integration effect



Spatial modulation of the multisensory integration effect

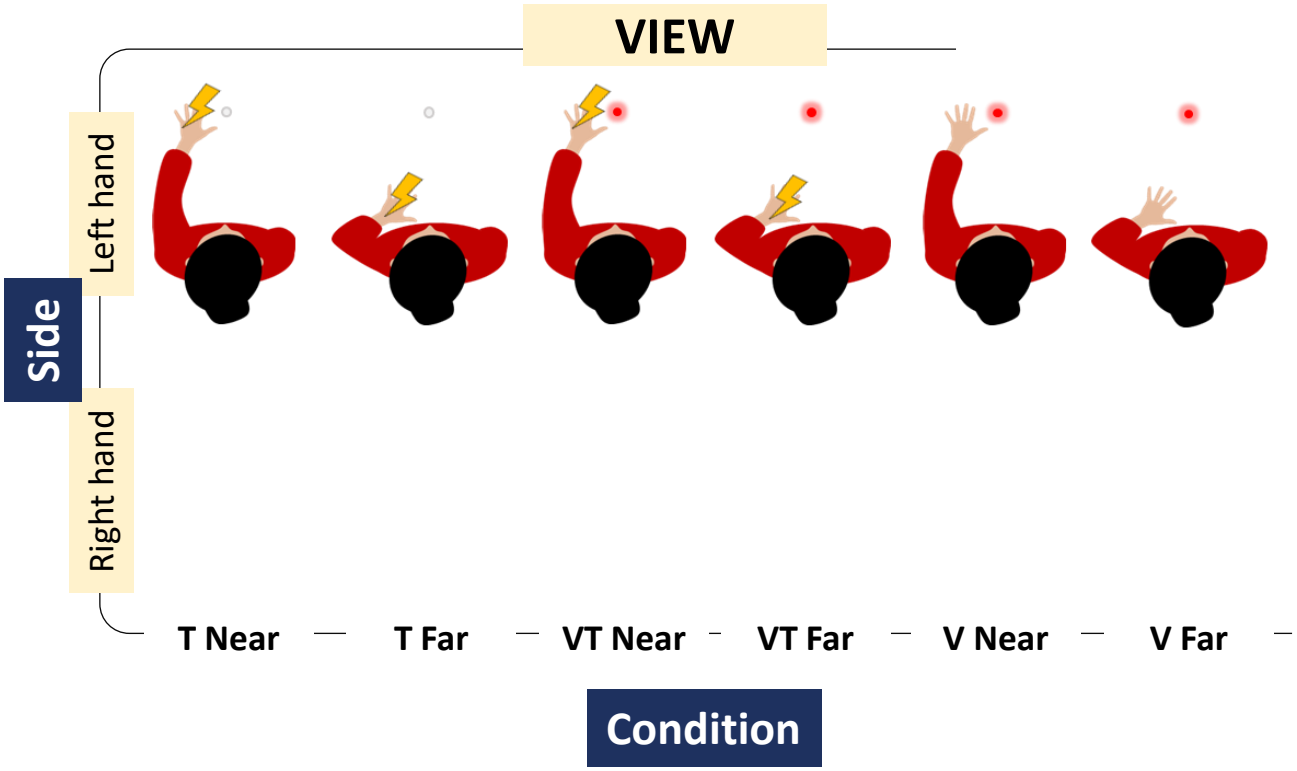


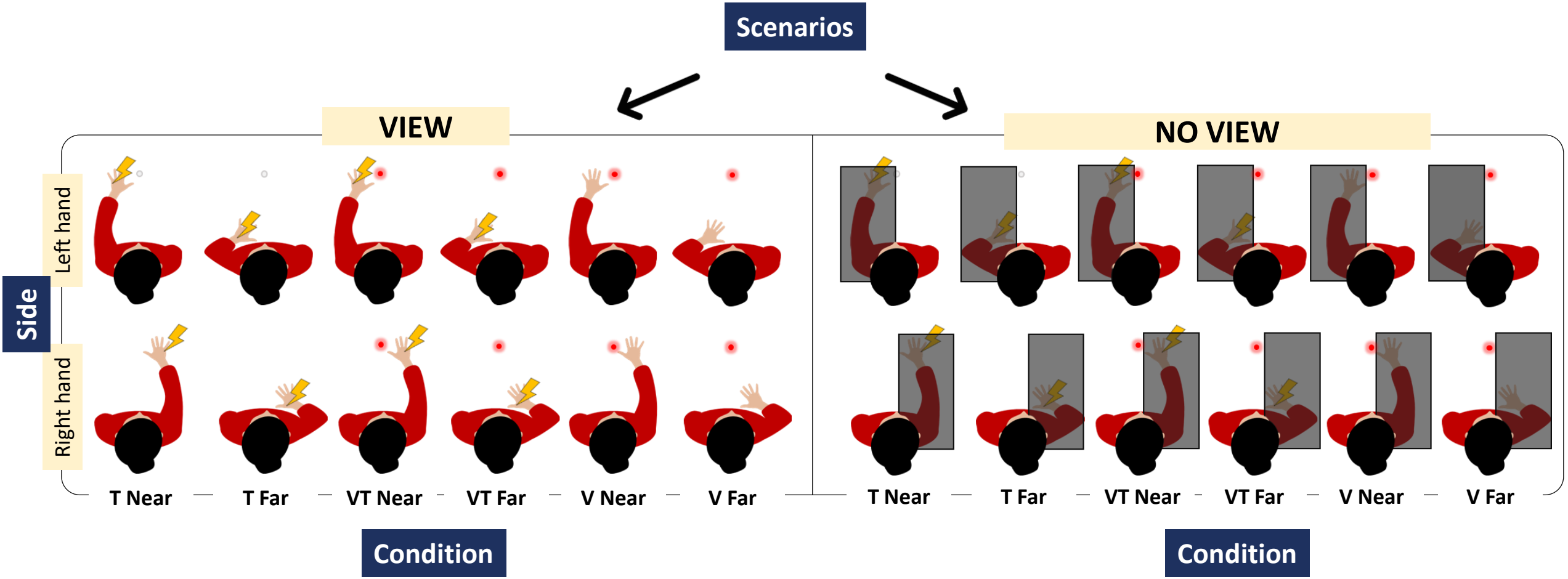
Visual stimulus is always in the same position.
It is the hand which is moving toward or not from it!



Unimodal trials

Bimodal trials

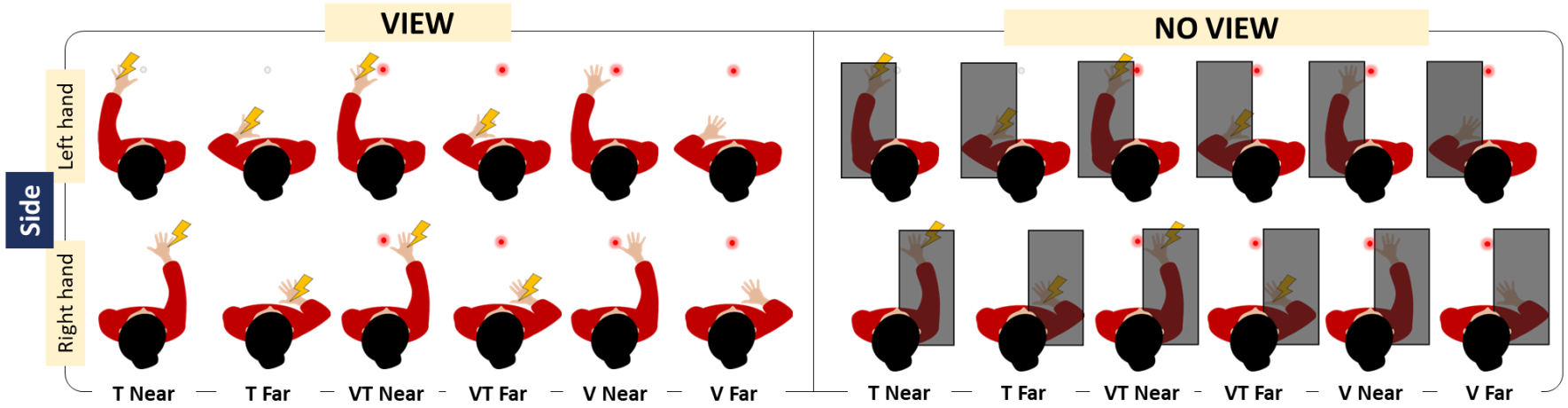

VIEW
Left hand
Side
Right hand
T Near
T Far
VT Near
VT Far
V Near
V Far
Condition



- **proprioceptive** and **visual** information only about the position of the arm

- **proprioceptive** information **only** about the position of the arm

UNIVERSITÀ DI TORINO



Affected side

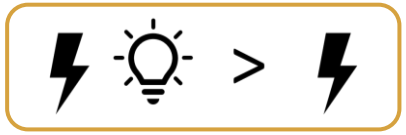
Intact side

MANIBUS Lab

Motor deprivation

Acquired

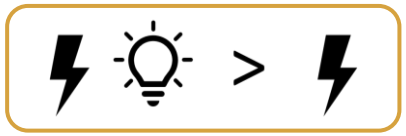
MSI effect



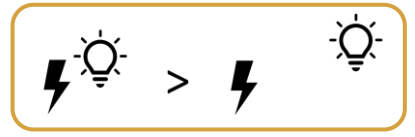
Spatial modulation of MSI

Congenital

MSI effect



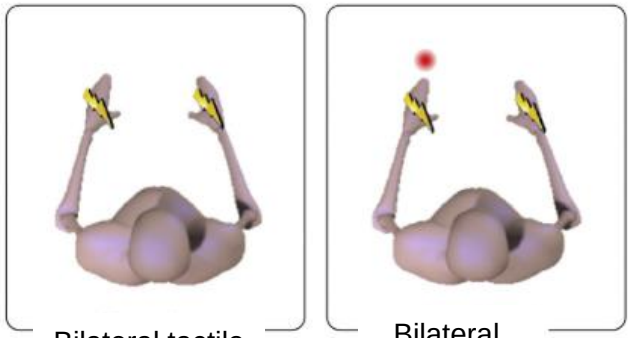
Spatial modulation of MSI



CORTEX 127 (2020) 94–107

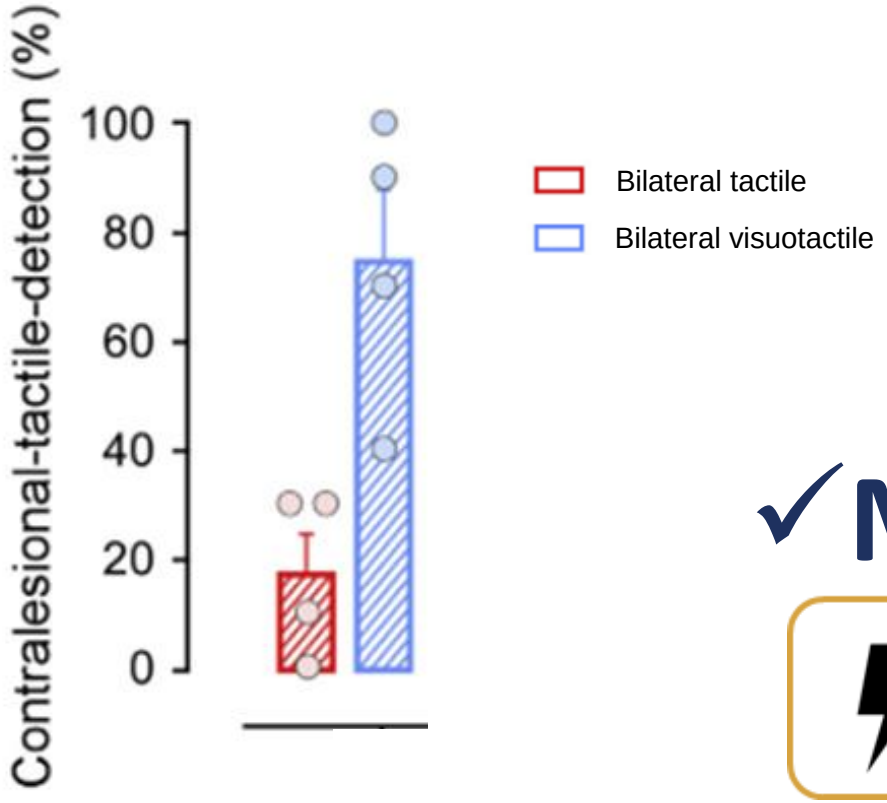
The sense of body-ownership gates cross-modal improvement of tactile extinction in brain-damaged patients

C. Fossataro [a], V. Bruno [a], E. Bosso [a], V. Chiotti [b], P. Gindri [a,c], A. Farnè [d] and F. Garbarini [a,e,*]

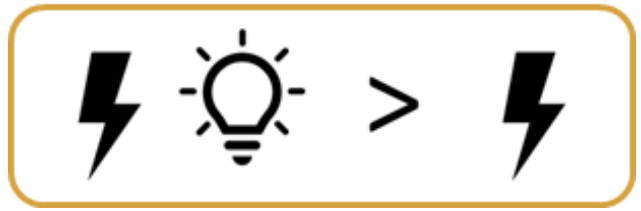


Bilateral tactile

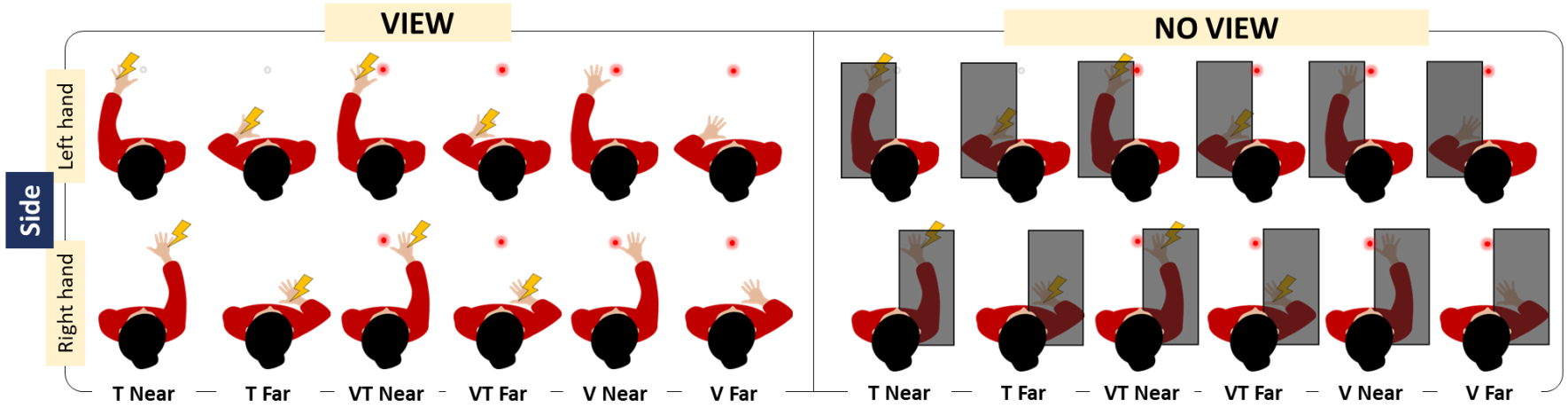
Bilateral visuotactile



✓MSI effect



UNIVERSITÀ DI TORINO



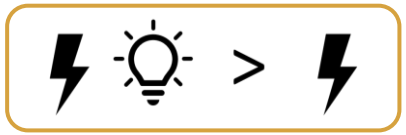
Affected side

Intact side

Motor deprivation

Acquired

MSI effect



Spatial modulation of MSI

NO VIEW

VIEW

Congenital

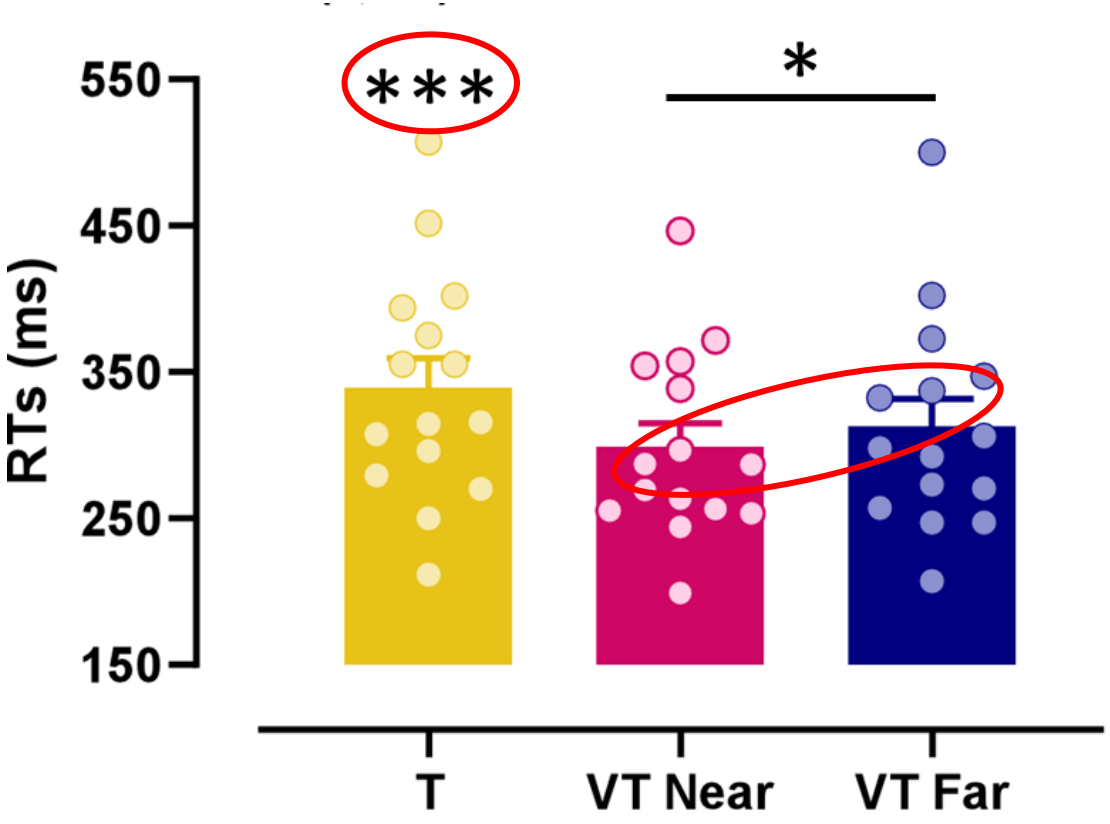
MSI effect

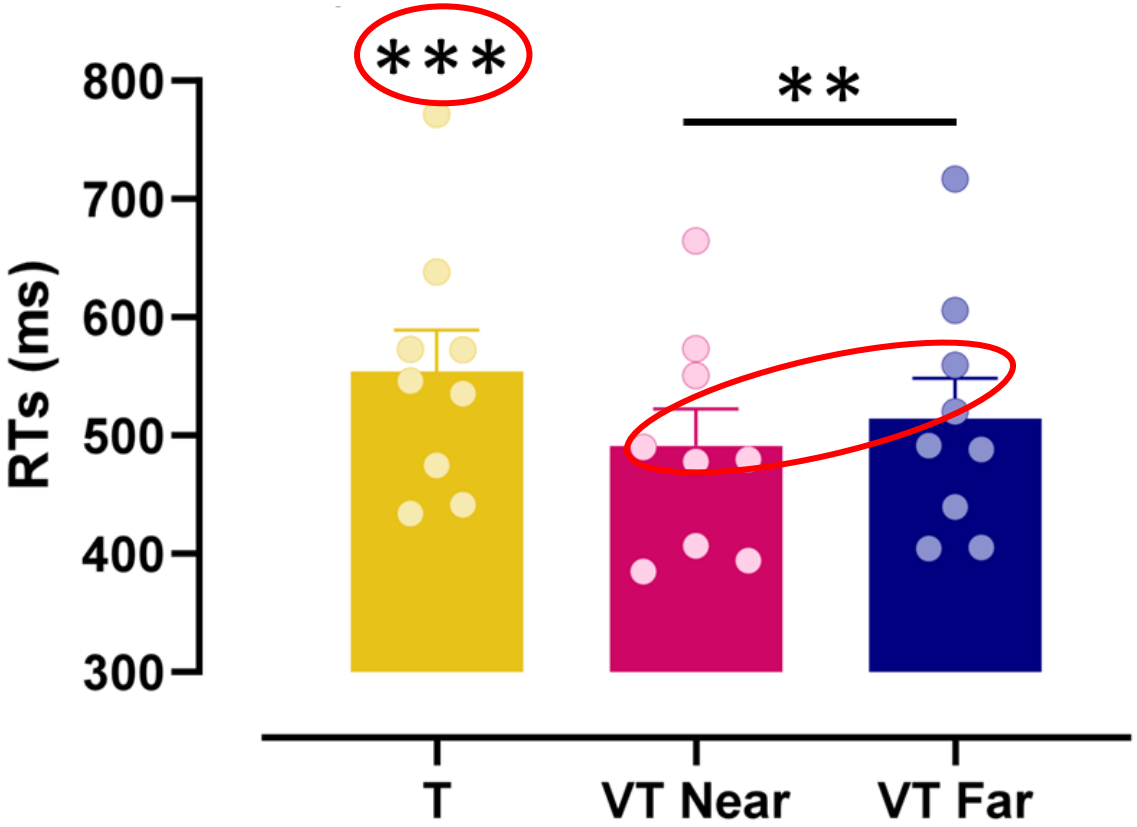
Spatial modulation of MSI

NO VIEW

VIEW

Whether the position of the arm is visible or not, participants **show spatial modulation of MSI effect**

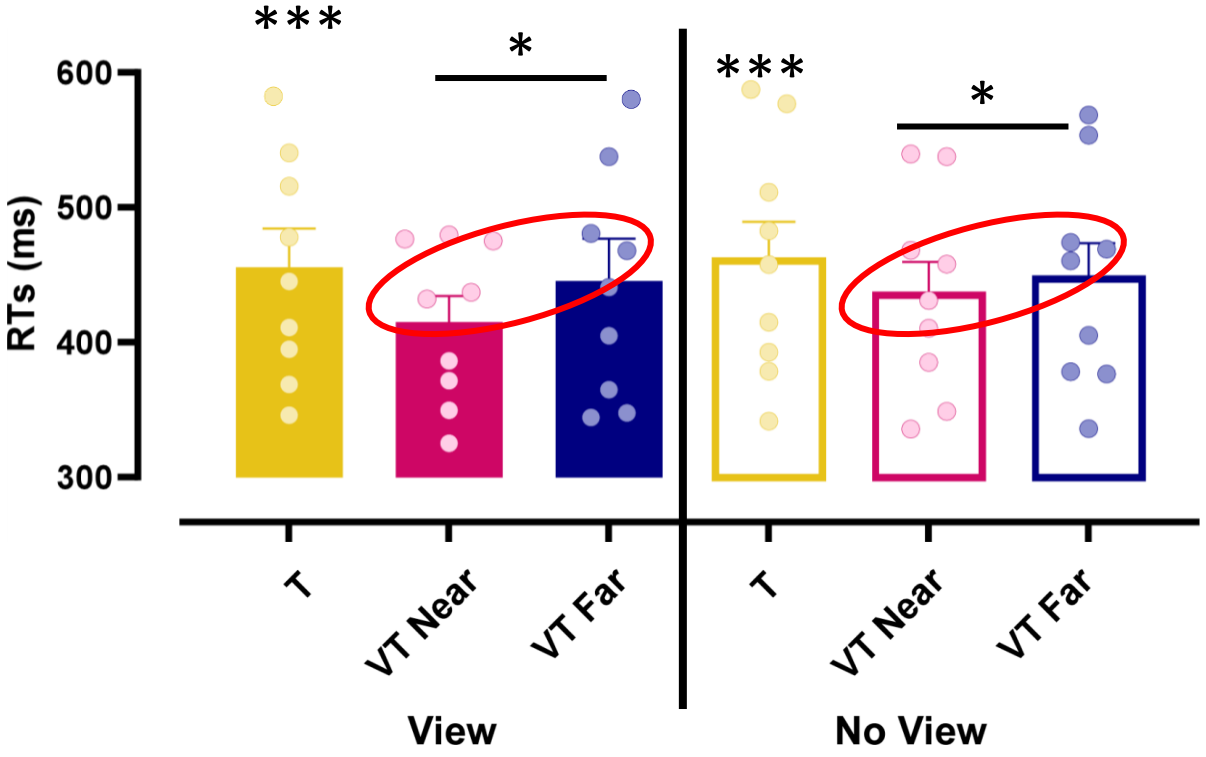


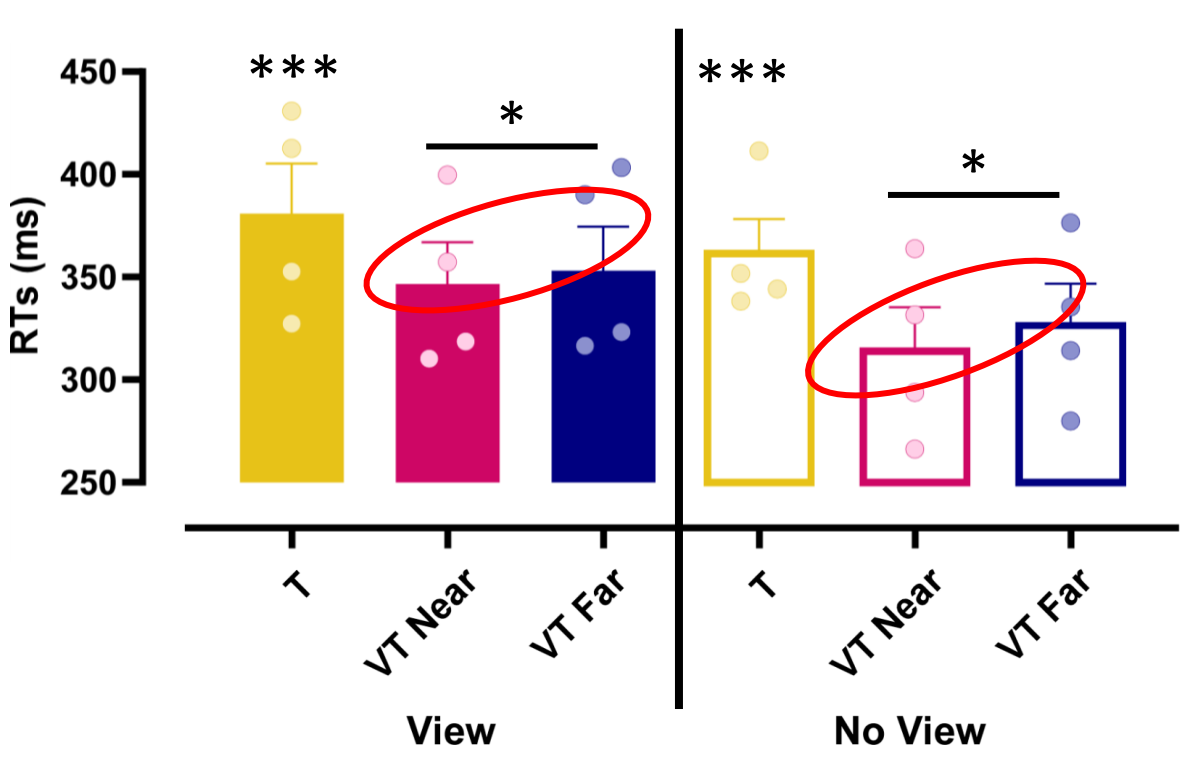


Intact side

with proprioception

without proprioception

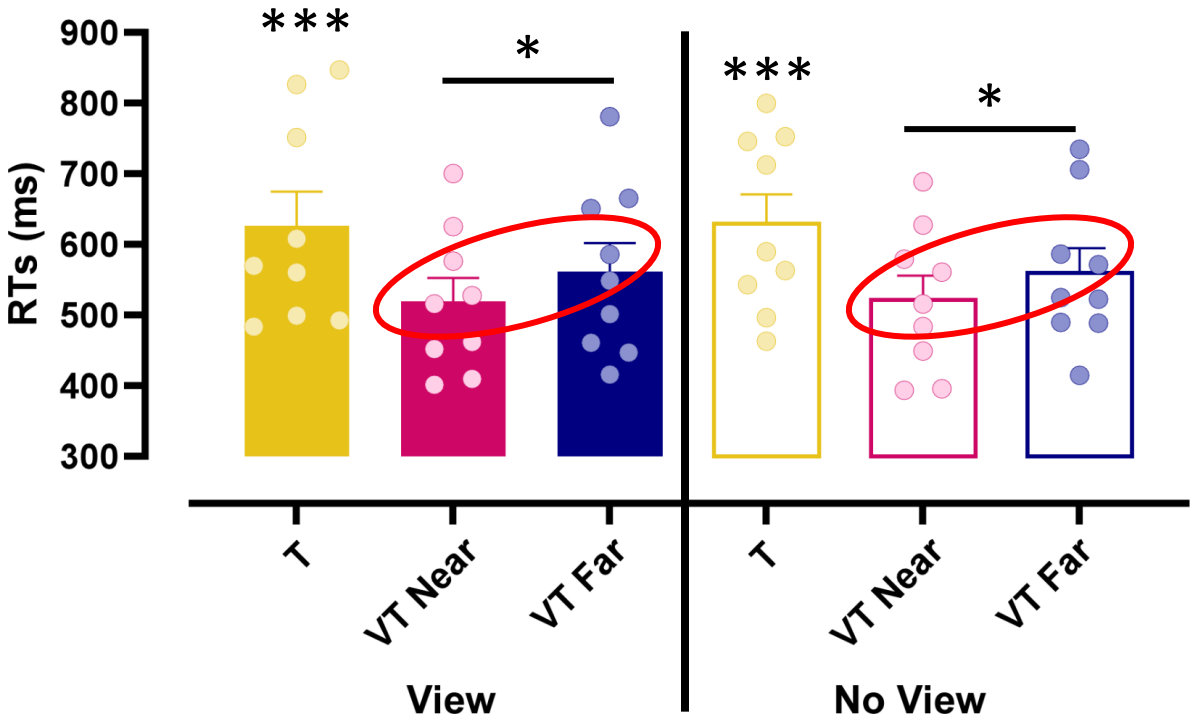


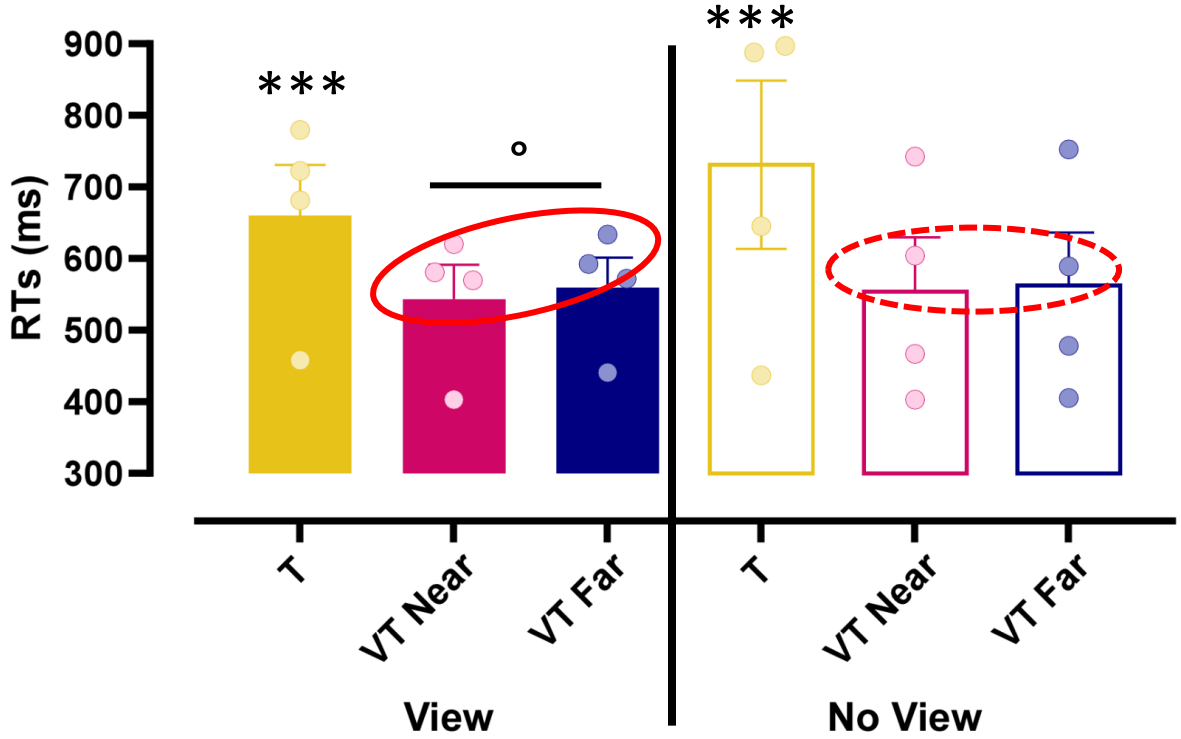


Affected side

with proprioception

without proprioception





The **motor context,** crucial for the development of **efficient proprioception**, allows the construction of an **effective multisensory integration** to guide successful interactions with others and the environment

Proprioceptive information

- Relevant for the emergence of the classical **multisensory integration effect** (VT > T), even if lacking in patients without proprioception

In patients without proprioception:

- in **No View** condition, **no spatial modulation** of MSI effect due to the absence of proprioceptive info

- In the **View** condition, the **vision vicariates** the lack of proprioception

Motor deprivation: Acquired *vs.* Congenital

They may fail to access the spatial representation of the hand irrespective of which channel they use (either proprioceptive or visual) due to the absence of an effective coupling between multisensory signals because of congenital motor deficits

Francesca Genovese

Prof.ssa Francesca Garbarini

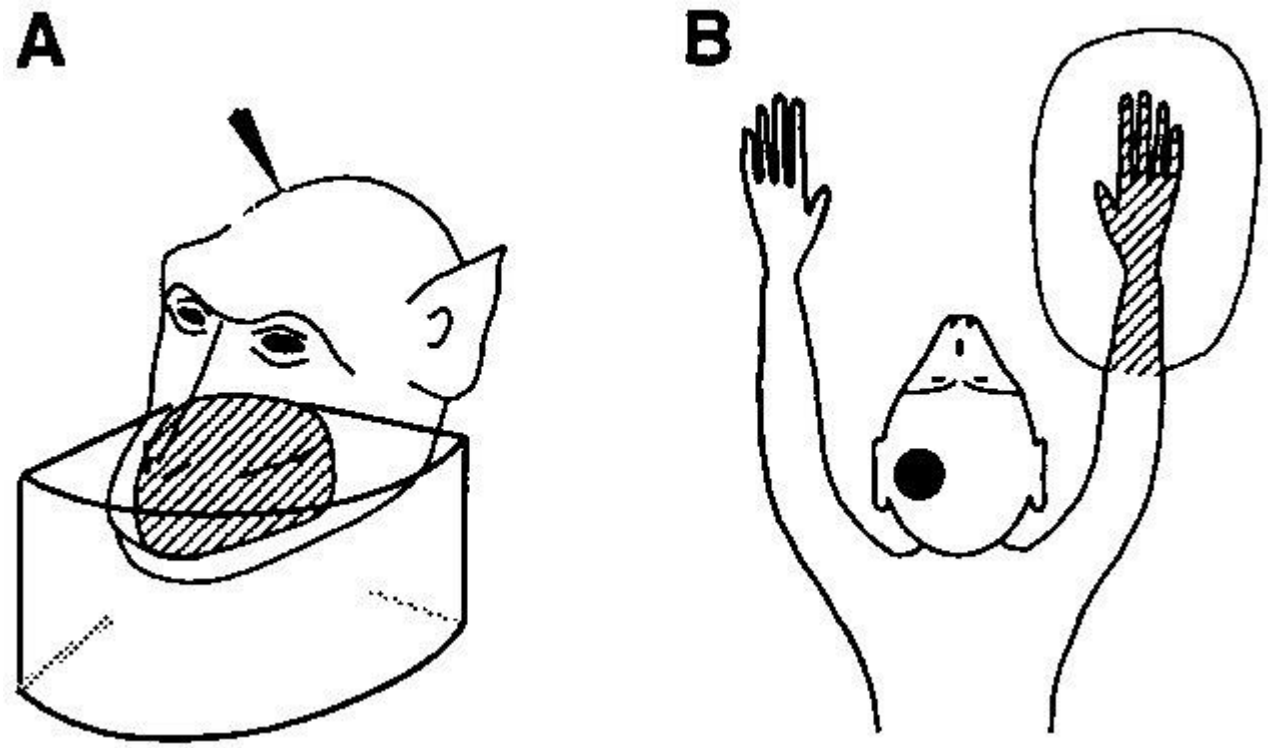
Grazie per l'attenzione!

When proprioception is lost, patients could vicariously exploit visual input to localize their own body in space (*SLv*), as shown by the presence of a spatially organized MSI when the affected hand is visible[12]. The ability to localize the arm position by sight has been described in non-human[25] and human[26,27] primates, with key brain regions that are
modulated by visuo-proprioceptive congruency.

Graziano, M. S. A., Cooke, D. F. & Taylor, C. S. R. Coding the location of the arm by sight. *Science (80-.).* **290**, 1782–1786 (2000).
26. Fossataro, C. *et al.* Immersive virtual reality reveals that visuo-proprioceptive discrepancy enlarges the hand-centred peripersonal space. *Neuropsychologia* **146**, 107540 (2020).
27. Limanowski, J. & Blankenburg, F. Integration of visual and proprioceptive limb position information in human posterior parietal, premotor, and extrastriate cortex. *J. Neurosci.* **36**, 2582–2589 (2016).

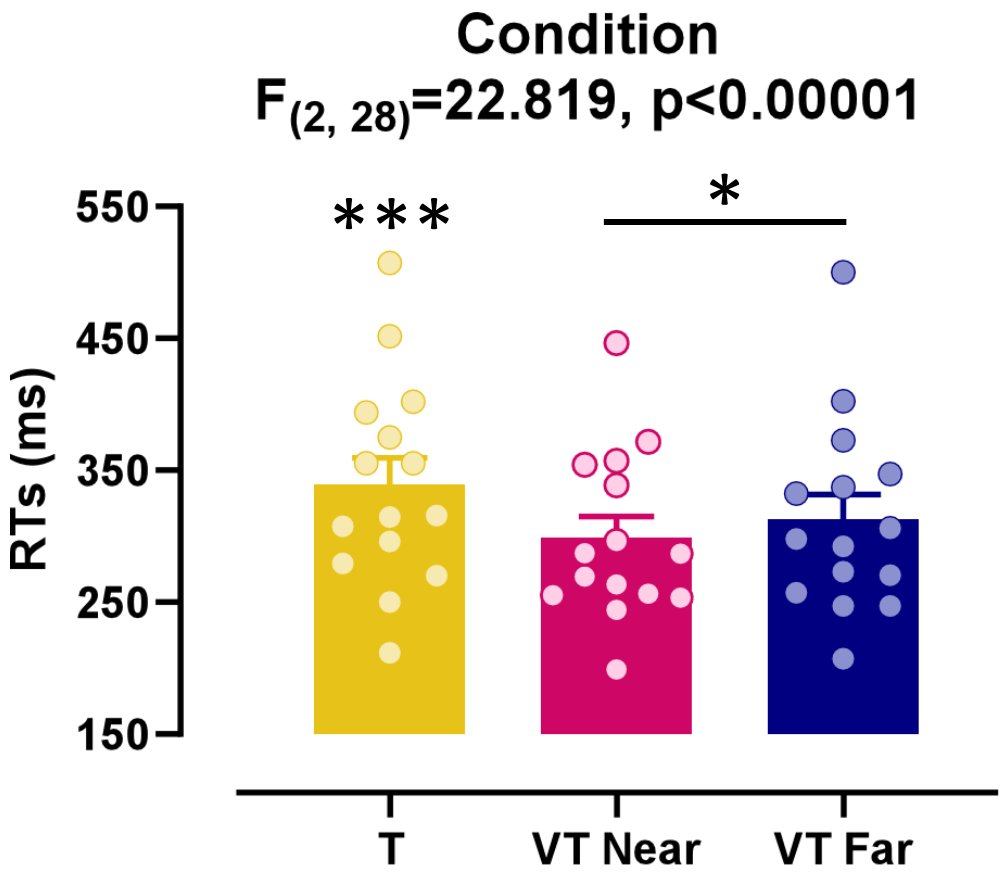
For reaching and grasping, as well as for manipulating objects, optimal hand motor control arises from the integration of multiple sources of sensory information, such as proprioception and vision. For this reason, proprioceptive deficits often observed in stroke patients have a significant impact on the integrity of motor functions. The present targeted review attempts to reanalyze previous findings about proprioceptive upper-limb deficits in stroke patients, as well as their ability to compensate for these deficits using vision.

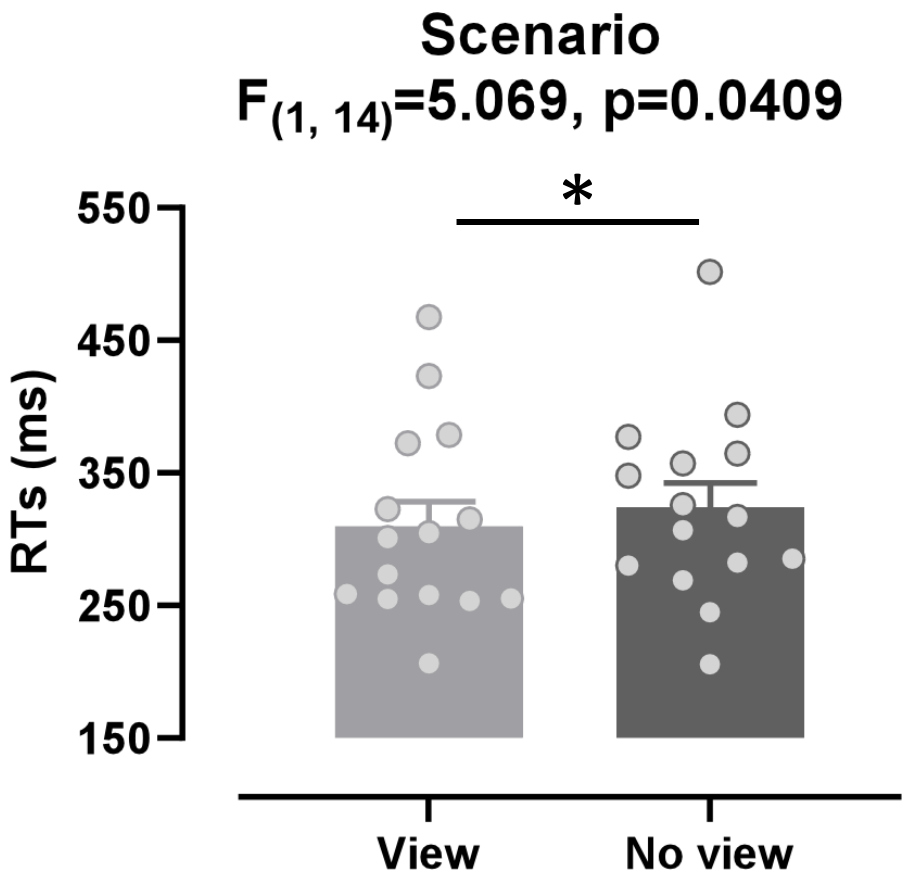
one of the main properties of PPS representation is that it implies a series of neuronal computations **allowing to keep aligned the coding of multisensory stimu**li, each originally computed by a specific sensory-modality dependent system of reference, into a unique frame of reference centered to a specific body part.



The ventral premotor cortex in primates is thought to be involved in sensory-motor integration. Many of its neurons respond to visual stimuli in the space near the arms or face. In this study on the ventral premotor cortex of monkeys, an object was presented within the visual receptive fields of individual neurons, then the lights were turned off and the object was silently removed. A subset of the neurons continued to respond in the dark as if the object were still present and visible. Such cells exhibit "object permanence," encoding the presence of an object that is no longer visible. These cells may underlie the ability to reach toward or avoid objects that are no longer directly visible.

Graziano et al., 1997 Science


Condition
$F_{(2, 28)}$=22.819, p<0.00001
RTs (ms)
550
450
350
250
150
***
*
T
VT Near
VT Far


Scenario
$F_{(1, 14)}$=5.069, p=0.0409
RTs (ms)
550
450
350
250
150
*
View
No view

Contents lists available at ScienceDirect

Infant Behavior and Development

Full length article

Sensory processing disorders in children with cerebral palsy

Sílvia Leticia Pavão (MSc)*, Nelci Adriana Cicuto Ferreira Rocha (PhD)

We observed that children with CP, compared to typical children, present most pronounced **impairments** in visual, vestibular and **multisensorial processing**. These sensory processing impairments seem to be related to an abnormal mechanism in the sensoriomotor network of children with CP, as a possible result of diminished thalamocortical projections (Papadelis et al., 2014). These structural deficits **may compromise the processing of tactile and somatosensory information in children with CP** (Reid et al., 2013)

Characteristics of the groups according to confidence intervals (CI) of the evaluated areas in Sensory Profile and differences between groups found in Sensory Profile categories.

Categories	Control Group (CI)	CP Group (CI)	Test Statistic (U)	Level of Significance (p)	Z-score	Effect size (r)
Sensory Processing Areas						
Visual Processing	[1.16–1.45]	[1.54–2.03]	834	p < 0.002*	−3.27	−0.32
Auditory Processing	[1.34–1.72]	[1.73–2.22]	867	0.005	−2.82	−0.27
Vestibular Processing	[1.78–2.24]	[2.31–2.75]	840	p < 0.002*	−3.03	−0.3
Touch Processing	[1.59–1.98]	[1.86–2.32]		0.05	−1.97	−0.19
Multi-Sensory Processing	[1.3–1.69]	[2.24–2.73]	529	p < 0.002*	−5.35	−0.53
Oral-Sensory	[1.29–1.66]	[1.45–1.94]	1068	0.16	−1.38	−0.13
Sensory Modulation						
Modulation Related to Body Position and Movement	[1.49–1.88]	[2.51–2.88]	422	p < 0.002*	−6.04	−0.6
Modulation of Movement Affecting Activity Level	[1.3–1.63]	[1.86–2.36]	709	p < 0.002*	−3.99	−0.39
Modulation of Sensory Input Affecting Emotional Responses	[1.19–1.56]	[2.3–2.76]	408	p < 0.002*	−6.29	−0.62
Sensory Processing Related to Endurance/Tone	[0.99–1.21]	3	43	p < 0.002*	−9.49	−0.94
Modulation of Visual Input Affecting Emotional Responses	[2.14–2.58]	[2.42–2.82]	1049	0.11	−1.6	−0.15
Social-Emotional Responses						
Emotional/Social Responses	[1.55–1.96]	[2–2.46]	842	p < 0.002*	−2.95	−0.29
Behavioral Outcomes of Sensory Processing	[1.16–1.49]	[1.91–2.45]	606	p < 0.002*	−4.93	−0.49
Thresholds for Response	[0.96–1.1]	[1.27–1.65]	782	p < 0.002*	−4.79	−0.47
Sensory Profile Factors						
Sedentary	[1.25–1.64]	[1.9–2.46]	715	p < 0.002*	−4.06	−0.4
Fine motor/Perceptual	[0.98–1.18]	[1.71–2.32]	636	p < 0.002*	−5.51	−0.54
Low Endurance/Tonus	[0.9–1.21]	[2.8–3.04]	73	p < 0.002*	−9.27	−0.92
Inattention/Distractibility	[1.5–1.94]	[2.07–2.62]	789	p < 0.002*	−3.4	−0.33
Poor Registration	[1.08–1.36]	[1.39–1.86]	877	p < 0.002*	−3.16	−0.31
Sensory Sensitivity	[1.05–1.32]	[1.98–2.52]	474	p < 0.002*	−6.12	−0.6
Sensory Seeking	[1.7–2.2]	[1.7–2.26]	1233	0.9	−0.1	−0.009
Emotional Reactivity	[1.53–1.91]	[2.07–2.53]	744	0.05	−3.67	−0.36