

Multisensory integration: what are the implications for psychomotor skills?

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Abstract : Human sensory perception is organized around the concepts of exteroception, proprioception, and interoception. The complexity of human sensory experience reveals a crucial system of sensory coordination: multisensory integration. This system relies on regions and networks of the central nervous system and, when development proceeds typically, allows access to higher-level skills such as awareness, body ownership, unity, and bodily boundaries. In autism spectrum disorders, these four concepts give rise to difficulties that are well-suited to psychomotor therapy.

Keywords : multisensory integration, psychomotor skills, self-awareness, body ownership
ASD, fragmentation, bodily limitations

Abstract : Human sensory processing is primarily organized around the concepts of exteroception, proprioception, and interoception. The complexity of human sensory experience reveals a crucial system of sensory coordination: multisensory integration. This process relates on specific regions and networks within the central nervous system and, under typical developmental conditions, enables the emergence of higher-level functions such as consciousness, a sense of bodily ownership, and a unified sense of bodily boundaries. In autism spectrum disorders, these four concepts are associated with specific impairments that fall squarely within the scope of psychomotor therapy.

Key words : multisensory integration, psychomotricity, self-consciousness, body ownership, autism spectrum disorder, disappearing hand, body boundaries

1/ Introduction

Psychomotor therapy is a paramedical profession that uses, for therapeutic purposes, techniques involving embodied experiences, most often called "mediations." These therapeutic mediations, whether water, dance, relaxation, etc., engage the senses, emotions, and certain aspects of representation. Becoming aware of one's bodily sensations proves, in fact, to be highly therapeutic for the patient. Few techniques involve only a single sensory modality (for example, sight). Most often, several modalities are stimulated. Indeed, the therapeutic approach, like many other situations in daily life, triggers several sensory modalities. The central nervous system interprets them as interconnected, whether they originate from the outside, the periphery (at the skin level), or from within the body. In everyday life, this allows the person, based on these signals, to find meaning in their environment. This capacity of the central nervous system to connect sensory and sensorimotor information, whether simultaneous or not, is called multisensory integration. Only partially conceived in newborns, it develops in the first years of life and, when development proceeds normally, grants access to higher-level skills such as body awareness, a sense of one's own unity, self-awareness, and bodily boundaries. It is crucial that psychomotor therapy, as a form of healthcare, considers all of these phenomena and their potential pathologies.

2/ Multisensory integration: what is it?

21/ Sensory Perception

We classically consider three main sets of sensory modalities: proprioception, interoception, and exteroception. A sensory modality is simply what the general public

It refers to a sense, as in the expression: "the five senses."

Proprioception provides information about the position of different body parts relative to each other, about the muscle strength required for various daily actions, and about kinesthesia, which accounts for the direction, amplitude, and speed of our movements.

Thanks to proprioception, we are informed of our body's positions and their changes.

Interoception encompasses information from the cardiac, respiratory, digestive, and endocrine systems.

Exteroception involves information about heat and cold, vibration, pain, as well as other sensory modalities: visual, auditory, gustatory, olfactory, light touch and pressure.

Current literature is not conclusive as to whether the vestibular system belongs to one of the three major sets of sensory modalities.

This classification suggests that our bodies are equipped with far more than just "5 senses."

In psychomotor therapy, sensory experience is crucial. It forms the basis of the vast majority of interventions offered to patients. And it is largely the links between sensory experience, emotions, and representations that justify the daily ambition of psychomotor therapists to approach the person in their "holism" and to have an original and specific therapeutic effect.

22/ Coordination of Different Sensory Modalities A sensory stimulus

may involve only one sensory modality. This is the case when we suddenly smell burnt food, even though we are in a different room than the kitchen. It is also the case when someone turns on the light without warning us. In the first case, only our sense of smell is involved. And in the second, only our sense of sight.

But most of the time, several sensory modalities are involved simultaneously: if the pot boils over and we're in the kitchen, we see it. We also hear the food bubbling. And we smell the burning. In other words, three different sensory modalities are present. They are coordinated, meaning our brain detects a common origin and a possible simultaneity. This coordination allows us to understand the situation and react appropriately.

Let's take another example: sitting in an armchair, with my eyes closed, I feel that I am being touched by something at the top of my lower limbs. A certain weight has been imposed on me.

This weight is a tactile sensation of pressure. I choose to keep my eyes closed. I feel that this weight is moving because my lower limbs are successively stimulated by touch in different places. Given its movement and the weight I feel on my legs, I deduce, still with my eyes closed, that it's one of my two cats. Yes, but which one? The large one with the thick collar or the other, only slightly lighter, with the smaller collar? My hand must therefore reach out to meet the animal. As it moves (kinesthesia), my fingers try to follow the animal's shape and encounter its fur (tactile sensation). Thanks also to the warmth I quickly become aware of, I have confirmation that I am indeed in the presence of one of my two pets. Moreover, I hear it (auditory sensation) begin to purr. I then become aware of the animal's weight on my lap. The (tactile) weight on my legs tells me the identity of the intruder, since my two cats are slightly different weights. To confirm my "discovery," I move my hand (kinesthesia) towards the animal's neck to search for the collar (touch). Still blindly, I find it and explore its shape and size (touch and kinesthesia), its roughness (touch), its warmth, and its material (touch).

I identify the collar. I have confirmation that I am in the presence of the larger of my two cats: Fulbert.

In this example, several sensory modalities occurred: tactile, thermal, kinesthesia,

and hearing. Whether simultaneous or not, they were identified by my brain, which associated them to allow me to identify the "object" that presented itself to me. Bullinger (2004) would refer to this as the coordination of sensory modalities. International literature uses the term multisensory integration.

23/ Multisensory integration: definitions and neuroanatomical basis. "Integrating" sensory information means that the central nervous system registers sensory stimuli and identifies their simultaneity (or lack thereof) in order to understand the environment around us. Here are some definitions proposed by research: Texeira, Machado et al. (2014) suggest that "the brain integrates visual, proprioceptive, tactile, pain, vibratory, and thermal inputs into spatial and sensorimotor representations in order to produce an appropriate motor response."

According to Dionne-Dostie, Paquette et al. (2015), "each sensory modality gives us only one 'view' of the world. [...] But our environment constantly confronts us with situations that stimulate several sensory modalities at once. [...] In everyday life, events are rarely unimodal; they are multisensory experiences during which a combination of information from several sensory modalities emerges. The brain 'integrates' this multisensory information to provide us with a complete and coherent representation of what is perceived, in order to implement appropriate behavioral responses. This phenomenon is called multisensory integration."

Cavadini, Casartelli et al. (2025) explain that "sensory inputs from the body come from different sources and are integrated by the CNS. They come from the skin and internal receptors located in muscles, joints, or from interoception. [...] Some sensory modalities are strongly linked, such as smell and taste. Touch is involved with all the other senses. Vision, hearing, and proprioception are highly associated with touch."

Lin and Shih-Yun (2025) state that "multisensory processing is associated with the interaction of multiple unimodal sensations."

Jung-Choi, Lyons et al. (2025) tell us that combining information from multiple sensory modalities allows for a unified perception called "multisensory integration."

Zhang, Magnotti et al. (2025) use the example of verbal language perception. They state that "human language perception is multisensory because it involves integrating vocal, and therefore auditory, information, and visual information, which comes from the speaker's face." Understanding others thus requires taking into account both auditory and visual information (facial expressions) in order to best understand the different channels of human language. In psychomotor therapy, the tonico-emotional dialogue, which operates through the muscles of the entire body, is considered to be involved in the auditory-visual integration of linguistic information. The tonico-emotional dialogue would therefore be an integral part of multisensory integration.

According to Bolhasani, Aboutaleb et al. (2026), multisensory integration is the brain's ability to combine information from multiple sensory modalities such as vision, hearing, touch, and proprioception. [...] This process is fundamental to the development of perception.

The neuroanatomical basis of multisensory integration has been relatively well studied in recent years. The key finding is that no single brain region is solely responsible for this ability. Rather, it involves a network of cortical and subcortical structures:

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1. One could say "combine" or "associate" or "coordinate."

- Ehrsson (2020) considers an involvement of the parietal and frontal associative cortices to integrate visual and somatosensory information.
- According to Arzy, Overney et al. (2026), certain visual and somatosensory information converges on neurons in the premotor cortex. The premotor cortex contains multisensory neurons that share tactile and visual receptive fields. It receives its afferents, in particular, from parietal regions that integrate visual, tactile, and proprioceptive information.

The integration of auditory, tactile, gustatory, and olfactory information occurs in the temporal gyrus, thalamus, insula, and frontal lobe (Scheliga, Kellermann et al., 2022). Within this network, the thalamus is thought to be the first subcortical relay to project to several cortical regions. Thus, a true multisensory integration network exists.

In summary, information travels from sensory receptors to certain subcortical nuclei before being projected to cortical regions. First to the parietal cortex, then to the premotor cortex and the insula, and finally to certain areas of the frontal cortex.

Let's stay with the parietal cortex for a while longer. For Teixeira, Machado et al. (2014), it integrates sensory information from various origins, particularly in its posterior part.

The spatial dimension of stimulation, as well as motor guidance, could be accommodated there.

As Ackerley (2023) points out, the processing of sensory information is also conditioned by its nature. Thus, strong links exist between taste and smell, while touch is connected to all other sensory modalities. Vision, hearing, and proprioception are highly associated with touch. And touch itself is very strongly connected to the vestibular system.

Cavadini, Casartelli et al. (2025) and Ackerley (2023) emphasize that the cerebellum provides a very important link with the various cortical areas. Its afferents are located in the brainstem (pons and inferior olive).

Research has also focused on the perception of human language. Zhang, Magnotti et al. (2025) state that the superior temporal sulcus integrates auditory and visual information.

The visual aspect concerns, of course, facial movements. When these and auditory information are synchronous, multisensory integration is present.

Regarding the oral food dimension, multisensory integration occurs at the levels of the primary and secondary parietal cortex, as well as in motor areas (M1, premotor cortex, basal ganglia, and cerebellum). This involves tactile information when food touches the inside of the oral cavity. Proprioception is active when the jaw exerts force. Taste, of course, also plays a role (Lin and Wu, 2025).

As we can see, multisensory integration is not localized to a single brain region. We are therefore dealing with a truly high-level, complex, and highly interconnected network. It is also worth noting the existence of multisensory neurons in different areas of the brain. These are nerve cells whose connections are made with fibers originating from receptors corresponding to different sensory modalities. The mechanism of multisensory integration truly relies on these neurons. They are found (Ehrsson, 2020) in the premotor and parietal cortices.

This is how some multisensory neurons respond to information from the entire body. According to Cavadini, Casartelli et al. (2025), multisensory neurons are also found in the cerebellum.

3/ Multisensory integration: what are the benefits in psychomotor therapy?

The literature is very rich regarding the abilities that the acquisition of...

Mechanisms of multisensory integration. Entire aspects of personality functioning (such as certain aspects of body image, for example) rely on this aspect of sensory development. Let us consider Beaumard, Lerouge et al. (2026), who discuss the notion of "atypical bodily manifestations," which are now the subject of research. For these authors, these include: – abnormal sensations

(sensory deficits) – abnormal perceptions

(autosopic phenomena, sensation of presence) – difficulties in identifying

certain body parts – representational difficulties

(difficulties in locating certain body parts, experiences

atypical body belonging and alteration of bodily unity)

– agency disorders (difficulty or impossibility in being or feeling like an "actor" in actions) –

affective disorders (anxiety, devaluation of one's own body).

What Ehrsson (2022) calls "body illusions" are modifications of the immediate awareness of one's own body and do not correspond to its actual state. They constitute a valuable tool for studying the perceptual processes and brain mechanisms underlying the feeling of having a body. This chapter analyzes body illusions from the perspective of psychology and cognitive neuroscience. I address classic paradigms such as the rubber hand illusion and limb movement illusions induced by muscle-tendon vibrations. Furthermore, I examine illusions involving both modifications of the location and movement of isolated limbs and more complex illusions involving interactions between multiple limbs and body segments.

I also address illusions related to changes in size, sense of belonging, or number of body parts. Finally, we highlight global body illusions that affect the perception of the body as a whole. Body illusions reveal how information from different sensory modalities—such as proprioception, touch, and vision—is continuously and automatically integrated to generate a coherent multisensory representation of the body in space.

Body ownership and self-awareness, in particular, are made possible through multisensory integration and will be our initial focus. This will be followed by considerations on the concepts of body ownership, consciousness, fragmentation (the impression of alterations to bodily unity), and bodily boundaries.

31/ Body ownership

Being the "owner" of one's body is a fundamental skill. And many patients receiving psychomotor therapy show serious difficulties in this area. What is it?

It was the groundbreaking experiment of the rubber hand illusion that sparked reflection on the issue of bodily ownership. Botvinick and Cohen (1998) hid one of their subjects' hands from view by having it placed flat on a support under the table.

The rest of the same limb was also hidden by a cloth up to the shoulder. The other hand was placed flat on the table. An opaque, vertical partition divided the field of vision into two areas: the visible hand on one side and an empty space on the other. A rubber hand lay flat on the table and in this empty—and visible—space. All three "hands" were thus placed flat, palms facing down (or against the hidden support). The experimenter then gently stroked the same area of the rubber hand and the hidden hand simultaneously with a paintbrush. At the end of the experiment, a questionnaire was given to the participants, and many said that it was as if "they seemed to feel the touch not of the hidden hand but of the visible hand (= the rubber hand). As if the rubber hand were sensitive to touch." Or, put another way: "It was as if the rubber hand were my hand" (sic).

This research therefore raised the question of bodily ownership. Botvinick and Cohen deduced that for a region of our body to belong to us, a robust mechanism was necessary.

Multisensory integration combining tactile, visual, and proprioceptive information: "The rubber hand experience reveals a triple interaction between vision, touch, and proprioception." Ehrsson, Wiech et al. (2007) expanded on this research, finding, using the same protocol, that bringing a needle close to the rubber hand, without touching it, elicited anxiety detectable through imaging. They concluded that: "when people experience an artificial limb as part of their own body, they show the same emotional responses as if it were their real limb that was threatened." In other words: "the artificial limb completely 'replaces' the real limb." Since an emotion is felt, interoceptive mechanisms are therefore involved, in addition to sensory mechanisms, in the sense of body ownership.

We can then understand the role of the insula identified by Scheliga, Kellermann et al. (2022). Here we find the well-known link among psychomotor therapists between emotions and sensations: it is inevitable to elicit emotions, however minimal, when sensations are stimulated in a patient.

We will remember from this paragraph that three sensory modalities, with the help of interoception, are necessary to integrate a part of the body as our own: vision, touch and proprioception.

It is therefore relevant for a psychomotor therapist to take this phenomenon into account in daily clinical practice. We will see later that disturbances in body ownership are possible.

32/ Self-Awareness

Neuroscience is now quite clear on what consciousness is. Damasio (2021) informs us that it is the capacity we possess to "think" in the first person. It is the "protagonist," in the words of the American neuroscientist, which regularly "occurs" in our psychic functioning. Its development during childhood begins with the construction of thalamocortical neural connections from sensory (primarily interoceptive, but also proprioceptive and exteroceptive) and emotional inputs. For Tordjman, Celume et al. (2019), self-awareness is linked to multisensory integration involving "especially vision, proprioception, and touch." This latter form of multisensory integration is therefore concerned with the mechanisms of consciousness as well as those of body awareness.

Self-awareness is based on multisensory integration and the integration of emotions³.

Self-awareness is therefore a capacity of human psychic functioning that concerns psychomotor therapists.

33/ Fragmentation or Alteration of Bodily Unity. The reality

of archaic bodily anxieties (Pireyre, 2021) is frequently debated. It is true that these phenomena were initially described by psychoanalysts and, until now, were based solely on clinical evidence. Pireyre (2026) proposed a sensorimotor interpretation of the *collapse* anxiety described by Winnicott, linking it to a neurodevelopmental disorder (NDD) of the gravitational sensory system. The notion of *fragmentation* was introduced by Melanie Klein and, like the NDD of the gravitational system, may not be anxiety-provoking and can also be considered from a sensorimotor perspective. Research has conceived the paradigm of the "missing hand illusion" to objectively demonstrate the possibility of experimentally deceiving the brain into believing that one of its hands has disappeared. The setup was as follows: "Unrelated subjects placed their hands inside a 'MIRAGE' multisensory illusion box and reached out to touch their right hand with their left. In the 'vanishing hand' critical condition, we created a situation where the right hand unexpectedly disappeared from the visual and tactile field; as a result, subjects reported the sensation of no longer having a right hand and the feeling that this hand was no longer part of their body. In two subsequent experiments, no physiological response was observed."

² This paragraph is, among other things, supported by Pireyre (2024).

³ When our emotions are integrated, we recognize them as belonging to us. They are then feelings.

⁴ It should be noted that the "disappearing" hand was simultaneously and ingeniously moved without the subject's knowledge.

observed when faced with a threat directed towards the missing hand, and the representations of the limb drawn by the participants themselves stopped at the wrist [...] the subjects reported having the impression that their hand had disappeared" (Newport and Gilpin, 2011).

Newport and Gilpin also observed emotional involvement and the participation of the insula. The "disappearance" of the hand was attributed to a failure of the brain to fuse tactile, visual, and proprioceptive information. Again, the network involving the parietal and premotor cortex was implicated.

It is therefore experimentally possible to trick the brain into believing that one of the two hands has disappeared. It should also be noted that Stone, Bullock et al. (2018) devised a similar experimental setup in which the subject's feet could "disappear." The "disappearance" is thus not limited to the hands. And in a slightly different study, Gutersta, Gentile et al. (2013) induced in subjects an impression of "invisibility or transparency" of their own hand.

It is artificially possible to experimentally create the impression of the disappearance of a body part, and therefore of fragmentation (or alteration of bodily unity). The neuroanatomical basis (network and structures) is similar to that required in the mechanisms of multisensory integration.

We can deduce

- that: – Fragmentation does indeed exist and is the opposite of the feeling of unity of the body – That it can provoke emotions, sometimes negative, due to the involvement of the insula – That it is based on well-defined areas and networks of the CNS which usually manage the mechanisms of multisensory integration.
- Disorders of the multisensory integration mechanisms can lead to impressions of fragmentation. We will see this later.

34/ The bodily boundary

This paragraph aims to argue for the reality of the involvement of multisensory integration in the sensorimotor mechanism of constructing the bodily boundary.

Spaegele et al. (2024) state that "bodily boundaries define the self, they separate it from the external environment [...] Those who have well-defined their bodily boundaries are better able to be attentive to their sensations and to interpret them appropriately." For Krzewska and Dolinska-Zygmunt (2013), "bodily boundaries are an important experience related to the formation of personality and identity [...] Sense of one's bodily boundaries is a notion that belongs to body image ."

For these two authors, it is entirely possible to describe the bodily boundary as a cognitive and emotional phenomenon. They define it as a feeling of separation between the person and objects. The skin is seen as a separation. It allows for distinction from the external environment. It is a real and "impassable" barrier, the ability to distinguish what is me and what is not me.

Michael and Park (2016) argue that proprioception and exteroception contribute "to the sense of bodily boundary." Touch, by interpreting stimuli imprinted on the skin, develops the notion of bodily boundary through "a multisensory dynamic, particularly tactile and proprioceptive."

According to Ronga, Galigani et al. (2021), "the map of bodily boundaries is developed by exploiting the mechanisms of multisensory integration." This is because "multisensory integration allows us to distinguish what pertains to the body and what pertains to the environment." And finally: "Bodily boundaries are constructed from multisensory signals."

The concept of bodily limits is indeed one of the consequences of acquiring integration.

Multisensory. In our bibliography, we should add Bullinger (2004), who states that the baby develops its bodily boundary in two distinct developmental stages based on sensory information and its coordination. Tonic variations, resulting from gestural actions, elicit sensations on the inner surface of the skin and initiate the formation of a rudimentary bodily boundary. This boundary is not yet stabilized. For this to occur, the multisensory integration of information received by the outer surface ("the effects of sensory input") of the skin is necessary. "The existence of the (bodily, NDA) boundary depends on the covariation between sensory signals and deep sensitivity." In other words, the bodily boundary is constructed from a strong and sustained coordination between sensory information: – external

information that excites the skin's sensory receptors –

internal information that mobilizes the inner surface of the skin through changes in tonicity.

Exteroception and proprioception are therefore both involved and integrated in the sensorimotor construction of bodily boundaries. Bodily boundaries are thus based on multisensory integration. Let us now examine what research says about pathology. Autism spectrum disorders will illustrate our discussion.

4/ Multisensory Integration Disorders and ASD

It is therefore possible to experimentally deceive the brain regarding the notions of body ownership, fragmentation (or alteration of bodily unity), and bodily boundaries. It is thus possible to consider the existence of pathological populations exhibiting such experiences. Current literature specifically explores these possibilities in the context of ASD. This section aims to describe the reality of multisensory integration disorders in individuals with ASD and to examine their consequences in terms of body ownership, self-awareness, fragmentation, and bodily boundaries.

It has long been known that sensory atypicalities are very common in ASD.

Recently, Mayes, Gentle et al. (2024) stated that alterations in sensory information processing and multisensory integration are "documented in many neurodevelopmental disorders." Difficulties or abnormalities in "multiple" sensory modalities are found extensively in autism spectrum disorders (ASD) (Maqsool, Afzal et al., 2025). Ostrolenk et al. (2019) noted that "69% to 95% of individuals with autism have sensory abnormalities that occur during development and involve all types of sensory modalities." In these individuals, these abnormalities may include, in particular, an alteration in proprioception (Mourad, Grosjean et al., 2025). Proprioception is the primary sensory modality involved in body schema. Because the sensorimotor development of the latter (Pireyre, 2021) is the result of multisensory integration involving proprioception, vision, and the vestibular system. It is also known that children with autism of preschool and primary school age exhibit body schema disorders (Rosa-Neto, Andreis et al., 2026). And "atypical multisensory integration involving proprioception exists in ASD and leads to disorders of self-representation" (Najafabadi and Rastegari, 2025).

The body schema, the result of a certain form of multisensory integration, is affected in ASD, perhaps due to proprioceptive but also vestibular disorders (Pireyre, 2025).

Visual-auditory integration is also less efficient in ASD than in controls (Norcia et al. (2021) and Feldman et al. (2018).

Kawakami and Otsuka (2021), for their part, link multisensory integration difficulties in ASD, both in children and adults, to a delay in sensorimotor development. This idea is also put forward by Ropar, Greenfield et al. (2018): it is the "development of visuo-tactile integration that is delayed."

Choi, Lyons et al. (2025) note differences in the mechanisms of multisensory integration in ASD compared to controls and link this phenomenon to alterations in the activation of the superior temporal sulcus and in the organization of long-wave connections

distance" between certain cortical areas. The "modulation of sensory inputs would be rendered inefficient by altered higher-level networks." According to these authors, social communication disorders and repetitive behaviors would be the consequences.

Disorders of multisensory integration in ASD are therefore very well documented nowadays and justify studying their consequences in the functioning of higher level skills.

41/ ASD and Body Ownership It is known

that individuals with autism are less susceptible to the rubber hand illusion. This means that the notion of body ownership might be "disrupted" in individuals with ASD, since it is less disturbing for them than for control subjects to consider an object as "belonging" to the body. De Clerk et al. (2021) link this phenomenon to disruptions in multisensory integration. Brierly et al. (2019) concur: "Some disorders, including autism, are associated with anomalies in multisensory integration that would make these individuals less susceptible to the rubber hand illusion." Ide and Wada (2017) are even more assertive, stating that "individuals with autism experience a weak sense of body ownership."

The rubber hand experiment teaches us that the integration of proprioceptive, visual, and tactile information is necessary to develop a sense of ownership over our bodies. This integration is frequently impaired in autism spectrum disorder (ASD). These individuals may therefore have little or no sense of ownership over their bodies.

42/ ASD and Self-Awareness

According to Arnaud (2012), "people with autism refer to themselves from the perspective of a third person." The "sense of self" (Lavenne-Collet, Tersiguel et al., 2023) seems to be "very early on lacking in children diagnosed with ASD [...] This is partly evident in difficulties with self-recognition tasks in the mirror" [...] and in the difficulty of distinguishing self/other [...] Impairments in the self/other distinction could be linked to deficits in the development of self-awareness based on bodily information."

In other words, when certain aspects of multisensory integration are impaired, self-awareness is also impaired, and therefore the distinction between self and others is also affected. Individuals with ASD are thus prone to disturbances in self-awareness.

Let's turn to Delafield-Butt and Trevarthen (2017), Bullinger (2004), and Damasio (2021) to delve deeper. These authors offer fairly similar theories when their proposals are examined in detail. The first two authors distinguish three levels of consciousness: primary, secondary, and tertiary. Ordinarily, we move from one to another without realizing it.

- Primary consciousness is managed by the brainstem and is the seat of "sensations, emotions, and motor intentions." This first level of consciousness can be compared to Damasio's (2021) concept of the proto-self, which states: "There is a body that is there and that lives." We can also consider Bullinger (2004), for whom a first stage of sensorimotor development consists, for the baby, in considering its sensations and emotions as "objects of knowledge."
- "The secondary level involves the brainstem and the limbic system. Initial sensorimotor coordination is possible here. One can move the foot or hand to touch." Bullinger speaks of a stage during which the gesture itself becomes the object of knowledge. This also corresponds, in Damasio's work, to the core Self in which "the protagonist can be *momentarily* present." That is to say, at this level, self-awareness is possible, *but only* occasionally.

- Tertiary consciousness shows “representational capacities of abstraction.” For Damasio, this stage corresponds to extended consciousness, i.e., identity, and for Bullinger to the instrumentation of sensorimotor systems (i.e., their coordination, in other words, multisensory integration) allowing both stable and lasting representations and operational consideration of space.

According to Delafield-Butt and Trevarthen (2017), “in autism, disturbances in primary consciousness hinder the development of secondary and tertiary levels of consciousness.” Therefore, multisensory integration difficulties in ASD prevent the development of more sophisticated levels of self-awareness. This is why some patients, stuck in primary consciousness, may remain, seemingly passively, frozen in an endless and more or less outwardly visible search for sensations.

43/ ASD and fragmentation (or alteration of bodily unity)

The objectification of fragmentation rests, as we have seen, on the experience of the illusion of the missing hand. To date, this research has not been conducted with individuals with ASD. Given that multisensory integration (proprioception-vision-tactile) is recognized as impaired in ASD and considered necessary in the general population to avoid “losing” a hand, according to Newport and Gilpin (2011), we can reasonably assume that individuals with autism may experience feelings of loss of a body part, since their multisensory integration mechanisms are impaired (particularly the integration of proprioceptive, visual, and tactile information). Psychomotor therapy regularly demonstrates this. For example, consider the case of the 11-year-old child who asked, “Would you like to climb to the top of the tallest tower in France, fall, and break into a thousand pieces?”

Fragmentation is possible in certain neuropathologies such as somatoparaphrenia and asomatognosia. In the former, Vallar and Ronchi (2009) explain that the patient experiences separation of parts of their body or even their entire body. In the latter, Arzy, Overney et al. (2006) describe individuals who speak of body parts that “have disappeared and/or are missing without visuospatial neglect or any other neuropathological phenomenon.” These individuals even draw their bodies without the “disappeared” hand. In this case, the authors link this “loss” of the hand to damage to cortical regions “integrating visual, tactile, and proprioceptive information.”

In other words, even though research has not yet studied the loss of body parts in ASD, current knowledge about multisensory integration and neuropathological data suggest that fragmentation does indeed exist, both in people with autism and in other populations.

44/ ASD and Bodily Boundaries

According to Bertilsson, Gard et al. (2022), “people with autism have difficulty experiencing their bodily boundaries [...] The difficulties with imitation observed in autism may mean that the boundaries between self and others can become blurred; this would induce a deficit in access to self-awareness.” A link can be made with Lavenne-Collot et al. (2023) who add that, in ASD, patients – have difficulty adopting the point of view of others – do not possess a true theory of mind – are subject to stronger

moments of emotional contagion than neurotypicals.

because they confuse the feelings of others with their own –
frequently use the hand of others – show echolalia
and echopraxia-type repetitive behaviors – and make mistakes in the use of personal pronouns
(you is used rather than me).

In other words, having blurred or even absent bodily boundaries would have many

consequences, both in body image and in social relationships. And this would be the case for people with ASD.

Individuals with ASD therefore each exhibit, in their own way and in their own way, multisensory integration disorders which cause difficulties in body ownership, self-awareness, fragmentation (or alteration of bodily unity) and bodily boundaries.

5/ Discussion

Our discussion will now focus on the consequences of considering the issue of multisensory integration in psychomotor therapy. We will discuss in turn sensorimotor functioning, terminology, child development, psychomotor assessment, and theorization.

In terms of sensorimotor functioning, multisensory

integration is therefore essential. It involves the three main domains of human sensory perception: exteroception, proprioception, and interoception. It regularly involves emotions.

When properly implemented, it allows the individual access to far higher capacities such as body ownership, awareness, bodily boundaries, and a sense of bodily unity. And we haven't even touched upon dyslexia, ADHD, phantom limb experiences, or out-of-body experiences, which research links to multisensory integration.

In terms of terminology,

international literature uses expressions that are sometimes difficult to translate, such as "body ownership" or "disappearing hand." As in the past, psychomotor therapists will not be able to rely on their Anglo-Saxon colleagues and will have to decide on their own vocabulary. The phrase "body ownership" is cumbersome and too strongly suggests a separation between the organism and the psyche. This fragmentation is too heavily influenced, in the opinion of a large part of the profession, by psychoanalytic theory. The term "consciousness" is too polysemous to refer solely to the concept of Damasio's protagonist. And the expression "bodily boundary," which is regularly used in both the singular and plural, including in this article, remains to be clarified. Furthermore, still concerning bodily boundaries, what about these notions of psychic, auditory, and other envelopes...?

In terms of development, newborns

are not without multisensory abilities. Provided that sensations are simultaneous, as early as six days after birth, a baby can reach for a visually presented object; from the first few months, the child can perceive and access meaning from multisensory information; newborns can visually recognize a texture they have manipulated by touch, and around one month old, a baby can clearly show a visual preference for an object they may have previously explored with their mouth (Dionne-Dostie, Paquette et al., 2025). Under certain conditions, a baby can therefore demonstrate multisensory abilities from the earliest days after birth. While this period is important in establishing multisensory integration, its development is still incomplete and will take several more years, as there is a specific window of opportunity for this development. Indeed, auditory-visual integration is still immature around ten to eleven years of age. However, according to Dionne-Dostie, Paquette et al. (2025), although our ability to integrate multisensory information matures late into childhood, it is strongly dependent on our early experiences.

6 that some students tell after a period of relaxation.

7 In the semiotic sense of the term.

In terms of psychomotor assessment tools, significant improvements are needed. Those currently available often only assess the presence of sensory hyper- or hypo-sensitivity or evaluate only a small number of multisensory integrations, whereas a comprehensive assessment should be possible. Furthermore, it is desirable that the profession, both in assessment and in treatment, address the concepts of bodily ownership, consciousness, fragmentation, and bodily boundaries in a much more in-depth way.

In terms of theorizing, it will be

noted that the sensorimotor approach angle has been used here to deal with phenomena previously often classified on the side of "the affective"⁸. "Thus, the notion of bodily boundaries replaces, without exactly juxtaposing, that of envelope. We could consider two phenomena: the bodily boundary, which is a sensorimotor notion, and that of envelope, which refers to the affective realm."

Research has yet to find a term for this fragmentation and uses the circumlocution "missing hand," whereas the subjects in the Newport and Gilpin experiment described a genuine "loss" of their hand. We could now speak of an alteration of bodily unity. At a time when the freedom of their theoretical choices is increasingly restricted for French psychomotor therapists, the reference to sensorimotor therapy allows them to approach the patient from a perspective that is very acceptable to most practitioners because it does not erase older concepts.

The concepts of bodily ownership, self-awareness, fragmentation, and bodily boundaries are genuine psychomotor phenomena that no other professional group than psychomotor therapists is equipped to address while fully complying with the recommendations of the French National Authority for Health (HAS), particularly for autism spectrum disorders (ASD). Indeed, since these four concepts are based on multisensory integration, and therefore on sensory experience, we can no longer remain at the level of overly simplistic or basic aspects of sensory experience. Its complexity and what it enables in human beings must lead us to further enrich our practice.

6/ Conclusion

The main idea of this article was to demonstrate the importance of multisensory integration, what it enables throughout a child's development, and the potential pathologies it can lead to, primarily in autism spectrum disorders (ASD). I hope I have achieved this objective and opened up new avenues for the application of psychomotor therapy. Our founding fathers had no idea of the advances in knowledge brought about by neuroscience.

I would like to state a few additional hypotheses. In the case of neurodegenerative pathologies, whether age-related or not, damage to the central nervous system (networks and regions) could have consequences on the capacity for multisensory integration and "disconnect" the person from their faculties of consciousness, belonging to the body, feeling of bodily unity and bodily boundary.

I mentioned earlier that psychomotor assessment tools could be developed to evaluate the higher-level consequences of multisensory integration disorders. I could add that body ownership, consciousness, bodily unity, and bodily boundaries are genuine psychomotor concepts since they represent, in their own way, certain forms of connection between organism and psyche. Taking these phenomena into account within the framework of personalized and adapted care could give patients with these difficulties the chance to no longer be more or less "ignored" by the healthcare system.

Finally, the theoretical angle chosen for this article is clear: it is sensorimotor. Sometimes in the sense of Bullinger, but more in the sense of neuroscience research. The idea is to adapt to a very strong evolution in the psychomotor therapy profession towards a neglect of the patient's affectivity. To the point that it seems to me that even the notion of tonico-emotional dialogue could be

⁸ Not to mention psychoanalytic.

⁹ The same applies to the notion of gravity and gravitational anxiety (Pireyre, 2025).

"In danger." As a veteran in the industry, I regret this, but adapting is possible without betraying oneself too much.

I hope that our young professionals will have the foresight not to forget that the "whole" patient implies that the patient is, first and foremost, a human being, and that a human being is, first and foremost, a being of emotions. I have faith.

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For the illusion of the disappearing hand (MIRAGE search), you can also refer to: <https://www.youtube.com/watch?v=YOsIO1BPsi0>

Conflict of interest: None.

AI was not used at any stage of the writing of this article.