2-2022

# From Hemispheric Asymmetry Through Sensorimotor Experiences to Cognitive Outcomes in Children with Cerebral Palsy

Iryna Babik
*Boise State University*

symmetry

MDPI

*Perspective*

# From Hemispheric Asymmetry through Sensorimotor Experiences to Cognitive Outcomes in Children with Cerebral Palsy

**Iryna Babik**

Department of Psychological Science, Boise State University, Boise, ID 83725, USA; irynababik@boisestate.edu

**Abstract:** Recent neuroimaging studies allowed us to explore abnormal brain structures and interhemispheric connectivity in children with cerebral palsy (CP). Behavioral researchers have long reported that children with CP exhibit suboptimal performance in different cognitive domains (e.g., receptive and expressive language skills, reading, mental imagery, spatial processing, subitizing, math, and executive functions). However, there has been very limited cross-domain research involving these two areas of scientific inquiry. To stimulate such research, this perspective paper proposes some possible neurological mechanisms involved in the cognitive delays and impairments in children with CP. Additionally, the paper examines the ways motor and sensorimotor experience during the development of these neural substrates could enable more optimal development for children with CP. Understanding these developmental mechanisms could guide more effective interventions to promote the development of both sensorimotor and cognitive skills in children with CP.

**Keywords:** development; hemispheric asymmetry; corpus callosum; sensorimotor experiences; cognition; cerebral palsy; interventions



**Citation:** Babik, I. From Hemispheric Asymmetry through Sensorimotor Experiences to Cognitive Outcomes in Children with Cerebral Palsy. *Symmetry* **2022**, *14*, 345. https://doi.org/10.3390/sym14020345

Academic Editors: Adriana Sampaio, Hsien-Yuan Lane and Ludmiła Zając-Lamparska

Received: 14 September 2021
Accepted: 24 January 2022
Published: 9 February 2022



## 1. Introduction

Hemispheric asymmetry reflects a fundamental principle of neuronal organization and plays a critical role in children's motor, sensorimotor, and cognitive development [1–3]. Early brain injury usually leads to atypical structural and functional brain asymmetries and interhemispheric connectivity, which may negatively affect children's motor control and use of upper extremities, resulting in suboptimal manual sensorimotor experiences [4–9]. Cerebral palsy (CP) defines a group of non-progressive neurodevelopmental disorders attributed to prenatal or perinatal brain injuries that negatively affect children's postural control and movement [10–12]. Because cognitive development is embodied in motor and sensorimotor experiences [13–18], children with CP may exhibit delays and impairments not only in motor and sensorimotor skills, but also in cognitive abilities [2,5,19–27].

The purpose of this perspective paper is to outline the neural mechanisms involved in the ways atypical hemispheric asymmetry, as a result of early brain insult, might affect the development of motor, sensorimotor, and cognitive skills. Understanding the role of these neural mechanisms in atypical developmental pathways should provide important insights into the nature of cognitive impairments in children with CP and enable the design and implementation of effective interventions (targeting early sensorimotor skills) that will promote children's cognitive development. This paper discusses the concept of typical hemispheric asymmetry, patterns of abnormal brain structure, and interhemispheric connectivity in children with CP, sensorimotor and cognitive impairments related to CP, the role of embodiment in the development of sensorimotor and cognitive skills, and possible interventions to improve developmental outcomes in children with CP.

## 2. Hemispheric Asymmetry and Information Processing

Functional hemispheric asymmetries reflect the fact that, although structurally quite similar, the two hemispheres have distinct representation in processing different types of information. The specialization of the two hemispheres increases the information processing efficiency by allowing parallel processing, decreasing duplication, and eliminating potential interhemispheric conflict [28–32]. In auditory information processing, the left hemisphere is responsible for distinguishing phonological differences of language-related sounds and producing those phonological distinctions during speech, whereas the right hemisphere specializes in processing melodies, rhythms, environmental noises, and the emotional prosody of speech [33–35]. In visual information processing, the left hemisphere is dominant for facial recognition and the generation of voluntary facial movements, whereas the right hemisphere is better at differentiating faces from non-faces [34]. Recent research also proposed that the left hemisphere is specialized for activation–inhibition coordination, thus justifying its dominance in both manual and verbal skills [36].

Importantly, previous research suggested that hemispheric specialization does not depend on the modality of processed information (e.g., haptic, auditory, or visual) but rather on the relative characteristics of the stimuli. One such account of the processing specialization that gained empirical support from previous research and is most applicable to the discussion of hemispheric lateralization in CP is the ***frequency-dependent hemispheric processing hypothesis*** [37,38]. According to this hypothesis, there are two neuronal systems associated with processing any complex, hierarchically organized stimuli: (1) extracting higher-frequency transitions in spatial and temporal patterns of ***local stimuli***, thus specializing in phonological distinctions, facial recognition, and decoding letters/words, and (2) processing lower-frequency transitions, or ***global stimuli***, which typically have a contextual character (e.g., rhythm, emotional tone, complex scenes, and relative position in space). Previous research reported that the left hemisphere is specialized in the ***analytic processing*** of high-frequency, local transitions, whereas the right hemisphere specializes in the ***holistic processing*** of low-frequency, global stimuli [36,39–44]. Note that the distinction between the two hemispheres in the "preferred" frequency of processed information is quite relative: each hemisphere is capable of processing the "non-preferred" range of frequencies but would not be as effective as the other one [37,45].

Given that hemispheric specialization increases the efficiency of information processing [28–32,46], stronger hemispheric asymmetry should be associated with better motor, sensorimotor, language, and cognitive performance. This hypothesis has been tested by relating children's handedness to their developmental outcomes. Handedness may serve as a convenient marker of the hemispheric specialization of function [47–54], with strong hand-use preference representing stronger underlying hemispheric lateralization. Thus, strong and consistent hand-use preference has been predicted to be associated with better developmental outcomes. Indeed, previous research found the benefits of early-developing, strong, and consistent handedness for object management skills associated with symbolic development [55,56], block stacking skills associated with the comprehension of spatial words and language acquisition [57,58], and language skills [59–61]. To further emphasize the role of hemispheric specialization in optimal development, atypical hemispheric specialization has been widely associated with neurobehavioral dysfunctions and intellectual disabilities, such as developmental stuttering, dyslexia, autism, Down syndrome, schizophrenia, and psychosis [62–72].

## 3. Hemispheric Asymmetry in Children with CP

Cerebral palsy is usually attributed to prenatal or perinatal brain insult [10–12]. The most common brain insults associated with CP are white matter lesions in periventricular areas, basal ganglia and thalamus lesions, gray matter lesions in cortical and subcortical regions, cerebral malformations, enlarged ventricles, focal infarcts, and diffused grey matter lesions [73–77]. Sensory tracts may be less affected by periventricular white matter lesions that typically occur after the refinement of thalamocortical tracts, whereas lesions to basal ganglia, thalamus, and cortical gray matter, occurring after thalamocortical projections reach cortex, may lead to severe disruptions in somatosensory function [73,76,78–82]. As a result, children with CP often exhibit abnormal patterns of tactile and visual information processing [83–91]. For example, in visual processing, children with CP often exhibit reduced contrast sensitivity and visual acuity, difficulty with fixation, abnormal saccadic movements, strabismus (an abnormal alignment of the eyes resulting in uncoordinated eye movements, double vision, difficulties in depth perception, etc.) and refractive errors [84,92–95]; in tactile processing, CP diagnosis is often associated with tactile registration and perception deficits [96,97]. Importantly, due to abnormal sensorimotor processing and interaction between sensory modalities, early spontaneous movements that allow for the refinement of sensorimotor connections in typically developing infants might not have this effect in children with brain lesions [98,99].

The motor system seems to be relatively more robust to early brain insults than the sensorimotor one; perhaps, its later developmental timeline permits considerable reorganization in the corticospinal tract, which is responsible for voluntary motor function. For example, in typically developing infants, during the first 6 (and up to 18) months after birth, competition between the hemispheres for information processing results in the gradual reorganization of neural pathways, with the reduction in the number of ipsilateral connections and strengthening of the contralateral ones. The latter exhibit lower thresholds, shorter latencies, and larger amplitudes compared to ipsilateral connections in response to transcranial magnetic stimulation [4,100]. Early brain damage in children with unilateral CP may disrupt contralateral corticospinal connections, resulting in atypical patterns of corticospinal tract connectivity [4,100–103]. Indeed, for about 30% of children with hemiplegic CP, control of the affected hand resides in the ipsilateral hemisphere [79,104–107]. Moreover, the movement of the affected hand typically corresponds to an increased activation in bilateral primary sensorimotor cortices [9,108].

On a behavioral level, this abnormal brain asymmetry leads to reduced control of the contralesional limb, spasticity, and mirror movements [104,106,109–111]. (Mirror movements are simultaneous, involuntary, and non-goal-directed movements of a limb that accompany goal-directed activity in the contralateral limb, typically prevalent in infants' motor repertoire during the 4.5–7.5-month age period [112,113]). Because ipsilateral connections are less effective than contralateral ones, the ipsilateral control of the affected hand in children with hemiplegic CP is typically associated with poor motor control and impaired performance [102]. The compromised transmission of sensory feedback from the affected hand to the motor cortex through inefficient ipsilateral connections, coupled with the manifestation of mirror movements and visual hemianopias (brain function conditions in which a person is only able to see one side of the visual field) likely forms the foundation for suboptimal motor control and bimanual coordination in children with unilateral CP [79,102,114]. Additionally, the interaction between the contralateral somatosensory pathways and ipsilateral corticospinal motor pathways may result in interhemispheric dissociation between sensorimotor inputs and outputs [2].

Unilateral brain injury leads to motor impairments in the contralateral side of the body, resulting in hemiplegic CP. The severity of motor impairment is highly associated with the extent of brain damage in the contralateral hemisphere [115–117]. Although both upper and lower extremities may be affected in hemiplegic CP, the current paper focuses on the function of the upper extremities. Children with hemiplegic CP tend to "disregard" the affected limb; the resulting lack of motor practice (i.e., "developmental disuse") reduces the likelihood of spontaneous reaching and grasping movements in the affected limb, thus impairing "practice" with its motor control and performance [118,119]. The tendency to only use one hand further impedes bimanual coordination, sophisticated object exploration, and self-care abilities, thus negatively affecting a child's independence and quality of life [118,120–122].

## 4. Interhemispheric Connectivity in Children with CP

The corpus callosum (CC) is the major commissural tract connecting and coordinating the two cerebral hemispheres to allow the integration of sensorimotor information and the optimization of information processing [123,124]. According to some accounts, the CC enables hemispheric specialization by inhibiting one hemisphere during the activation of the contralateral hemisphere in cases when simultaneous activity would compromise information processing [125,126]. More recent research, however, suggests that efficient lateralized processing is achieved by weaker callosal connections between functionally lateralized homologous cortical areas and stronger callosal connections between the non-lateralized areas [127,128].

In typically developing children, the formation of the CC starts around the 12th week of gestation, with all fibers being in place by the 20th week of gestation. However, the process of myelination, which starts around the 4th prenatal month, continues well into adulthood [53,129–131]. Importantly, in the first years of life, the underdeveloped CC may not allow appropriate information sharing between the two hemispheres, thus restricting asymmetric sensorimotor processing to a specific hemisphere and facilitating the development of hemispheric specialization of function [132–135].

Previous research showed that children with CP have a smaller CC and reduced white matter integrity in the CC compared to their typically developing peers, with the extent of structural changes in the CC being directly related to the size of the lesion [5,9,136,137]. These structural differences in the CC may negatively affect motor and sensorimotor function in children with CP [5]. For example, the reduced white matter integrity in the CC is associated not only with motor impairment in the affected hand but also with motor deficits in the non-affected hand and poor bimanual skills [9,138–141]. Furthermore, a lack of transcallosal inhibition allows for the bilateral activation of primary sensorimotor cortices, which results in mirror movements [2].

Importantly, the CC is responsible for the integration of the motor and somatosensory information, as well as bilateral coordination in motor and visuomotor tasks, especially those requiring simultaneous/parallel processing and the timely adjustment of movements performed by two hands [123,140,142–144]. Note that the acquisition of new motor skills typically requires one to learn finely timed, ordered sequences of actions and the bimanual coordination of parallel movements, both requiring effective interhemispheric transfer via the CC [141,142,144–148]. Thus, an underdeveloped CC in children with CP might interfere with their execution of finely timed sequences of actions, bimanual performance, and motor learning in general [139,141,149–152].

## 5. Sensorimotor and Motor Outcomes in Children with CP

"Developmental disuse" of the affected limb in children with hemiplegic CP may manifest as: (1) motor neglect [119,153,154], (2) visuoperceptual and spatial neglect [155–157], or (3) deficits in body representation [153,158,159]. Each type is discussed below.

### *5.1. Motor Neglect in Manual Skills*

In typical development, starting from weeks 7–8 prenatally, human fetuses exhibit spontaneous movements (also called general movements) of the extremities, which are highly predictive of future neurodevelopmental outcomes [160–165]. An abundance of variable and complex spontaneous movements allows appropriate motor and sensorimotor feedback that facilitates the refinement of motor and sensorimotor pathways, thus improving motor control and coordination [166–169].

Newborn infants typically demonstrate spontaneous, swiping arm movements [170,171]. With time, these diffuse movements become more coordinated and goal-directed, resulting in infants' reaching for and grasping of objects at the age of 3–4 months [112,172–177]. By this age, infants are capable of both unimanual and symmetrical bimanual reaches [178]. Increasing specialization in brain activity and improved interhemispheric connectivity result in the gradual transformation of earlier synchronized and symmetrical bimanual movements into de-coupled, asymmetrical role-differentiated bimanual manipulations by the age of 7–13 months [112,138,179–185]. (In role-differentiated bimanual manipulation, the two hands perform complementary actions while manipulating an object: one hand plays a passive, supportive role while the other one actively manipulates movable parts of a toy [186]). Furthermore, diverse motor and sensorimotor experiences continue to increase the specificity of the developing motor system: pruning of ipsilateral corticospinal pathways and increasing callosal functioning both lead to a decrease in mirror movements during the 9–12-month age period [100,112,187,188].

Infants with CP exhibit a lack of spontaneous movements or abnormal spontaneous movements (e.g., cramped-synchronized movements – sudden, synchronous movements of the trunk and limbs; [162,166,189–191], which result in missed opportunities to establish an adequate “forward” internal model, thus negatively affecting the child’s ability to predict the sensorimotor consequences of their own movements and execute anticipatory motor planning [192–194]. Moreover, children with CP demonstrate not only atypical spontaneous activity and decreased active range of motion but also impaired selective motor control that is manifested in muscle group synergies and mirror movements [195–197]. Muscle synergies interfere with the execution of voluntary, goal-directed movements; for example, a simple act of bringing a cup to the mouth would require simultaneous wrist extension and elbow flexion; atypical flexor synergy, in this case, would prevent wrist extension and, thus, impede the functional movement [195]. It is important also to recognize the crucially collaborative role of pyramidal (corticospinal) and extrapyramidal tracts in the development of motor control; for example, reticulospinal and vestibulospinal tracts were found to be associated with the coordination of finger movements that typically rely upon corticospinal tracts [198].

Furthermore, mirror movements of fingers, hands, and arms in children with CP may impede effective independent control of the hands [196]. Whereas mirror movements disappear with increasing age in typically developing children, those with CP show no such trend: strong mirror movements (15 times stronger than those observed in typically developing controls) were recorded in children with CP at the ages of 6–18 years [196]. Some research suggested that mirror movements are more prevalent in the affected hand [199,200], whereas more recent research found stronger mirror movements in the unaffected hand as a result of the voluntary activity of the affected hand [196,201]. On a behavioral level, damage to one or both hemispheres in children with CP disrupts movement in the contralateral side of the body; the resulting “developmental disuse” of an affected limb negatively affects bimanual coordination during tasks that require the participation of both hands [120]. Mirror movements further disrupt bimanual coordination and performance in children with CP, given that bimanual activities typically require independent control of the two hands, achieved by the inhibition of involuntary movements [196,202,203]. Thus, children with CP often exhibit significant delays and impairments in motor control, the execution of goal-directed movements, and bimanual coordination, which may impede their motor and sensorimotor awareness and anticipatory motor planning.

### *5.2. Visuoperceptual and Spatial Neglect*

Importantly, “developmental disuse” of the affected limb in children with hemiplegic CP may stem not only from motor dysfunction but also visuoperceptual deficits [153,155–157,204]. Indeed, previous research showed that early brain injuries produce specific spatial cognitive deficits [205–209]. Unilateral brain damage in children with hemiplegic CP may disrupt the processing of visual information, resulting in unilateral spatial neglect manifested as an inability to attend, process, and report on sensory events occurring in one side of extrapersonal space [155–157,210,211]. For example, children with hemiplegic CP tend to draw asymmetrical pictures of the human body, often distorting the side of the picture corresponding to their own affected limb [153,212]. Although spatial neglect in children with hemiplegic CP is often identified with paper-and-pencil tests, the latter might be less effective than functional assessments [211]. In general, the scarcity of quality research on spatial neglect in pediatric populations has resulted in the lack of valid assessment and treatment methods [211].

Note that there are two generally hypothesized functionally distinct visual pathways in the cerebral cortex: (1) the ventral (occipito-temporal) pathway, responsible for the discrimination of shapes, objects, words, and faces, and (2) the dorsal (occipito-parietal) pathway, mapping complex visual scenes and executing visually guided movements, such as reaching and grasping [213–215]. Previous research showed a strong association between periventricular leukomalacia (PVL—a form of brain injury affecting white matter near the ventricles; PVL is closely associated with premature birth) and cerebral visual impairment, which could manifest as deficits in both ventral and dorsal pathways [83–86,88,90]. In addition, disruptions in structural and functional hemispheric connectivity as a result of periventricular leukomalacia reportedly affect visual pathways involved in the processing of body motion [216]. As a result, children with CP may exhibit deficits in visual attention, the recognition of object and faces, handling of complex scenes, and navigation. Neuroimaging research supported behavioral observations: visuoperceptual deficits have been associated with white matter reduction and ventricular enlargement in the occipital and parietal regions of the brain, as well as structural abnormalities of the corpus callosum's splenium [217–220].

In agreement with the ***frequency-dependent hemispheric processing hypothesis*** (Sergent [37–39]), suggesting the right-hemisphere dominance in global processing and the left-hemisphere specialization in local processing, children with right-hemisphere lesions reportedly showed difficulties in spatial integration, whereas children with left-hemisphere lesions struggled with processing pattern detail in both two-dimensional and three-dimensional arrangements [205,207]. For example, in their drawings of people and houses, children with right-hemisphere damage would depict appropriate parts but fail to arrange them into spatially coherent, meaningful forms [209]. Spatial cognitive deficits were found to be more persistent in children with right-hemisphere lesions [205]; these findings correspond well with previous research showing limitations in brain plasticity for non-verbal functioning as a result of early right-hemisphere insult [157,207,209,221,222].

Importantly, deficits in both manual and visuospatial skills in children with CP often result in their impaired visuomanual coordination. For example, children with CP, especially those with right-hemisphere lesions, exhibited difficulty with drawing, copying designs/complex figures, and handwriting skills [207,209,223,224]. Note that in typically developing children, the visuomotor coordination skill of design copying, measured at the age of 3–4 years, was found to be predictive of reading, math, and science performance from kindergarten through to the age of 13–14 years [225,226].

I propose that the relation between early visuomanual skills and future linguistic and mathematical performance may be mediated by the influence of visuomanual skills on a child's symbolic development. Given that pictures and designs are symbols representing reality, the ability to perceive, analyze, and coordinate the movements required to reproduce a picture should promote a child's symbolic development [227–229]. This symbolic development, in turn, is relevant for the development of linguistic and mathematical processing [230–237].

### *5.3. Body Representation and Mental Imagery*

Mental representation of one's own body involves the processing and monitoring of afferent visual, somatosensory, and motor inputs, as well as interoceptive and proprioceptive feedback as a result of motor execution [238–240]. ***Triadic taxonomy*** is the most common way to describe different aspects of body representation. The triad is: (1) the Body Schema, relying on sensory–motor information to define the body's position in space, (2) the Body Structural Representation, consisting of a mental topographic map of the body, and (3) the Body Semantics (also called Body Image), reflecting the linguistic and conceptual representation of the body used in communication and self-identity [241–243].

Previous research identified cortical areas responsible for the processing of these three body representation types: the Body Schema was reportedly associated with the posterior parietal cortex, the Body Structural Representation was linked to the ventral lateral occipitotemporal transition, whereas the Body Semantics was related to the insula [244]. Although the hemispheric laterality of body representations and body motion is still unclear [244], previous research suggested that adolescents and adults with left-hemisphere damage (right hemiparetic CP) showed significant deficits in their processing of the Body Schema and Body Structural Representation [159,245–248].

During typical development, the Body Semantics (measured with the Object–Body Part Association Task [249]) seems to reach a more complete pattern of performance first—by the age of 4–5 years, followed by the Body Structural Representation (measured with the Frontal Body Evocation Task of the Body Representation test [250]), which seems to reach an adult-like pattern of performance by the age of 9–10 years. The Body Schema (measured with the Hand Laterality Task [251]) seems to take the longest to reflect adult-like performance [250,252–256]. The concept of the Body Semantics has been found to be positively related to that of the Body Structural Representation [253,257]. The Body Schema is usually evaluated using so-called "***motor imagery***" tasks that require mental simulation of physical movement to make laterality judgments based on pictures of body parts (e.g., hands and feet) presented in different orientations. Typically developing individuals tend to show a linear increase in reaction time in response to increasing rotation angle [158,159,242,249,258].

Among children with CP, 63.64% of 5–12-year-olds showed poor performance in body representation processing in at least one of the three types: 56.3% in the Body Structural Representation, and 21.2% in both the Body Schema and the Body Semantics [158]. The performance of children with CP on the three body representation types seems to follow the same developmental sequence observed in typically developing children: among 5–7-year-old children, there was no difference found in mental imagery performance between those with CP and their typically developing peers, whereas 8–12-year-old children with CP showed deficits in the Body Schema and the Body Structural Representation, but not in the Body Semantics [158]. Additionally, adolescents with hemiplegic CP were slower in their hand laterality judgments compared to a neurologically healthy control group, especially while judging pictures representing the affected hand, suggesting that deficits in motor control negatively affect motor imagery [259].

Moving beyond the triadic taxonomy, processing ***self-body representation*** has been shown to be as affected in children with CP as processing generic body representations discussed above. Using self-portraits to study self-body representation, significantly more asymmetry between the length of the affected vs. non-affected upper limbs was found in the drawings of 5–10-year-old children with CP compared to typically developing controls [212]. Interestingly, children with CP exaggerated the asymmetry of their own body not only in comparison to their typically developing peers, but also in comparison to other children with hemiparesis; these asymmetries in body representations of children with CP may reflect their perception of their own functional deficits experienced in the hemiparetic limb [212,260].

Impairments in the production of body motion in individuals with CP are closely associated with deficits in ***body motion perception*** [216,261,262]. The latter is typically studied using series of static point-light body motion displays in which bright white dots on a black background represent the main joints and the head of a "walking" or "gesture-producing" human body [262,263]. Previous research associated the processing of body motion with portions of the parietal and frontal cortices, the right posterior superior temporal sulcus, the right parieto-temporal junction and fusiform gyrus, as well as the amygdala [264–276]. The involvement of the amygdala should not be surprising, because the correct interpretation of others' body movements, or body language, provides valuable social cues to other people's emotions, dispositions, and intentions [277–279], which would guide approach vs. avoidance reactions.

Typically developing children gradually improve their perception of body motion in point-light displays until ceiling levels are reached at the age of 5 years [263]. By contrast, children and adolescents with CP show significant difficulties in the processing of body motion and gestures [262,263,280,281]. For example, individuals with hemiplegia show deficits in both the recognition of gestures that appeared to be performed by their affected arm [262] and the imitation of meaningful gestures pointing to different parts of the body [245,282]. Note that gestures advance children's symbolic development: children's pointing to an object often triggers their caregivers' naming the object, thus forming the connection between the label (symbol) and the object it stands for in the child's mind [283–285]. Gestures also mediate the positive relation between motor and language development [231,284,286–290]. Thus, difficulties with gesture processing in children with CP might have negative consequences for their language and cognitive development.

Importantly, deficits in body representations in children with CP might stem from difficulties in other domains, such as linguistic, semantic, visual, attentional, or ***mental imagery*** [158]. In this case, similar deficits would be observed in both body-related and non-body-related stimuli. Indeed, in the control, non-body stimuli condition, 41.9% of children with CP showed difficulties in visuospatial tasks and 48.5% struggled with mental rotation [158]. Mental rotation, representing mental imagery, is a spatial skill that requires the mental transformation of a stimulus (e.g., object) to accurately predict the stimulus' appearance from a different angle or to judge whether two stimuli viewed from different perspectives are the same [291,292]. Research in typically developing children showed that active object exploration and self-locomotor experience (e.g., crawling) advance mental rotation skills [293–295], suggesting that visuomanual coordination, multimodal exploration (e.g., visual, auditory, oral, or tactile), and proprioceptive experiences during object exploration might inform children's high-level cognitive abilities [296]. Furthermore, mental rotation abilities are positively related to reading English, which requires discrimination between mirror-image letters such as "b" and "d", or "p" and "q" [297,298]. Mental rotation was also positively related to children's performance in math [299–303] and geometry [304].

Mental rotation is a very useful skill that we use in everyday life to ***navigate*** our environment: we might make left–right–left turns on our way to a grocery store, but then we have to make right–left–right turns to come back home; we also need mental rotation skills to read maps and decide which way to turn according to the map. Not surprisingly, CP individuals with periventricular leukomalacia, as well as those with hippocampal volume reduction, often exhibit difficulties navigating their environment and finding their way [305–309]. Visual navigation has been associated with the right prefrontal lobe and hippocampus [310–312]. Note that the volumetric extent of the right frontal lesions in individuals with periventricular leukomalacia was negatively related to visual navigation ability, as tested by the paper-and-pencil labyrinth test of the Wechsler Intelligence Scale for Children III [313]. It has been proposed that periventricular lesions, especially those to more anterior areas, may disrupt connectivity between the hippocampus and frontal cortices, thus negatively affecting visual navigation [216]. Importantly, pictures, schemes, and maps depicting a scaled version of our environment are symbols representing that environment; thus, an ability to interpret a map represents a child's symbolic development [227–229], a sophisticated cognitive skill later used for language development in that words are symbolic representations of objects and ideas [230,232,234–237].

Furthermore, body awareness (i.e., perception of own body) and motor imagery performance are fundamental for ***anticipatory motor planning*** [159,314] and motor control [239], which, in turn, affect the execution of daily-life activities (e.g., personal hygiene, dressing, eating, using tools, and ambulating) and one's overall quality of life [118,122]. Motor planning is typically tested using end-state comfort tasks in which a subject is required to sacrifice the postural comfort of the initial grasp in order to place an object (e.g., a cup) into a particular orientation with the comfortable final-state grasp [315,316]. In this case, the end-state comfort is more important than the initial-grasp comfort, because the latter would result in the participant's inability to complete the task due to biomechanically impossible end-postures [159]. Individuals with hemiplegic CP, especially those with congenital damage to the left hemisphere, showed inadequate anticipatory planning in end-state comfort tasks [159,246,314,317–321].

These findings are in line with the previously reported involvement of the left hemisphere in action planning [322,323]. The reduced capacity for motor imagery may prevent individuals with CP from performing the required mental simulation of the perceptual–motor consequences of the initial grasp in order to achieve a biomechanically comfortable end-posture [159,324–326]. Motor planning also is critically important in sequential tasks that involve role-differentiated bimanual manipulation (e.g., acquiring an object with the non-preferred hand to actively manipulate movable parts of the object with the preferred hand [179]) or means-end problem solving and tool-use, both requiring one to act on the "means" object to affect the "end" object [327–333]. In summary, motor imagery is embodied in motor control and the execution of actions: the performance of movements results in motor and sensorimotor afferents that stimulate the development of neural motor programs, which consist of body representations to guide new movements [259,334–336].

## 6. Cognitive Outcomes in Children with CP

The heterogeneous nature of CP makes any generalizations in the realm of cognitive function difficult. On the other hand, matching abnormal structures and neuronal activation in specific brain areas to cognitive outcomes provides important insights into brain substrates of cognitive functioning. Importantly, clinical data on children with CP provides non-refutable evidence that cognitive development is embodied in early motor and sensorimotor experiences (discussed in more detail in Section 7 below).

### *6.1. Linguistic Skills*

In children with CP, the results of dichotic listening tests suggested that language lateralization transferred to the right hemisphere after left hemisphere damage [21,337]. Importantly, damage to either hemisphere reportedly alters the typical lateralization of language [21,337]. Additionally, **irrespective of the lesion side**, the size, location, and timing of the lesion would determine, to a large extent, the pattern of brain reorganization [21,337]. For example, cortical–subcortical lesions were associated with the interhemispheric reorganization of language, whereas lesions to periventricular white matter resulted in intrahemispheric reorganization [337]; lesions at term age were more likely to result in interhemispheric reorganization than those occurring preterm [337]; and the size of the lesion was also directly related to the extent of atypical language lateralization [21]. Importantly, atypical language lateralization after left-hemisphere lesions was associated with deficits in expressive vocabulary and receptive–expressive grammar [338–341]; a short-term (15 months post-baseline) follow-up showed more deficits in expressive language skills in children with left-hemisphere damage compared to those with right-hemisphere damage [21]. Thus, early neural plasticity (the ability of spared cortical areas to assume functions typically assigned to the damaged areas [341]), reflected in the reorganization of the hemispheric lateralization of language after damage to the left hemisphere, may come at a cost of slow language acquisition [21,338,341].

Interestingly, previous research with typically developing adults showed significantly better verbal comprehension in cases when language and spatial processing were dissociated between the two hemispheres as compared to cases when the two types of information were processed in the same hemisphere [46]. This cognitive advantage of hemispheric specialization was explained with the "***hemispheric crowding***" hypothesis [105,106,342–345], which suggests that the overload of one hemisphere with processing of multiple types of information (e.g., linguistic and spatial) would result in cognitive deficits due to computational capacity limits of that hemisphere. In this case, individuals with early left-hemisphere damage and interhemispheric language reorganization, having both linguistic and spatial processing "crowded" in the right hemisphere, would be expected to show cognitive deficits.

Although atypical hemispheric lateralization seems to affect children's performance across multiple linguistic subdomains [346], some skills may be affected more than others. For example, 7-to-14-year-old children with left-hemisphere damage (right hemiplegia) have been shown to have more difficulties with syntactical awareness and sentence repetition than with receptive vocabulary [347]. To explain these findings, it was proposed that neural reorganization as a result of early brain lesions may produce competition of different functions for synaptic sites; as a result of such competition, early-developing functions (e.g., receptive vocabulary) might "crowd-out" later-developing, more sophisticated functions, such as syntactical awareness [342,347].

Furthermore, children with CP often exhibit slower reading despite adequate letter recognition [22,348–350]. Most reading difficulties in children with CP could be attributed to their deficits in phonological processing and/or visuospatial perception [22,351]. The latter deserves special attention in the context of the current paper. Note that fast reading is achieved through the holistic, global processing of meaningful high-frequency words, whereas analytic processing is typically used by beginners or individuals with reading deficits [352–355]. Whereas for typically developing individuals global processing seems to precede local processing [43], deficits in global processing in individuals with CP make them deviate from this typical pattern of information processing [19,356]. Thus, reading difficulties in children with CP may stem from the lack of global advantage, but future research should test this hypothesis.

### 6.2. Subitizing, Counting and Arithmetic Skills

The development of more sophisticated math skills, such as counting and arithmetic, may depend on earlier-developing subitizing skills [23,25,26,356]. Subitizing is an ability to rapidly and accurately estimate the number of presented items without counting them [357]. Subitizing involves the seemingly automatic recognition of visual patterns (e.g., a triangle made of three dots, a rectangle made of four dots) involving up to 4–6 elements [358–361]. Children with CP exhibited a much lower subitizing limit and a sharp decline in accuracy with an increase in the number of elements in presented patterns than typically developing controls [19]. In contrast to typically developing children, those with CP also showed equal difficulty with classic subitizing (providing a number estimation) and pattern recognition (naming the presented pattern), suggesting that their subitizing difficulties are not number dependent, but rather stem from impaired visuospatial short-term memory, a deficit in visuospatial pattern recognition, and/or an inability to perceive spatial patterns as a Gestalt [19]. A Gestalt represents a holistic form of pattern perception (similar to global processing, discussed above) that allows the integration of local elements into global entities [362,363], such as seeing a big letter H despite the fact that it is constructed from small letters S [43].

On a behavioral level, subitizing is remarkably similar to Gestalt perception in that they both require the processing of information in the top-down manner, quickly incorporating low-level elements into high-level configurations and attending to the latter first [364]. On a neural level, subitizing and global processing seem to share the same substrates: subitizing reportedly relies on posterior temporo- and occipito-parietal areas [356,365–368], whereas Gestalt perception involves posterior temporo-parietal brain regions [369–375].

Importantly, previous research suggested that children with CP are delayed not only in subitizing [19,356], but also counting [27,356] and arithmetic skills [24]. It is likely that subitizing is a prerequisite for later-developing, more sophisticated math skills. Although previous research showed a positive relation of subitizing to counting and arithmetic skills [23,25,26,356], it is hard to establish causality here, in that all of these skills may rely on the same set of sensorimotor and cognitive skills. Indeed, both subitizing and counting skills depend on adequate visuomanual coordination [356,376]. For example, finger agnosia (difficulties with finger recognition and discrimination) was found to be highly predictive of both subitizing limit [356] and numerical abilities (abilities to group, compare, and count small numbers of objects) in children with CP [377], whereas dyspraxia (a neurological disorder that negatively affects motor coordination) in children with CP resulted in difficulties with coordination of pointing and counting, which impeded quantity evaluation [378].

Additionally, visuomanual coordination may assist young children in counting, because they typically use fingers for pointing at objects before they learn to rely on visual pointing; manual pointing allows one to keep track of already counted elements and likely facilitates the acquisition of mental number representations and counting principles [379–384]. Given that both goal-directed manual actions and number processing activate the same brain regions (e.g., intraparietal sulcus [385]), there may be a close relation between these domains [27,386]. Importantly, visuomanual coordination may enable the perception of global structures within local elements in spatial arrangements, which should further facilitate subitizing [356].

Finally, language plays an important role in solving arithmetic problems that have a verbal component [387]. Neuroimaging research showed that linguistic areas (e.g., left angular gyrus) are activated by math word problems [388]. Even after controlling for general intelligence and working memory, numerical abilities were associated with children's grammar skills, word decoding, and phonological awareness [27,389]. Thus, difficulties in language skills in children with CP may contribute to their suboptimal math performance.

In terms of hemispheric specialization, a strong association has been reported between subitizing and right hemisphere processing. For example, the use of a tachistoscopic technique in typically developing adults showed right-hemisphere (left visual field) advantage in subitizing [390–393]. Similarly, in children with CP, right-hemisphere lesions were related to difficulties with subitizing, especially on canonical (i.e., dice patterns) rather than random patterns [19,356]. Thus, previous research in both typically and atypically developing children and adults suggests that damage to the right hemisphere may negatively affect subitizing through disruptions in Gestalt processing. There is more ambiguity in the research on neural substrates of counting. Whereas research on typically developing adults suggested left-hemisphere (right visual field) advantage in counting tasks [392], in children with hemiplegic CP, poor arithmetic skills were associated with right-hemisphere lesions (left-hand impairment), suggesting the involvement of the right hemisphere in the processing of complex mental calculations [27,348,394–396]. It could be the case that lateralization for the complex skill of counting shifts with age, with early counting skills (dependent on visuomotor processing) residing in the right hemisphere, but with later-developing, more sophisticated counting skills (dependent on analytical processing) being processed in the left hemisphere. Alternative explanations are also possible: (1) children with hemiplegic CP might show atypical lateralization of this process; or (2) in children with CP, this skill may critically depend on bilateral recruitment.

### 6.3. Executive Function Skills

Executive functions are high-level neurocognitive skills that include goal-directed behavior: attention, impulse control, flexible thinking, problem-solving, and planning to achieve short- and long-term goals [20,397]. Information processing related to executive functions is predominantly coordinated by the prefrontal cortex [398–400], with deficits in executive functions (e.g., inhibition and shifting skills) being associated with atypical lateralization in the frontoparietal network [401,402]. Because executive functions depend on the integrity of white matter (especially in the periventricular and anterior areas) that permit extensive connectivity between different brain regions, brain lesions in children with CP place them at risk for impairments in executive functions [20,403]. Additionally, white matter disruptions may be associated with the reduced speed of information processing, which further negatively affects children's performance of executive functions [20,404,405]. Indeed, children with unilateral or bilateral CP were found to be significantly impaired in working memory, sustained and divided attention, response inhibition, and shifting skills [20,405–409].

Deficits in impulsive inhibition in children with CP [20,405,408] may signal a potential for behavioral problems and impairments in social skills in this population [410,411], whereas impaired working memory, attention, and shifting skills may result in learning difficulties and cognitive delays. For example, previous research showed that subitizing, counting, and arithmetic skills depend on executive function skills, such as focused attention, shifting, working memory, and updating (the latter facilitates the performance of mental operations through replacing no longer relevant facts in the working memory with incoming relevant information) [24,396,397,408,412–419]. Thus, executive function deficits in children with CP might negatively affect the development of their subitizing, counting, and numerical abilities, which, in turn, are precursors for later-developing math skills [420–423]. Additionally, deficits in sustained and divided attention in children with CP are potentially detrimental for academic success [20,405,409].

Deficits in attention skills in 9–13-year-old children with CP have been attributed to children's distractibility [20]. Interestingly, previous research found a positive relation between the number of extraneous movements and attention skills in typical development. For example, it has been demonstrated that 4.5-to-7.5-month-old infants who showed better visual attention during object manipulation exhibited fewer extraneous movements [113]. This finding can be compared to the report that more easily distracted school-aged children manifested more extraneous movements [424]. Perhaps, in typically developing children, these two behaviors may have inverse trajectories: whereas mirror movements decrease by the end of the first year of life [100,112,187,188], visual attention abilities gradually increase during the first year [425,426]. Thus, it is likely that persistent mirror/extraneous movements in children with CP disrupt the development of attention skills. In this case, interventions targeting early sensorimotor experiences and bimanual coordination may not only improve contralateral hemispheric connectivity and interhemispheric transfer of information but also facilitate attention skills through a reduction in mirror movements.

## 7. The Role of Experience in the Development of Hemispheric Asymmetry

There are two important conceptual frameworks that may explain developmental pathways during infancy and childhood: the embodied cognition and the dynamic systems theories. The ***embodied (or grounded) cognition theory*** proposes that the development of cognition stems from early motor and sensorimotor activities and experiences [13–15,18,427,428]. This connection between early sensorimotor experiences and later cognitive outcomes can be explained on both the neuronal and behavioral levels. On a neuronal level, spontaneous, self-generated movements provide children with multisensory feedback, thus establishing and gradually refining topological representations of surrounding objects, as well as the boundaries and abilities of their own body in their brains, further shaping afferent and efferent motor and sensory pathways and establishing the foundation for advances in perception, motor control, and visuomanual coordination [98,99].

As pointed out above, brain lesions in children with CP lead to abnormal brain structures and interhemispheric connectivity These structural and functional changes result in the persistence of involuntary muscle synergies and mirror movements that disrupt movement coordination during voluntary, goal-directed activities and have an especially debilitating effect on bimanual coordination [2,139,152,195–197].

Furthermore, the abnormal prevalence of ipsilateral corticospinal connections over contralateral ones in children with CP not only produces less effective information processing but also further disrupts the development of hemispheric specialization [102]. Because hemispheric specialization is a foundation behind more effective information processing and optimal developmental outcomes [28–32], children with CP often exhibit delays and impairments in motor performance and cognition [2,5,19–27,149].

On a behavioral level, delays and impairments in spontaneous movements, postural control, locomotion, and hand control may diminish motor and sensorimotor feedback received by a child and decrease a child's opportunities to gather information and learn, thus leading to delayed or impaired cognitive functioning. Specifically, spontaneous movements facilitate the development of motor control, postural control, and visuomanual coordination [164,166,169,429,430]. Adequate head and trunk control, in turn, promote independent sitting, thus freeing the child's hands for reaching and object exploration, which further improve motor control and visuomanual coordination [171,431–438].

Gradual de-coupling of the two hands enables the sophisticated, role-differentiated bimanual manipulation of objects, which allows a child to learn object properties and affordances, means-end relations between objects, and motor planning skills, later used for the execution of complex, finely timed action sequences in means-end problem solving, artifact construction, and tool-use [175,184,186,439–442]. Importantly, multimodal, goal-directed object exploration reportedly advances children's language and cognitive development [231,295,442–454]. Additionally, the development of independent sitting, crawling, and walking permits a different perspective on the surrounding environment: these developments enable more opportunities to approach objects and people, explore objects, communicate with others, and exercise very important skills of planning and decision making on seemingly trivial "when and where to move" choices; these postural and locomotor opportunities facilitate children's language, cognitive, and social outcomes [16,455–457].

In children with CP, early deficits in postural control impede the development of non-object-oriented exploration and reaching (non-object-oriented behaviors are exploratory behaviors of one's own body and surrounding objects in the absence of portable objects and people (e.g., head control against gravity, midline position of the head and hands, open hand posture, looking at hands, mouthing hands, touching own body or surfaces, etc. [166]), which, in turn, may result in limited opportunities to manipulate objects and explore the world [433,438,456], establish hand-eye coordination [433,458–460], and practice visuospatial skills [441]. In children with CP, delayed visuospatial abilities might concatenate into learning difficulties, impaired non-verbal and verbal intelligence, and difficulties in the acquisition of mathematical and executive function skills [19,22,27,347,377,394,406,461]. Thus, the embodied cognition theory reveals a critical role of experience in the development of children with CP.

The ***dynamic systems theory*** (DST [16,452,462–464]) also describes the ways in which disruptions of developmental pathways can lead to suboptimal outcomes in children with CP. DST suggests that a dynamic interplay among the child's biological constraints, experiences, environmental affordances, and developmental timelines controls the trajectory of development. There are two key principles of DST that are relevant for this paper: the continuity and dynamic nature of development. The ***continuity principle*** implies that early skills concatenate into more sophisticated, later-developing ones, and early experiences, to a large extent, determine a child's future abilities and outcomes [16,174,429,463,465]. For example, during the first two years of life, the sensorimotor behaviors infants use to explore their bodies and surrounding surfaces in the absence of toys (e.g., holding hands in midline, looking at hands, touching body with hands) are strongly associated with behaviors manifested by infants during object exploration tested in a separate procedure (e.g., the bimanual holding of objects, looking at an object in the hand, touching body with an object in the hand [429]).

It is also important to emphasize the relation of postural control and locomotor experiences to upper-extremity performance. The emergence of sitting, crawling, and walking imposes new constraints on a child's body control and requires significant reorganization in body schemas, which may affect a child's hand use and performance. For example, the onset of crawling, characterized by alternating hand movements, has been associated with the prevalence of unimanual reaches, whereas the onset of independent walking, typically stimulating a symmetrical, "high-guard" hands' position to keep balance, corresponded with the surge in bimanual reaching [466,467]. Importantly, as infants practice crawling, initiating the first movement with the preferred hand, their hand-use may become more lateralized; at the same time, it is also possible that the shift toward more lateralized reaching would facilitate the transition from rocking to crawling [468].

This bidirectional relation between different motor and sensorimotor skills highlights the ***dynamic principle*** of development. There are many examples of the dynamic nature of development. For instance, not only do reaching and object exploration facilitate cognitive development through information gathering, learning, and problem solving, but also the advanced cognition may, in turn, guide more sophisticated object exploration. First, infants only mouth every toy, extracting shape, texture, and other properties; later, they shake every toy, revealing audible, mass, and other properties; then, they start adjusting their actions to the properties of the toys—shaking toys that make noise, pushing the buttons, spinning the wheels, etc. Furthermore, according to the dynamic principle, biology may influence experience, but the latter, in turn, would influence the biological substrate. For example, as children with CP get more opportunities to use the affected hand in unimanual and bimanual tasks, the received sensorimotor feedback may further reorganize their brain structures and also enhance interhemispheric connectivity [469–471].

Thus, for both embodied cognition and dynamic systems theories, biological, psychological, and sociocultural contexts determine the motor and sensorimotor capacities of a child, which, in turn, allow or prohibit particular types of experiences that would shape specific cognitive outcomes [17]. Importantly, motor and sensorimotor experiences affect not only more sophisticated cognitive functions, but also the individual's biology (e.g., neuronal structures and connectivity). Although early brain insults tend to set an individual on a specific developmental trajectory, both embodied cognition and dynamic systems theories propose that it is possible to change this trajectory by changing the motor and sensorimotor experiences available to the individual.

## 8. Possible Interventions for Children with CP

Knowledge of the developmental trends and functional deficits in children with CP permits the design and implementation of effective, evidence-based interventions to improve children's development. As noted above, CP is considered a group of "non-progressive" disorders [11,12]; this means that the brain damage associated with CP is permanent and static [472]. However, that label should not prevent the investigation of potential developmental changes on neural, physiological, physical, or behavioral levels [473]. Modern accounts of brain plasticity allow for considerable progress in individuals' development even under conditions of brain damage [474–477].

However, there are a few complications in the rehabilitation of patients with CP. The first problem stems from the heterogeneous nature of CP: "one-size-fits-all" approaches are not effective due to significant differences in the timing of brain insult, location and extent of the damage, factors associated with the brain injury, as well as symptomatology and functionality in patients with CP [475,478–480]. Second, some interventions may have suboptimal effects in individuals with CP having comorbid disorders, such as deficits in sensation and perception, learning difficulties, cognitive impairments, communication disorders, behavioral issues, or epilepsy [481–483]. Third, in contrast to older patients with acquired brain lesions, children with CP born with brain lesions that negatively affect their motor and sensorimotor functions, do not have neural "memories" of typical movement or body control [194,473]. Thus, instead of focusing on the "recovery" of lost functions, intervention providers should create training paradigms that promote sensorimotor and motor development on the canvas of compromised brain structures and connectivity [472,484]. Due to existing brain lesions, it is often not feasible to re-establish the typical lateralization of functions in patients with CP. However, interventions may not only strengthen unilateral circuits residing in the atypical hemisphere, but also, and more importantly, facilitate the formation and activation of more efficient contralateral corticospinal connections [108,485,486].

Finally, given our current understanding of development [487], the timing of intervention also plays a critical role in its effectiveness, with early interventions (e.g., small steps, baby-bimanual, baby-constraint-induced movement therapy (baby CIMT), and the Goals, Activity and Motor Enrichment intervention (GAME) having better potential for improvements in individuals with CP [488–494]. However, only about 60% of infants are typically referred for intervention before the age of 12 months [495,496] because the CP diagnosis, in most cases, gets confirmed only by the late age period of 13–19 months [497,498].

The results of published clinical trials suggest there are benefits to training-based interventions for individuals with CP. The following interventions have been shown to be effective: environmental enrichment, home programs, fitness training, constraint-induced movement therapy, bimanual intensive therapy, action observation training, goal-directed training, task-specific training, and mobility training using treadmills and partial body-weight support systems, among others [499–516]. Effective interventions focus on participants' motivation, attention, and sense of agency; the production of self-initiated movements; meaningful, context-focused, real-life activities; task-specific and goal-directed activities; and high intensity of training with incremental increases in task difficulty [477,493,517–519]. The largest benefits may come from early interventions that promote variability in children's postures and movement patterns and provide opportunities to self-generate movements, including erroneous movements, to allow learning from experience [98,517,520,521]. Additionally, if a training task seems interesting and meaningful to children, they are more likely to engage in it, see the results of their own actions, and enjoy the practice; such a positive attitude would likely stimulate spontaneous, self-initiated practice, thus improving retention, adherence to the training protocols, and stimulating further advancements in movement and function [477,518].

Active participation in activities instills a sense of agency in children with CP —being in control of their movements and being able to predict the sensory consequences of their own actions [522,523]. The latter ability develops as a result of the everyday motor and sensorimotor experiences of the child, and reduced interactions with the environment creates delays in the development of the predictive "forward" model in children with CP [192,193]. Importantly, the establishment of an adequate predictive "forward" model may be the mechanism behind improvements in motor performance as a result of active exploration of the environment in early interventions for children with CP [192–194,524,525]. Moreover, while active exploration advances predictive abilities, the latter, in turn, may further facilitate a child's motor and cognitive development [194]. By contrast, passive activities seem to be less effective, or completely ineffective, in children with CP: passive movements orchestrated by a physical therapist do not activate the child's motor circuits, do not engage the child in problem solving, and do not stimulate the development of the predictive "forward" model [493,518,526].

The most common form of CP is unilateral CP, which impairs one limb and negatively affects a child's ability to perform tasks requiring bimanual coordination [120]. Typical upper-extremity rehabilitation therapies for unilateral CP include: (1) forced-use therapy (FUT [527,528]), (2) CIMT [118,529–533], and (3) bimanual intensive training (BIM) or hand–arm bimanual intensive therapy (HABIT [534–536]). FUT works through casting/splinting of the child's better functioning limb to encourage movement of the more affected limb; the unstructured physical training of the affected hand is supposed to take place as a natural consequence of restricting the other hand. However, unable to use the functional hand, the frustrated child, being in full control of the therapy, often chooses to neglect diligent practice, thus defeating the purpose of the therapy [118,527,528]. Obviously, FUT is not a therapy that fosters the child's positive attitude, engagement, and compliance. CIMT is a more comprehensive form of restraint-based intervention, involving a constraint of the better functioning limb (similar to FUT) with an added structure provided by the supervising physical therapist, encouraging the use of the child's affected hand/arm [118]. Although logistically and financially taxing, CIMT has been shown to be effective in advancing fine motor skills of the affected hand in children with hemiplegic CP [118,529,536,537]. However, both FUT and CIMT, with their focus on unilateral behaviors, fail to train bimanual coordination [527,535]. By contrast, BIM, using the structural approach of CIMT, but without any physical constraints, facilitates exercise regimens that emphasize bimanually coordinated activities, affords greater physical freedom to the patient, and typically results in higher levels of the patient's enthusiasm [535]. However, BIM falls short of CIMT in the improvement of fine manual movement and the simultaneous, dissociated activity of both limbs [538]; it also shares CIMT's practical and financial limitations.

Another feasible therapy option would be a garment such as the PlaySkin Duo™ designed at the University of Delaware (Dr. Michele Lobo, Move to Learn Innovation Lab, Department of Physical Therapy; https://emmazuckerman.wixsite.com/design/playskin-duo; accessed on 15 January 2022). The PlaySkin Duo™ is a soft garment that slightly constrains the use of the healthy, or better functioning, hand/arm by connecting it to the torso of the garment using an elastic band, which increases the difficulty of moving this arm, while still allowing the child to use it. Every time the child reaches for a toy with the better functioning hand, the slight tug on the arm softly constrains the movement, encouraging the child to use the affected hand. In a sense, the PlaySkin Duo™ works like BIM, but without a physical therapist sitting with the child and constantly reminding the child to use the affected hand. Importantly, the PlaySkin Duo™ keeps the hands of the child unobstructed, thus allowing not only bimanual coordination, but also fine motor practice with both hands. Further research is needed to evaluate the effectiveness of the PlaySkin Duo™ garment on motor function in children with CP.

Early interventions are more effective than those implemented later in a child's life [488–490]. Despite the fact that CP is typically only diagnosed during the second year of a child's life [497,498], it is still possible to advance the sensorimotor and motor development of infants at risk for CP (e.g., those born preterm and/or with a brain injury) by embedding them into an enriched environment. Enriched environments stimulate the nervous system by providing children with more opportunities for exploration, object manipulation, and learning [194]. Enriched environment interventions can be implemented even before a child's motor and sensorimotor deficits become apparent. Early interventions implementing positioning a child in different postures (e.g., supine, prone, side-lying, supported sitting and standing, with frequent transitions among postures) to allow exploration of body affordances and body–environment interactions, as well as toy-oriented activities to promote reaching, visuomotor coordination, and object exploration, have been shown to be effective in facilitating children's motivation to play, self-generated movements, postural control, reaching, bimanual object exploration, crawling, walking, and problem-solving skills [435,448,539–549]. Similarly, early interventions such as the GAME intervention [492,494], the Supporting Play Exploration and Early Development Intervention (SPEEDI [550]), and the Sitting Together and Reaching to Play intervention (START-Play [551,552]) have been shown to improve children's sensorimotor and motor skills.

Furthermore, early interventions involving wearable technologies, such as "sticky mittens" [442,553] or exoskeletons [327,531,554–556] might help children with CP who struggle with low muscle tone. The "sticky mittens" may allow a higher level of object engagement and more sophisticated object exploration in the absence of fine-motor movements in the affected hand; the experience of "grasping" a toy with the assistance of Velcro may reinforce the action and allow children to observe the consequences of their own actions [442]. In typically developing infants, brief "sticky mittens" training improved bimanual reaching, object exploration, visual attention, and spatial skills [442,557–560]. Note that instead of "sticky mittens" that cover the child's hand, physical therapists may use a Velcro band [448] that permits the fingers to engage with objects and create a more typical visual and haptic sensory feedback.

Furthermore, the Playskin Lift™ (Playskin; https://sites.udel.edu/move2learn/how-todiy/; accessed on 15 January 2022) exoskeletal garment might offer the anti-gravity support, extend the child's reaching space, facilitate visuomanual coupling and bimanual reaching, as well as improve the multimodality, variability, and intensity of exploratory play behaviors [327,556]. Whereas "sticky mittens" deliver a more distal support at the hand, the Playskin provides a more proximal assistance at the shoulder. However, both "sticky mittens" and Playskin devices might not facilitate independent, unassisted object play in children with hemiplegia; without explicit, external encouragement, children with hemiplegia might continue to disregard the affected limb.

Considerable disruptions of sensorimotor pathways in individuals with CP justify training methods that involve the use of sensory information in the motor task context. Thus, musical instrument practice may be a good rehabilitation method to stimulate multi-modal audio-visuomotor coordination, bimanual coordination, and the implementation of timely action sequences [473,561]. Indeed, both short- and long-term musical training reportedly corresponded with significant structural changes in the brain, resulting in a larger volume and thickness of motor and auditory cortices, a larger corpus callosum and cerebellum, increased white matter integration in pyramidal tracts, and larger gray matter density in precentral gyrus, involved in functional hand and finger movements [562–569]. Despite the obvious benefits of music training, this rehabilitation method has rarely been used in patients with CP, although the few studies on the effects of piano training in individuals with CP reported positive neural outcomes (better connectivity between primary motor cortex and the cerebellum [570]) and behavioral outcomes (keystroke timing variability and playing speed [570,571]). Although it was concluded that musical instrument training may improve not only motor coordination, but also sensorimotor interactions [473,561,572], more research is needed in this area.

Although current rehabilitation methods in individuals with CP are typically focused on motor execution, it is possible to facilitate motor performance through advances in motor planning by targeting children's motor imagery skills [573–576]. As noted above, motor imagery skills are involved in anticipatory motor planning and motor control [159,239,314]. A lack of motor experience in children with CP negatively affects their motor imagery [159,246,259,577]. Because both motor performance and motor imagery seem to share the same neural substrates (e.g., supplementary motor areas, premotor cortex, primary motor cortex (M1), and parietal lobe [578]), it may be possible to increase activation and connectivity in those areas by targeting both skills in parallel [576,577,579,580]. Previous research showed improvements in motor performance of the affected upper limb after motor imagery training in stroke patients [581,582] and those with CP [583]; however, more research is needed to provide evidence for the use of motor imagery in individuals with CP [576].

There is a lack of randomized clinical trials that show the efficacy of parental interventions to advance early motor and sensorimotor skills in children with CP [584]. More often, parental education is offered in conjunction with an ongoing physical therapy [492,585–587]. Importantly, in research with typically developing infants and those born preterm, parent-provided interventions encouraging infants' independent head control, frequent transitions among different postures, general arm movements, reaching to midline, and reaching with both hands led to significant improvements in children's postural control, reaching, and object exploration [435,442,448,542–546,588]. Future research should further investigate the utility of parent education in the rehabilitation of motor and sensorimotor skills in children with CP.

## 9. Conclusions

Modern neurodevelopmental research demonstrates that brain restructuring, as a result of brain damage, leads to atypical hemispheric specialization, as manifested in the predominance of ipsilateral corticospinal connections, reduced transcallosal transfer of information, diminished hemispheric specialization, and the allocation of multiple functions to the same hemisphere (e.g., language lateralized to the right hemisphere, along with visuospatial skills). These patterns of atypical hemispheric lateralization reduce the effectiveness of information processing and produce suboptimal cognitive outcomes in children with CP. These findings emphasize the need for early interventions that promote callosal functioning to establish optimal hemispheric asymmetry.

These intervention programs should be based on evidence-based research emphasizing the role of self-generated experiences in early development, as proposed by the embodied cognition theory. Moreover, according to the dynamic systems theory, all the functions of a child are bidirectionally interrelated and codeveloping. For example, brain lesions may limit motor and sensorimotor exploration, but enhanced early motor and sensorimotor experiences, in turn, are capable of restructuring the brain and improving hemispheric connectivity. Additionally, early sensorimotor experiences promote motor control and coordination, thus permitting complex object manipulation, which provides unique learning opportunities and advances a child's cognitive development. Importantly, the resulting cognitive advances inform a child's object exploration, thus permitting more sophisticated object manipulations and stimulating learning in a circular feedback manner.

Basic research examining the system of core deficits associated with CP, along with understanding the developmental pathways from early motor and sensorimotor skills to cognitive outcomes, must influence the design and implementation of interventions, shifting their focus toward targeting early sensorimotor skills. Because early, self-generated, spontaneous movements establish the foundation for motor and postural control, locomotion, reaching, and object exploration (which collectively facilitate cognitive development), early interventions should focus on promoting and facilitating abundant and variable spontaneous movements in children with CP. Because the typical timeline of CP diagnosis (by the age of 13–19 months) may prevent early intervention, there also should be a focus on early diagnosis to ensure earlier interventions capable of promoting optimal development. Importantly, the analysis of early spontaneous movements can open a door to early diagnosis in children with CP [160,162,164,166].

Finally, despite the heterogeneous nature of CP, it is still possible to link specific brain lesions and structural abnormalities to corresponding cognitive outcomes with the implementation of multisite studies testing large numbers of subjects (e.g., thousands) with standardized assessment methods. In the same way, despite significant differences in the location, extent, and timing of brain damage in children with CP, it is still possible to determine factors capable of advancing their development through testing the effectiveness of different interventions using large, multisite studies. In this case, individual differences in responsiveness to intervention could be identified and appropriate adjustments could be made. Thus, the future of intervention research for CP seems to involve more multisite, large-scale studies.

**Funding:** There was no external funding for this review.

**Institutional Review Board Statement:** The current review covered studies that had IRB approval.

**Informed Consent Statement:** The current review covered studies that followed IRB guidelines while acquiring informed consent from the participants.

**Data Availability Statement:** The current review only addressed published data.

**Acknowledgments:** The author would like to thank her lifelong mentor, George F. Michel, for his continuous support and guidance.

**Conflicts of Interest:** The author has no conflict of interest to report.

## References

1. Hugdahl, K.; Westerhausen, R. *The Two Halves of the Brain*; The MIT Press: Cambridge, MA, USA, 2010.
2. Qin, Y.; Sun, B.; Zhang, H.; Li, Y.; Zhang, T.; Luo, C.; Sun, C.; Yao, D. Aberrant interhemispheric functional organization in children with dyskinetic cerebral palsy. *BioMed Res. Int.* **2019**, *2019*, 4362539. [CrossRef]
3. Toga, A.W.; Thompson, P. Mapping brain asymmetry. *Nat. Rev. Neurosci.* **2003**, *4*, 37–48. [CrossRef] [PubMed]
4. Eyre, J.A. Corticospinal tract development and its plasticity after perinatal injury. *Neurosci. Biobehav. Rev.* **2007**, *31*, 1136–1149. [CrossRef]
5. Kułak, W.; Sobaniec, W.; Kubas, B.; Walecki, J. Corpus callosum size in children with spastic cerebral palsy: Relationship to clinical outcome. *J. Child Neurol.* **2007**, *22*, 371–374. [CrossRef]
6. Li, J.Y.; Espay, A.J.; Gunraj, C.A.; Pal, P.K.; Cunic, D.I.; Lang, A.E.; Chen, R. Interhemispheric and ipsilateral connections in Parkinson's disease: Relation to mirror movements. *Mov. Disord.* **2007**, *22*, 813–821. [CrossRef] [PubMed]
7. Sabaté, M.; González, B.; Rodríguez, M. Brain lateralization of motor imagery: Motor planning asymmetry as a cause of movement lateralization. *Neuropsychologia* **2004**, *42*, 1041–1049. [CrossRef] [PubMed]

8. Takeuchi, N.; Oouchida, Y.; Izumi, S.-I. Motor control and neural plasticity through interhemispheric interactions. *Neural Plast.* **2012**, *2012*, 823285. [CrossRef] [PubMed]
9. Weinstein, M.; Green, D.; Geva, R.; Schertz, M.; Fattal-Valevski, A.; Artzi, M.; Myers, V.; Shiran, S.; Gordon, A.; Gross-Tsur, V.; et al. Interhemispheric and intrahemispheric connectivity and manual skills in children with unilateral cerebral palsy. *Brain Struct. Funct.* **2013**, *219*, 1025–1040. [CrossRef] [PubMed]
10. Bax, M.; Goldstein, M.; Rosenbaum, P.; Leviton, A.; Paneth, N.; Dan, B.; Jacobsson, B.; Damiano, D. Proposed definition and classification of cerebral palsy, April 2005. *Dev. Med. Child Neurol.* **2005**, *47*, 571–576. [CrossRef] [PubMed]
11. Morris, C. Definition and classification of cerebral palsy: A historical perspective. *DMCN* **2007**, *49*, 3–7. [CrossRef] [PubMed]
12. Rosenbaum, P.; Paneth, N.; Leviton, A.; Goldstein, M.; Bax, M.; Damiano, D.; Jacobsson, B. A report: The definition and classification of cerebral palsy April 2006. *Dev. Med. Child Neurol.* **2007**, *109*, 8–14.
13. Barsalou, L.W. Grounded cognition. *Annu. Rev. Psychol.* **2008**, *59*, 617–645. [CrossRef] [PubMed]
14. Chemero, A. *Radical Embodied Cognitive Science*; MIT Press: Cambridge, MA, USA, 2011.
15. Pezzulo, G. Grounding procedural and declarative knowledge in sensorimotor anticipation. *Mind Lang.* **2011**, *26*, 78–114. [CrossRef]
16. Thelen, E.; Smith, L.B. *A Dynamic Systems Approach to the Development of Cognition and Action*; MIT Press: Cambridge, MA, USA, 1994.
17. Varela, F.J.; Thompson, E.; Rosch, E. *The Embodied Mind, Cognitive Science and Human Experience*; MIT Press: Cambridge, MA, USA, 1991.
18. Wilson, M.S. Six views of embodied cognition. *Psychon. Bull. Rev.* **2002**, *9*, 625–636. [CrossRef]
19. Arp, S.; Fagard, J. What impairs subitizing in cerebral palsied children? *Dev. Psychobiol.* **2005**, *47*, 89–102. [CrossRef] [PubMed]
20. Bottcher, L.; Flachs, E.M.; Uldall, P. Attentional and executive impairments in children with spastic cerebral palsy. *Dev. Med. Child Neurol.* **2009**, *52*, e42–e47. [CrossRef]
21. Chilosi, A.M.; Pecini, C.; Cipriani, P.; Brovedani, P.; Brizzolara, D.; Ferretti, G.; Cioni, G. Atypical language lateralization and early linguistic development in children with focal brain lesions. *DMCN* **2005**, *47*, 725–730.
22. Critten, V.; Messer, D.; Sheehy, K. Delays in the reading and spelling of children with cerebral palsy: Associations with phonological and visual processes. *Res. Dev. Disabil.* **2018**, *85*, 131–142. [CrossRef] [PubMed]
23. Desoete, A.; Ceulemans, A.; Roeyers, H.; Huylebroeck, A. Subitizing or counting as possible screening variables for learning disabilities in mathematics education or learning? *Educ. Res. Rev.* **2009**, *4*, 55–66. [CrossRef]
24. Jenks, K.M.; De Moor, J.; van Lieshout, E.; Maathuis, K.G.; Keus, I.; Gorter, J.W. The effect of cerebral palsy on arithmetic accuracy is mediated by working memory, intelligence, early numeracy, and instruction time. *Dev. Neuropsychol.* **2007**, *32*, 861–879. [CrossRef]
25. Jordan, N.C.; Glutting, J.; Ramineni, C. The importance of number sense to mathematics achievement in first and third grades. *Learn. Individ. Differ.* **2010**, *20*, 82–88. [CrossRef] [PubMed]
26. Kroesbergen, E.H.; van Luit, J.E.H.; van Lieshout, E.C.D.M.; van Loosbroek, E.; van de Rijt, B.A.M. Individual differences in early numeracy: The role of executive functions and subitizing. *J. Psychol. Educ. Assess* **2009**, *27*, 226–236. [CrossRef]
27. Van Rooijen, M.; Verhoeven, L.; Steenbergen, B. Early numeracy in cerebral palsy: Review and future research. *Dev. Med. Child Neurol.* **2011**, *53*, 202–209. [CrossRef] [PubMed]
28. Corballis, M.C. *The Lopsided Ape*; Oxford University Press: New York, NY, USA, 1991.
29. Corballis, M.C. The evolution of lateralized brain circuits. *Front. Psychol.* **2017**, *8*, 1021. [CrossRef] [PubMed]
30. Gonzalez, C.L.; van Rootselaar, N.A.; Gibb, R.L. Sensorimotor lateralization scaffolds cognitive specialization. *Prog. Brain Res.* **2018**, *238*, 405–433. [CrossRef]
31. Güntürkün, O.; Ocklenburg, S. Ontogenesis of Lateralization. *Neuron* **2017**, *94*, 249–263. [CrossRef] [PubMed]
32. Rogers, L.J.; Zucca, P.; Vallortigara, G. Advantages of having a lateralized brain. *Proc. R. Soc. B Boil. Sci.* **2004**, *271*, S420–S422. [CrossRef] [PubMed]
33. Gardner, H.; Brownell, H.H.; Wapner, W.; Michelow, D. Missing the point: The role of the right hemisphere in the processing of complex linguistic materials. In *Pragmatics—Critical Concepts*; Kasher, A., Ed.; Routledge: London, UK, 1998; Volume 6, pp. 170–192. [CrossRef]
34. Gazzaniga, M.S.; Ivry, R.B.; Mangun, G.R. *Cognitive Neuroscience: The Biology of the Mind*, 3rd ed.; W.W. Norton & Company, Inc.: New York, NY, USA, 2009.
35. Kimura, D. The asymmetry of the human brain. *Sci. Am.* **1973**, *228*, 70–78. [CrossRef] [PubMed]
36. Young, G. *Developmental Laterality Research: Childhood*; Springer: New York, NY, USA, 2019; pp. 57–72. [CrossRef]
37. Sergent, J. Basic determinants in visual-field effects with special reference to the Hannay et al. (1981) study. *Brain Lang.* **1982**, *16*, 158–164. [CrossRef]
38. Sergent, J. Theoretical and methodological consequences of variations in exposure duration in visual laterality studies. *Percept. Psychophys.* **1982**, *31*, 451–461. [CrossRef] [PubMed]
39. Sergent, J. Influence of task and input factors on hemispheric involvement in face processing. *J. Exp. Psychol. Hum. Percept. Perform.* **1985**, *11*, 846–861. [CrossRef] [PubMed]
40. Bogen, J.E. The other side of the brain: II. An appositional mind. *Bull. Los Angel. Neuro. Soc.* **1969**, *34*, 191–200.

41. Flevaris, A.V.; Robertson, L.C. Spatial frequency selection and integration of global and local information in visual processing: A selective review and tribute to Shlomo Bentin. *Neuropsychologia* **2016**, *83*, 192–200. [CrossRef] [PubMed]
42. Godfrey, H.K.; Grimshaw, G.M. Emotional language is all right: Emotional prosody reduces hemispheric asymmetry for linguistic processing. *Laterality* **2016**, *21*, 568–584. [CrossRef]
43. Navon, D. Forest before trees: The precedence of global features in visual perception. *Cogn. Psychol.* **1977**, *9*, 353–383. [CrossRef]
44. Thatcher, R. Neurolinguistics: Theoretical and evolutionary perspectives. *Brain Lang.* **1980**, *11*, 235–260. [CrossRef]
45. Sergent, J. The cerebral balance of power: Confrontation or cooperation. *J. Exp. Psychol. Hum. Percept. Perform.* **1982**, *8*, 253–272. [CrossRef]
46. Powell, J.L.; Kemp, G.; García-Finaña, M. Association between language and spatial laterality and cognitive ability: An fMRI study. *NeuroImage* **2012**, *59*, 1818–1829. [CrossRef] [PubMed]
47. Annett, M. *Handedness and Brain Asymmetry: The Right Shift Theory*; Psychology Press: Hove, UK, 2002.
48. Corballis, M.C. From mouth to hand: Gesture, speech and the evolution of right-handedness. *Behav. Brain Sci.* **2003**, *26*, 199–260. [CrossRef] [PubMed]
49. Corballis, M.C. The evolution and genetics of cerebral asymmetry. *Philos. Trans. R. Soc. B Biol. Sci.* **2008**, *364*, 867–879. [CrossRef] [PubMed]
50. Flöel, A.; Buyx, A.; Breitenstein, C.; Lohmann, H.; Knecht, S. Hemispheric lateralization of spatial attention in right- and left-hemispheric language dominance. *Behav. Brain Res.* **2005**, *158*, 269–275. [CrossRef]
51. Knecht, S.; Jansen, A.; Frank, A.; van Randenborgh, J.; Sommer, J.; Kanowski, M.; Heinze, H.J. How atypical is atypical language dominance? *Neuroimage* **2003**, *18*, 917–927. [CrossRef]
52. McManus, C. *Right Hand, Left Hand: The Origins of Asymmetry in Brains, Bodies, Atoms, and Cultures*; Harvard University Press: Cambridge, MA, USA, 2002.
53. Pujol, J.; Deus, J.; Losilla, J.M.; Capdevila, A. Cerebral lateralization of language in normal left-handed people studied by functional MRI. *Neurology* **1999**, *52*, 1038. [CrossRef] [PubMed]
54. Vingerhoets, G. Phenotypes in hemispheric functional segregation? Perspectives and challenges. *Phys. Life Rev.* **2019**, *30*, 1–18. [CrossRef] [PubMed]
55. Bruner, J.S. *Going beyond the Information Given*; Routledge: Abingdon-on-Thames, UK, 2006; pp. 17–33. [CrossRef]
56. Kotwica, K.A.; Ferre, C.L.; Michel, G.F. Relation of stable hand-use preferences to the development of skill for managing multiple objects from 7 to 13 months of age. *Dev. Psychobiol.* **2008**, *50*, 519–529. [CrossRef] [PubMed]
57. Marcinowski, E.C.; Campbell, J.M. Building on what you have learned. *Int. J. Behav. Dev.* **2017**, *41*, 341–349. [CrossRef]
58. Marcinowski, E.C.; Campbell, J.M.; Faldowski, R.A.; Michel, G.F. Do hand preferences predict stacking skill during infancy? *Dev. Psychobiol.* **2016**, *58*, 958–967. [CrossRef] [PubMed]
59. Gonzalez, S.L.; Campbell, J.M.; Marcinowski, E.C.; Michel, G.F.; Coxe, S.; Nelson, E.L. Preschool language ability is predicted by toddler hand preference trajectories. *Dev. Psychol.* **2020**, *56*, 699–709. [CrossRef] [PubMed]
60. Nelson, E.L.; Campbell, J.M.; Michel, G.F. Early handedness in infancy predicts language ability in toddlers. *Dev. Psychol.* **2014**, *50*, 809–814. [CrossRef] [PubMed]
61. Nelson, E.L.; Gonzalez, S.L.; Coxe, S.; Campbell, J.M.; Marcinowski, E.C.; Michel, G.F. Toddler hand preference trajectories predict 3-year language outcome. *Dev. Psychobiol.* **2017**, *59*, 876–887. [CrossRef] [PubMed]
62. Costa, D.; Kroll, R. Stuttering: An update for physicians. *Can. Med. Assoc. J.* **2000**, *162*, 1849–1855.
63. Elliott, D.; Weeks, D.J. Cerebral specialization for speech perception and movement organization in adults with Down's syndrome. *Cortex* **1993**, *29*, 103–113. [CrossRef]
64. Grouios, G.; Sakadami, N.; Poderi, A.; Alevriadou, A. Excess of non-right handedness among individuals with intellectual disability: Experimental evidence and possible explanations. *J. Intellect. Disabil. Res.* **1999**, *43*, 306–313. [CrossRef] [PubMed]
65. Hartley, X.Y. Lateralization of speech stimuli in young Down's syndrome children. Cereb. *Cortex* **1981**, *17*, 241–248. [CrossRef]
66. Hugdahl, K.; Heiervang, E.; Nordby, H.; Smievoll, A.I.; Steinmetz, H.; Stevenson, A.; Lund, A. Central auditory processing, MRI morphometry and brain laterality: Applications to dyslexia. *Scand. Audiol.* **1998**, *27*, 26–34. [CrossRef] [PubMed]
67. Illingworth, S.; Bishop, D.V. Atypical cerebral lateralisation in adults with compensated developmental dyslexia demonstrated using functional transcranial Doppler ultrasound. *Brain Lang.* **2009**, *111*, 61–65. [CrossRef] [PubMed]
68. Kleinhans, N.M.; Müller, R.-A.; Cohen, D.N.; Courchesne, E. Atypical functional lateralization of language in autism spectrum disorders. *Brain Res.* **2008**, *1221*, 115–125. [CrossRef]
69. Laval, S.; Dann, J.; Butler, R.; Loftus, J.; Rue, J.; Leask, S.; Bass, N.; Comazzi, M.; Vita, A.; Nanko, S.; et al. Evidence for linkage to psychosis and cerebral asymmetry (relative hand skill) on the X chromosome. *Am. J. Med. Genet.* **1998**, *81*, 420–427. [CrossRef]
70. Ribolsi, M.; Koch, G.; Magni, V.; Di Lorenzo, G.; Rubino, I.; Siracusano, A.; Centonze, D. Abnormal brain lateralization and connectivity in schizophrenia. *Rev. Neurosci.* **2009**, *20*, 61–70. [CrossRef] [PubMed]
71. Whitehouse, A.J.; Bishop, D. Hemispheric division of function is the result of independent probabilistic biases. *Neuropsychologia* **2009**, *47*, 1938–1943. [CrossRef]
72. Wood, F.; Stump, D.; McKeehan, A.; Sheldon, S.; Proctor, J. Patterns of regional cerebral blood flow during attempted reading aloud by stuttering both on and off haloperidol medication: Evidence for inadequate left frontal activation during stuttering. *Brain Lang.* **1980**, *9*, 141–144. [CrossRef]

73. Bax, M.; Tydeman, C.; Flodmark, O. Clinical and MRI correlates of cerebral palsy: The European cerebral palsy study. *JAMA* **2006**, *296*, 1602–1608. [CrossRef]
74. Krägeloh-Mann, I.; Horber, V. The role of magnetic resonance imaging in elucidating the pathogenesis of cerebral palsy: A systematic review. *Dev. Med. Child Neurol.* **2007**, *49*, 144–151. [CrossRef] [PubMed]
75. Pagnozzi, A.M.; Dowson, N.; Doecke, J.; Fiori, S.; Bradley, A.; Boyd, R.N.; Rose, S. Automated, quantitative measures of grey and white matter lesion burden correlates with motor and cognitive function in children with unilateral cerebral palsy. *NeuroImage Clin.* **2016**, *11*, 751–759. [CrossRef] [PubMed]
76. Reid, S.; Dagia, C.D.; Ditchfield, M.R.; Carlin, J.B.; Reddihough, D.S. Population-based studies of brain imaging patterns in cerebral palsy. *Dev. Med. Child Neurol.* **2014**, *56*, 222–232. [CrossRef] [PubMed]
77. Towsley, K.; Shevell, M.I.; Dagenais, L. Population-based study of neuroimaging findings in children with cerebral palsy. *Eur. J. Paediatr. Neurol.* **2011**, *15*, 29–35. [CrossRef] [PubMed]
78. Gupta, D.; Barachant, A.; Gordon, A.; Ferre, C.; Kuo, H.-C.; Carmel, J.B.; Friel, K.M. Effect of sensory and motor connectivity on hand function in pediatric hemiplegia. *Ann. Neurol.* **2017**, *82*, 766–780. [CrossRef] [PubMed]
79. Guzzetta, A.; Bonanni, P.; Biagi, L.; Tosetti, M.; Montanaro, D.; Guerrini, R.; Cioni, G. Reorganisation of the somatosensory system after early brain damage. *Clin. Neurophysiol.* **2007**, *118*, 1110–1121. [CrossRef] [PubMed]
80. Kostović, I.; Jovanov-Milošević, N. The development of cerebral connections during the first 20–45 weeks' gestation, seminars in fetal and neonatal medicine. *WB Saunders* **2006**, *11*, 415–422.
81. Staudt, M. Brain plasticity following early life brain injury: Insights from neuroimaging. *Semin. Perinatol.* **2010**, *34*, 87–92. [CrossRef]
82. Wilke, M.; Staudt, M.; Juenger, H.; Grodd, W.; Braun, C.; Krägeloh-Mann, I. Somatosensory system in two types of motor reorganization in congenital hemiparesis: Topography and function. *Hum. Brain Mapp.* **2009**, *30*, 776–788. [CrossRef] [PubMed]
83. Dutton, G.N.; Bax, M. *Visual Impairment in Children Due to Damage to the Brain*, 1st ed.; MacKeith Press: London, UK, 2010.
84. Fazzi, E.; Signorini, S.G.; LA Piana, R.; Bertone, C.; Misefari, W.; Galli, J.; Balottin, U.; Bianchi, P.E. Neuro-ophthalmological disorders in cerebral palsy: Ophthalmological, oculomotor, and visual aspects. *Dev. Med. Child Neurol.* **2012**, *54*, 730–736. [CrossRef] [PubMed]
85. Good, W.V.; Jan, J.E.; Burden, S.K.; Skoczenski, A.; Candy, T.R. Recent advances in cortical visual impairment. *Dev. Med. Child Neurol.* **2001**, *43*, 56–60. [CrossRef] [PubMed]
86. Jacobson, L.; Dutton, G.N. Periventricular leukomalacia: An important cause of visual and ocular motility dysfunction in children. *Surv. Ophthalmol.* **2000**, *45*, 1–13. [CrossRef]
87. Kurz, M.J.; Heinrichs-Graham, E.; Becker, K.M.; Wilson, T.W. The magnitude of the somatosensory cortical activity is related to the mobility and strength impairments seen in children with cerebral palsy. *J. Neurophysiol.* **2015**, *113*, 3143–3150. [CrossRef]
88. Lanzi, G.; Fazzi, E.; Uggetti, C.; Cavallini, A.; Danova, S.; Egitto, M.G.; Ginevra, F.; Salati, R.; Bianchi, P.E. Cerebral visual impairment in periventricular leukomalacia. *Neuropediatrics* **1998**, *29*, 145–150. [CrossRef]
89. Maitre, N.L.; Barnett, Z.P.; Key, A.P.F. Novel assessment of cortical response to somatosensory stimuli in children with hemiparetic cerebral palsy. *J. Child Neurol.* **2012**, *27*, 1276–1283. [CrossRef]
90. Philip, S.S.; Guzzetta, A.; Chorna, O.; Gole, G.; Boyd, R.N. Relationship between brain structure and cerebral visual impairment in children with cerebral palsy: A systematic review. *Res. Dev. Disabil.* **2020**, *99*, 103580. [CrossRef]
91. Wingert, J.R.; Sinclair, R.J.; Dixit, S.; Damiano, D.L.; Burton, H. Somatosensory-evoked cortical activity in spastic diplegic cerebral palsy. *Hum. Brain Mapp.* **2010**, *31*, 1772–1785. [CrossRef]
92. Matta, A.P.D.C.; Nunes, G.; Rossi, L.; Lawisch, V.; Dellatolas, G.; Braga, L. Outpatient evaluation of vision and ocular motricity in 123 children with cerebral palsy. *Dev. Neurorehabilit.* **2008**, *11*, 159–165. [CrossRef]
93. Ghate, D.; Vedanarayanan, V.; Kamour, A.; Corbett, J.J.; Kedar, S. Optic nerve morphology as marker for disease severity in cerebral palsy of perinatal origin. *J. Neurol. Sci.* **2016**, *368*, 25–31. [CrossRef]
94. Kozeis, N.; Panos, G.D.; Zafeiriou, D.I.; de Gottrau, P.; Gatzioufas, Z. Comparative study of refractive errors, strabismus, microsaccades, and visual perception between preterm and full-term children with infantile cerebral palsy. *J. Child Neurol.* **2015**, *30*, 972–975. [CrossRef] [PubMed]
95. Park, M.J.; Yoo, Y.J.; Chung, C.Y.; Hwang, J.-M. Ocular findings in patients with spastic type cerebral palsy. *BMC Ophthalmol.* **2016**, *16*, 195. [CrossRef] [PubMed]
96. Auld, M.L.; Boyd, R.N.; Moseley, L.; Ware, R.; Johnston, L.M. Tactile function in children with unilateral cerebral palsy compared to typically developing children. *Disabil. Rehabil.* **2012**, *34*, 1488–1494. [CrossRef] [PubMed]
97. Clayton, K.; Fleming, J.M.; Copley, J. Behavioral responses to tactile stimuli in children with cerebral palsy. *Phys. Occup. Ther. Pediatr.* **2003**, *23*, 43–62. [CrossRef] [PubMed]
98. Ferre, C.L.; Babik, I.; Michel, G.F. A perspective on the development of hemispheric specialization, infant handedness, and cerebral palsy. *Cortex* **2020**, *127*, 208–220. [CrossRef]
99. Ferre, C.L.; Carmel, J.B.; Flamand, V.H.; Gordon, A.M.; Friel, K.M. Anatomical and functional characterization in children with unilateral cerebral palsy: An atlas-based analysis. *Neurorehabilit. Neural Repair* **2020**, *34*, 148–158. [CrossRef]
100. Eyre, J.A.; Taylor, J.P.; Villagra, F.; Smith, M.; Miller, S. Evidence of activity-dependent withdrawal of corticospinal projections during human development. *Neurology* **2001**, *57*, 1543–1554. [CrossRef] [PubMed]

101. Gordon, A.; Bleyenheuft, Y.; Steenbergen, B. Pathophysiology of impaired hand function in children with unilateral cerebral palsy. *Dev. Med. Child Neurol.* **2013**, *55*, 32–37. [CrossRef] [PubMed]
102. Reid, L.; Rose, S.E.; Boyd, R.N. Rehabilitation and neuroplasticity in children with unilateral cerebral palsy. *Nat. Rev. Neurol.* **2015**, *11*, 390–400. [CrossRef] [PubMed]
103. Rose, S.; Guzzetta, A.; Pannek, K.; Boyd, R. MRI structural connectivity, disruption of primary sensorimotor pathways, and hand function in cerebral palsy. *Brain Connect.* **2011**, *1*, 309–316. [CrossRef] [PubMed]
104. Farmer, S.F.; Harrison, L.M.; Ingram, D.A.; Stephens, J.A. Plasticity of central motor pathways in children with hemiplegic cerebral palsy. *Neurology* **1991**, *41*, 1505. [CrossRef] [PubMed]
105. Staudt, M.; Grodd, W.; Gerloff, C.; Erb, M.; Stitz, J.; Krägeloh-Mann, I. Two types of ipsilateral reorganization in congenital hemiparesis: A TMS and fMRI study. *Brain* **2002**, *125*, 2222–2237. [CrossRef]
106. Staudt, M.; Lidzba, K.; Grodd, W.; Wildgruber, D.; Erb, M.; Krageloh-Mann, I. Right-hemispheric organization of language following early left-sided brain lesions: Functional MRI topography. *Neuroimage* **2002**, *16*, 954–967. [CrossRef] [PubMed]
107. Staudt, M.; Gerloff, C.; Grodd, W.; Holthausen, H.; Niemann, G.; Krägeloh-Mann, I. Reorganization in congenital hemiparesis acquired at different gestational ages. *Ann. Neurol.* **2004**, *56*, 854–863. [CrossRef] [PubMed]
108. You, S.H.; Jang, S.H.; Kim, Y.-H.; Kwon, Y.-H.; Barrow, I.; Hallett, M. Cortical reorganization induced by virtual reality therapy in a child with hemiparetic cerebral palsy. *DMCN* **2005**, *47*, 628–635.
109. Forssberg, H.; Eliasson, A.C.; Redon-Zouitenn, C.; Mercuri, E.; Dubowitz, L. Impaired grip-lift synergy in children with unilateral brain lesions. *Brain* **1999**, *122*, 1157–1168. [CrossRef]
110. Gordon, A.M.; Duff, S.V. Relation between clinical measures and fine manipulative control in children with hemiplegic cerebral palsy. *DMCN* **1999**, *41*, 586–591.
111. Hung, Y.-C.; Charles, J.; Gordon, A.M. Bimanual coordination during a goal-directed task in children with hemiplegic cerebral palsy. *Dev. Med. Child Neurol.* **2004**, *46*, 746–753. [CrossRef] [PubMed]
112. D'Souza, H.; Cowie, D.; Karmiloff-Smith, A.; Bremner, A.J. Specialization of the motor system in infancy: From broad tuning to selectively specialized purposeful actions. *Dev. Sci.* **2017**, *20*, e12409. [CrossRef]
113. Soska, K.C.; Galeon, M.A.; Adolph, K.E. On the other hand: Overflow movements of infants' hands and legs during unimanual object exploration. *Dev. Psychobiol.* **2012**, *54*, 372–382. [CrossRef] [PubMed]
114. Muetzel, R.L.; Collins, P.F.; Mueller, B.A.; Schissel, A.M.; Lim, K.O.; Luciana, M. The development of corpus callosum microstructure and associations with bimanual task performance in healthy adolescents. *NeuroImage* **2008**, *39*, 1918–1925. [CrossRef] [PubMed]
115. Kidokoro, H.; Kubota, T.; Ohe, H.; Hattori, T.; Kato, Y.; Miyajima, Y.; Ogawa, A.; Okumura, A.; Watanabe, K.; Kojima, S. Diffusion-weighted magnetic resonance imaging in infants with periventricular leukomalacia. *Neuropediatrics* **2008**, *39*, 233–238. [CrossRef]
116. Lee, J.D.; Park, H.J.; Park, E.S.; Oh, M.K.; Park, B.; Rha, D.W.; Cho, S.R.; Kim, E.Y.; Park, J.Y.; Kim, C.H.; et al. Motor path-way injury in patients with periventricular leucomalacia and spastic diplegia. *Brain* **2011**, *134*, 1199–1210. [CrossRef] [PubMed]
117. Staudt, M.; Pavlova, M.; Böhm, S.; Grodd, W.; Krägeloh-Mann, I. Pyramidal tract damage correlates with motor dysfunction in bilateral Periventricular Leukomalacia (PVL). *Neuropediatrics* **2003**, *34*, 182–188. [CrossRef]
118. Charles, J.; Gordon, A.M. A critical review of constraint-induced movement therapy and forced use in children with hemiplegia. *Neural Plast.* **2005**, *12*, 245–261. [CrossRef]
119. Houwink, A.; Aarts, P.B.; Geurts, A.C.; Steenbergen, B. A neurocognitive perspective on developmental disregard in children with hemiplegic cerebral palsy. *Res. Dev. Disabil.* **2011**, *32*, 2157–2163. [CrossRef] [PubMed]
120. Green, D.; Schertz, M.; Gordon, A.; Moore, A.; Margalit, T.S.; Farquharson, Y.; Ben Bashat, D.; Weinstein, M.; Lin, J.-P.; Fattal-Valevski, A. A multi-site study of functional outcomes following a themed approach to hand-arm bimanual intensive therapy for children with hemiplegia. *Dev. Med. Child Neurol.* **2013**, *55*, 527–533. [CrossRef] [PubMed]
121. Russo, R.N.; Goodwin, E.J.; Miller, M.D.; Haan, E.A.; Connell, T.M.; Crotty, M. Self- esteem, self-concept, and quality of life in children with hemiplegic cerebral palsy. *J. Pediatr.* **2008**, *153*, 473–477.e2. [CrossRef]
122. Steenbergen, B.; Gordon, A.M. Activity limitation in hemiplegic cerebral palsy: Evidence for disorders in motor planning. *DMCN* **2006**, *48*, 780–783.
123. Pandya, D.; Karol, E.; Heilbronn, D. The topographical distribution of interhemispheric projections in the corpus callosum of the rhesus monkey. *Brain Res.* **1971**, *32*, 31–43. [CrossRef]
124. Sperry, R.W. Cerebral organization and behavior. *Science* **1961**, *133*, 1749–1757. [CrossRef] [PubMed]
125. Meyer, B.-U.; Röricht, S.; Von Einsiedel, H.G.; Kruggel, F.; Weindl, A. Inhibitory and excitatory interhemispheric transfers between motor cortical areas in normal humans and patients with abnormalities of the corpus callosum. *Brain* **1995**, *118*, 429–440. [CrossRef]
126. Schnitzler, A.; Kessler, K.; Benecke, R. Transcallosally mediated inhibition of interneurons within human primary motor cortex. *Exp. Brain Res.* **1996**, *112*, 381–391. [CrossRef] [PubMed]
127. Karolis, V.R.; Corbetta, M.; de Schotten, M.T. The architecture of functional lateralisation and its relationship to callosal connectivity in the human brain. *Nat. Commun.* **2019**, *10*, 1417. [CrossRef] [PubMed]
128. Markov, N.T.; Ercsey-Ravasz, M.; Van Essen, D.C.; Knoblauch, K.; Toroczkai, Z.; Kennedy, H. Cortical high-density counterstream architectures. *Science* **2013**, *342*, 1238406. [CrossRef]

129. Addamo, P.K.; Farrow, M.; Hoy, K.; Bradshaw, J.L.; Georgiou-Karistianis, N. The effects of age and attention on motor overflow production—A review. *Brain Res. Rev.* **2007**, *54*, 189–204. [CrossRef]
130. Knyazeva, M.G.; Farber, D.A. Formation of interhemispheric interaction in ontogeny: Electrophysiological analysis. *Hum. Physiol.* **1991**, *17*, 1–11.
131. Salamy, A. Commissural transmission: Maturational changes in humans. *Science* **1978**, *200*, 1409–1411. [CrossRef]
132. Gazzaniga, M.S. Cerebral specialization and interhemispheric communication: Does the corpus callosum enable the human condition? *Brain* **2000**, *123*, 1293–1326. [CrossRef] [PubMed]
133. Hellige, J.B. *Hemispheric Asymmetry: What's Right and What's Left*; Harvard University Press: Cambridge, MA, USA, 1993.
134. Michel, G.F. A neuropsychological perspective on infant sensorimotor development. In *Advances in Infancy Research*; Rovee-Collier, C., Lipsitt, L.P., Eds.; Ablex: Norwood, NJ, USA, 1988; pp. 1–38.
135. Horowitz, A.; Barazany, D.; Tavor, I.; Bernstein, M.; Yovel, G.; Assaf, Y. In vivo correlation between axon diameter and conduction velocity in the human brain. *Brain Struct. Funct.* **2015**, *220*, 1777–1788. [CrossRef] [PubMed]
136. Davatzikos, C.; Barzi, A.; Lawrie, T.; Hoon, A.H.; Melhem, E.R. Correlation of corpus callosal morphometry with cognitive and motor function in periventricular leukomalacia. *Neuropediatrics* **2003**, *34*, 247–252. [CrossRef] [PubMed]
137. Moses, P.; Courchesne, E.; Stiles, J.; Trauner, D.; Egaas, B.; Edwards, E. Regional size reduction in the human corpus callosum following pre- and perinatal brain injury. *Cereb. Cortex* **2000**, *10*, 1200–1210. [CrossRef]
138. Fagard, J.; Corroyer, D. Using a continuous index of laterality to determine how laterality is related to interhemispheric transfer and bimanual coordination in children. *Dev. Psychobiol.* **2003**, *43*, 44–56. [CrossRef] [PubMed]
139. Hung, Y.-C.; Robert, M.T.; Friel, K.M.; Gordon, A.M. Relationship between integrity of the corpus callosum and bimanual coordination in children with unilateral spastic cerebral palsy. *Front. Hum. Neurosci.* **2019**, *13*, 334. [CrossRef] [PubMed]
140. Preilowski, B.F. Bilateral motor interaction: Perceptual-motor performance of partial and complete 'split-brain' patients. In *Cerebral Localization*; Zulch, K.J., Creutzfeld, O., Galbraith, G.C., Eds.; Springer: Berlin, Germany, 1975; pp. 115–132.
141. Sacco, S.; Moutard, M.-L.; Fagard, J. Agenesis of the corpus callosum and the establishment of handedness. *Dev. Psychobiol.* **2006**, *48*, 472–481. [CrossRef] [PubMed]
142. Jeeves, M.A.; Silver, P.H.; Milne, A.B. Role of the corpus callosum in the development of a bimanual motor skill. *Dev. Neuropsychol.* **1988**, *4*, 305–323. [CrossRef]
143. Seltzer, B.; Pandya, D.N. Posterior parietal projections to the intraparietal sulcus of the rhesus monkey. *Exp. Brain Res.* **1986**, *62*, 459–469. [CrossRef] [PubMed]
144. Preilowski, B.F. Possible contribution of the anterior forebrain commissures to bilateral motor coordination. *Neuropsychologia* **1972**, *10*, 267–277. [CrossRef]
145. Andres, F.G.; Gerloff, C. Coherence of sequential movements and motor learning. *J. Clin. Neurophysiol.* **1999**, *16*, 520–527. [CrossRef]
146. Serrien, D.J.; Brown, P. The integration of cortical and behavioural dynamics during initial learning of a motor task. *Eur. J. Neurosci.* **2003**, *17*, 1098–1104. [CrossRef] [PubMed]
147. Sperry, R.W. Hemisphere deconnection and unity in conscious awareness. *Am. Psychol.* **1968**, *23*, 723–733. [CrossRef] [PubMed]
148. Sun, F.T.; Miller, L.M.; Rao, A.A.; D'Esposito, M. Functional connectivity of cortical networks involved in bimanual motor sequence learning. *Cereb. Cortex* **2006**, *17*, 1227–1234. [CrossRef] [PubMed]
149. Chiarello, C. A house divided? Cognitive functioning with callosal agenesis. *Brain Lang.* **1980**, *11*, 128–158. [CrossRef]
150. Jeeves, M.A. Callosal agenesis: Neuronal and developmental adaptations. In *Two Hemispheres, One Brain: Functions of the Corpus Callosum*; Lepore, F., Ptito, M., Jasper, H.H., Eds.; Alan, R. Liss: New York, NY, USA, 1986; pp. 403–422.
151. Meissner, T.W.; Friedrich, P.; Ocklenburg, S.; Genç, E.; Weigelt, S. Tracking the functional development of the corpus callosum in children using behavioral and evoked potential interhemispheric transfer times. *Dev. Neuropsychol.* **2017**, *42*, 172–186. [CrossRef]
152. Sauerwein, H.C.; Lassonde, M.C.; Cardu, B.; Geoffroy, G. Interhemispheric integration of sensory and motor functions in agenesis of the corpus callosum. *Neuropsychologia* **1981**, *19*, 445–454. [CrossRef]
153. Fontes, P.L.B.; Cruz, T.K.F.; Souto, D.O.; Moura, R.; Haase, V.G. Body representation in children with hemiplegic cerebral palsy. *Child Neuropsychol.* **2017**, *23*, 838–863. [CrossRef]
154. Punt, T.D.; Riddoch, M.J. Motor neglect: Implications for movement and rehabilitation following stroke. *Disabil. Rehabil.* **2006**, *28*, 857–864. [CrossRef]
155. Ajuriaguerra, J.; Stucki, J.D. Developmental disorders of the body schema. In *Disorders of Speech, Perception and Symbolic Behaviour*; Vinken, P.J., Bruyn, G.W., Eds.; North Holland: New York, NY, USA, 1969; pp. 392–407.
156. Katz, N.; Cermak, S.; Shamir, Y. Unilateral neglect in children with hemiplegic cerebral palsy. *Percept. Mot. Ski.* **1998**, *86*, 539–550. [CrossRef]
157. Trauner, D.A. Hemispatial neglect in young children with early unilateral brain damage. *Dev. Med. Child Neurol.* **2007**, *45*, 160–166. [CrossRef]
158. Di Vita, A.; Cinelli, M.C.; Raimo, S.; Boccia, M.; Buratin, S.; Gentili, P.; Inzitari, M.T.; Iona, T.; Iosa, M.; Morelli, D.; et al. Body representations in children with cerebral palsy. *Brain Sci.* **2020**, *10*, 490. [CrossRef] [PubMed]
159. Mutsaarts, M.; Steenbergen, B.; Bekkering, H. Impaired motor imagery in right hemiparetic cerebral palsy. *Neuropsychologia* **2007**, *45*, 853–859. [CrossRef] [PubMed]

160. Groen, S.E.; de Blécourt, A.C.E.; Postema, K.; Hadders-Algra, M. Quality of general movements predicts neuromotor development at the age of 9–12 years. *DMCN* **2005**, *47*, 731–738.
161. Hadders-Algra, M.; Nieuwendijk, A.W.K.; Maitijn, A.; Eykern, L.A. Assessment of general movements: Towards a better understanding of a sensitive method to evaluate brain function in young infants. *Dev. Med. Child Neurol.* **1997**, *39*, 88–98. [CrossRef] [PubMed]
162. Hadders-Algra, M.; Mavinkurve-Groothuis, A.M.C.; Groen, S.E.; Stremmelaar, E.F.; Martijn, A.; Butcher, P.R. Quality of general movements and the development of minor neurological dysfunction at toddler and school age. *Clin. Rehabil.* **2004**, *18*, 287–299. [CrossRef]
163. Lüchinger, A.B.; Hadders-Algra, M.; van Kan, C.M.; Vries, J.I.P.D. Fetal onset of general movements. *Pediatr. Res.* **2008**, *63*, 191–195. [CrossRef]
164. Prechtl, H. Qualitative changes of spontaneous movements in fetus and preterm infant are a marker of neurological dysfunction. *Early Hum. Dev.* **1990**, *23*, 151–158. [CrossRef]
165. Prechtl, H.F.; Einspieler, C.; Cioni, G.; Bos, A.F.; Ferrari, F.; Sontheimer, D. An early marker for neurological deficits after perinatal brain lesions. *Lancet* **1997**, *349*, 1361–1363. [CrossRef]
166. Babik, I.; Galloway, J.C.; Lobo, M.A. Infants born preterm demonstrate impaired exploration of their bodies and surfaces throughout the first 2 years of life. *Phys. Ther.* **2017**, *97*, 915–925. [CrossRef]
167. Einspieler, C.; Prechtl, H.F. Prechtl's assessment of general movements: A diagnostic tool for the functional assessment of the young nervous system. *Dev. Disabil. Res. Rev.* **2005**, *11*, 61–67. [CrossRef]
168. Piek, J.P. The role of variability in early motor development. *Infant Behav. Dev.* **2002**, *25*, 452–465. [CrossRef]
169. van der Meer, A.L.H.; van der Weel, F.R.; Lee, D.N. The functional significance of arm movements in neonates. *Science* **1995**, *267*, 693–695. [CrossRef] [PubMed]
170. Bower, T.G.R. *Development in Infancy*; Freeman: San Francisco, CA, USA, 1982.
171. von Hofsten, C. Foundations for perceptual development. *Adv. Infancy Res.* **1982**, *2*, 241–265.
172. Lee, M.-H.; Liu, Y.-T.; Newell, K.M. Longitudinal expressions of infant's prehension as a function of object properties. *Infant Behav. Dev.* **2006**, *29*, 481–493. [CrossRef]
173. Michel, G.F.; Harkins, D.A. Postural and lateral asymmetries in the ontogeny of handedness during infancy. *Dev. Psychobiol.* **1986**, *19*, 247–258. [CrossRef]
174. Thelen, E.; Corbetta, D.; Kamm, K.; Spencer, J.P.; Schneider, K.; Zernicke, R.F. The transition to reaching: Mapping intention and intrinsic dynamics. *Child Dev.* **1993**, *64*, 1058–1098. [CrossRef]
175. Thomas, B.L.; Karl, J.M.; Whishaw, I.Q. Independent development of the Reach and the Grasp in spontaneous self-touching by human infants in the first 6 months. *Front. Psychol.* **2015**, *5*, 1526. [CrossRef]
176. von Hofsten, C. Structuring of early reaching movements: A longitudinal study. *J. Mot. Behav.* **1991**, *23*, 280–292. [CrossRef]
177. Wallace, P.S.; Whishaw, I.Q. Independent digit movements and precision grip patterns in 1–5-month-old human infants: Hand-babbling, including vacuous then self-directed hand and digit movements, precedes targeted reaching. *Neuropsychologia* **2003**, *41*, 1912–1918. [CrossRef]
178. Fagard, J.; Jacquet, A.Y. Changes in reaching and grasping objects of different sizes between 7 and 13 months of age. *Br. J. Dev. Psychol.* **1996**, *14*, 65–78. [CrossRef]
179. Babik, I.; Michel, G.F. Development of role-differentiated bimanual manipulation in infancy: Hand preferences for object acquisition and RDBM—continuity or discontinuity? *Dev. Psychobiol.* **2016**, *58*, 257–267. [CrossRef] [PubMed]
180. Babik, I.; Michel, G.F. Development of role-differentiated bimanual manipulation in infancy: Part 3. Its relation to the development of bimanual object acquisition and bimanual non-differentiated manipulation. *Dev. Psychobiol.* **2016**, *58*, 268–277. [CrossRef]
181. de Oliveira, S.C. The neuronal basis of bimanual coordination: Recent neurophysiological evidence and functional models. *Acta Psychol.* **2002**, *110*, 139–159. [CrossRef]
182. Gibson, E.J.; Pick, A.D. *An Ecological Approach to Perceptual Learning and Development*; Oxford University Press: Oxford, UK, 2000.
183. Kimmerle, M.; Mick, L.A.; Michel, G.F. Bimanual role-differentiated toy play during infancy. *Infant Behav. Dev.* **1995**, *18*, 299–307. [CrossRef]
184. Kimmerle, M.; Ferre, C.L.; Kotwica, K.A.; Michel, G.F. Development of role-differentiated bimanual manipulation during the infant's first year. *Dev. Psychobiol.* **2010**, *52*, 168–180. [CrossRef]
185. Liuzzi, G.; Hoerniß, V.; Zimerman, M.; Gerloff, C.; Hummel, F.C. Coordination of uncoupled bi-manual movements by strictly timed interhemispheric connectivity. *J. Neurosci.* **2011**, *31*, 9111–9117. [CrossRef]
186. Babik, I.; Michel, G.F. Development of role-differentiated bimanual manipulation in infancy: Part 1. The emergence of the skill. *Dev. Psychobiol.* **2016**, *58*, 243–256. [CrossRef]
187. Martin, J.H. The Corticospinal system: From development to motor control. *Neuroscientist* **2005**, *11*, 161–173. [CrossRef]
188. Ritterband-Rosenbaum, A.; Herskind, A.; Li, X.; Willerslev-Olsen, M.; Olsen, M.D.; Farmer, S.F.; Nielsen, J.B. A critical period of corticomuscular and EMG-EMG coherence detection in healthy infants aged 9–25 weeks. *J. Physiol.* **2017**, *595*, 2699–2713. [CrossRef]
189. Bos, A.F.; Martijn, A.; Okken, A.; Prechtl, H.F.R. Quality of general movements in preterm infants with transient periventricular echodensities. *Acta Paediatr.* **1998**, *87*, 328–335. [CrossRef]

190. Ferrari, F.; Cioni, G.; Einspieler, C.; Roversi, M.F.; Bos, A.F.; Paolicelli, P.B.; Ranzi, A.; Prechtl, H.F.R. Cramped synchronized general movements in preterm infants as an early marker for cerebral palsy. *Arch. Pediatr. Adolesc. Med.* **2002**, *156*, 460–467. [CrossRef] [PubMed]
191. Hadders-Algra, M. Putative neural substrate of normal and abnormal general movements. *Neurosci. Biobehav. Rev.* **2007**, *31*, 1181–1190. [CrossRef] [PubMed]
192. Haggard, P. Sense of agency in the human brain. *Nat. Rev. Neurosci.* **2017**, *18*, 196–207. [CrossRef] [PubMed]
193. Kawato, M.; Wolpert, D. Internal models for motor control. *Sens. Guid. Mov.* **1998**, *218*, 291–307. [CrossRef]
194. Ritterband-Rosenbaum, A.; Justiniano, M.D.; Nielsen, J.B.; Christensen, M.S. Are sensorimotor experiences the key for successful early intervention in infants with congenital brain lesion? *Infant Behav. Dev.* **2019**, *54*, 133–139. [CrossRef]
195. Cahill-Rowley, K.; Rose, J. Etiology of impaired selective motor control: Emerging evidence and its implications for research and treatment in cerebral palsy. *Dev. Med. Child Neurol.* **2014**, *56*, 522–528. [CrossRef]
196. Kuhtz-Buschbeck, J.P.; Sundholm, L.K.; Eliasson, A.C.; Forssberg, H. Quantitative assessment of mirror movements in children and adolescents with hemiplegic cerebral palsy. *DMCN* **2000**, *42*, 728–736.
197. Sukal-Moulton, T.; Gaebler-Spira, D.; Krosschell, K.J. Clinical characteristics associated with reduced selective voluntary motor control in the upper extremity of individuals with spastic cerebral palsy. *Dev. Neurorehabilit.* **2021**, *24*, 215–221. [CrossRef]
198. Honeycutt, C.F.; Kharouta, M.; Perreault, E. Evidence for reticulospinal contributions to coordinated finger movements in humans. *J. Neurophysiol.* **2013**, *110*, 1476–1483. [CrossRef]
199. Cernacek, J. Contralateral motor irradiation cerebral dominance: It's changes in hemiplegia. *Arch. Neurol.* **1961**, *4*, 165–172. [CrossRef] [PubMed]
200. Green, J.B. An electromyographic study of mirror movements. *Neurology* **1967**, *17*, 91. [CrossRef] [PubMed]
201. Nass, R. Mirror movement asymmetries in congenital hemiplegia: The inhibition hypothesis revisited. *Neurology* **1985**, *35*, 1059–1062. [CrossRef] [PubMed]
202. Connolly, K.; Stratton, P. Developmental changes in associated movements. *Dev. Med. Child Neurol.* **1968**, *10*, 49–56. [CrossRef]
203. Wolff, P.H.; Gunnoe, C.E.; Cohen, C. Associated movements as a measure of developmental age. *Dev. Med. Child Neurol.* **1983**, *25*, 417–429. [CrossRef] [PubMed]
204. Ego, A.; Lidzba, K.; Brovedani, P.; Belmonti, V.; Gonzalez-Monge, S.; Boudia, B.; Ritz, A.; Cans, C. Visual-perceptual impairment in children with cerebral palsy: A systematic review. *Dev. Med. Child Neurol.* **2015**, *57*, 46–51. [CrossRef] [PubMed]
205. Stiles, J.; Nass, R. Spatial grouping activity in young children with congenital right or left hemisphere brain injury. *Brain Cogn.* **1991**, *15*, 201–222. [CrossRef]
206. Stiles, J.; Thal, D. Linguistic and spatial cognitive development following early focal brain injury: Patterns of deficit and recovery. In *Brain Development and Cognition: A Reader*; Johnson, M.H., Ed.; Blackwell Publishing: Hoboken, NJ, USA, 1993.
207. Stiles, J.; Trauner, D.; Engel, M.; Nass, R. The development of drawing in children with congenital focal brain injury: Evidence for limited functional recovery. *Neuropsychologia* **1997**, *35*, 299–312. [CrossRef]
208. Stiles-Davis, J.; Sugarman, S.; Nass, R. The development of spatial and class relations in four young children with right-cerebral-hemisphere damage: Evidence for an early spatial constructive deficit. *Brain Cogn.* **1985**, *4*, 388–412. [CrossRef]
209. Stiles-Davis, J.; Janowsky, J.; Engel, M.; Nass, R. Drawing ability in four young children with congenital unilateral brain lesions. *Neuropsychologia* **1988**, *26*, 359–371. [CrossRef]
210. Bolognini, N.; Vallar, G. *Hemianopia, Spatial Neglect, and Their Multisensory Rehabilitation*; Academic Press: Cambridge, MA, USA, 2019; pp. 423–447. [CrossRef]
211. Hart, E.; Grattan, E.; Woodbury, M.; Herbert, T.L.; Coker-Bolt, P.; Bonilha, H. Pediatric unilateral spatial neglect: A systematic review. *J. Pediatr. Rehabil. Med.* **2021**, *14*, 345–359. [CrossRef]
212. Nuara, A.; Papangelo, P.; Avanzini, P.; Fabbri-Destro, M. Body representation in children with unilateral cerebral palsy. *Front. Psychol.* **2019**, *10*, 354. [CrossRef]
213. Blake, R.; Shiffrar, M. Perception of human motion. *Annu. Rev. Psychol.* **2007**, *58*, 47–73. [CrossRef]
214. Dutton, G.N. Cognitive vision, its disorders and differential diagnosis in adults and children: Knowing where and what things are. *Eye* **2003**, *17*, 289–304. [CrossRef] [PubMed]
215. Goodale, M.A.; Milner, A.D. Separate visual pathways for perception and action. *Trends Neurosci.* **1992**, *15*, 20–25. [CrossRef]
216. Pavlova, M.A.; Krägeloh-Mann, I. Limitations on the developing preterm brain: Impact of periventricular white matter lesions on brain connectivity and cognition. *Brain* **2013**, *136*, 998–1011. [CrossRef] [PubMed]
217. Fazzi, E.; Bova, S.M.; Uggetti, C.; Signorini, S.G.; Bianchi, P.E.; Maraucci, I.; Zoppello, M.; Lanzi, G. Visual–perceptual impairment in children with periventricular leukomalacia. *Brain Dev.* **2004**, *26*, 506–512. [CrossRef]
218. Koeda, T.; Takeshita, K. Visuo-perceptual impairment and cerebral lesions in spastic diplegia with preterm birth. *Brain Dev.* **1992**, *14*, 239–244. [CrossRef]
219. Skranes, J.S.; Vik, T.; Nilsen, C.; Smevik, O.; Andersson, H.W.; Brubakk, A.M. Cerebral magnetic resonance imaging and mental and motor function of very low birth weight children at six years of age. *Neuropediatrics* **1997**, *28*, 149–154. [CrossRef]
220. Hout, B.M.V.D.; De Vries, L.S.; Meiners, L.C.; Stiers, P.; Van Der Schouw, Y.T.; Jennekens-Schinkel, A.; Wittebol-Post, D.; Van Der Linde, D.; Vandenbussche, E.; Van Nieuwenhuizen, O. Visual perceptual impairment in children at 5 years of age with perinatal haemorrhagic or ischaemic brain damage in relation to cerebral magnetic resonance imaging. *Brain Dev.* **2004**, *26*, 251–261. [CrossRef]

221. Schatz, A.M.; Ballantyne, A.O.; Trauner, D.A. A Hierarchical analysis of block design errors in children with early focal brain damage. *Dev. Neuropsychol.* **2000**, *17*, 75–83. [CrossRef]
222. Vicari, S.; Stiles, J.; Stern, C.; Resca, A. Spatial grouping activity in children with early cortical and subcortical lesions. *Dev. Med. Child Neurol.* **1998**, *40*, 90–94. [CrossRef] [PubMed]
223. Abercrombie, M.L.J.; Tyson, M.C. Body image and draw-a-man test in cerebral palsy. *Dev. Med. Child Neurol.* **1966**, *8*, 9–15. [CrossRef] [PubMed]
224. Bumin, G.; Kavak, S.T. An investigation of the factors affecting handwriting performance in children with hemiplegic cerebral palsy. *Disabil. Rehabil.* **2008**, *30*, 1374–1385. [CrossRef] [PubMed]
225. Cameron, C.E.; Brock, L.L.; Murrah, W.M.; Bell, L.H.; Worzalla, S.L.; Grissmer, D.; Morrison, F.J. Fine motor skills and executive function both contribute to kindergarten achievement. *Child Dev.* **2012**, *83*, 1229–1244. [CrossRef]
226. Grissmer, D.; Grimm, K.J.; Aiyer, S.; Murrah, W.M.; Steele, J.S. Fine motor skills and early comprehension of the world: Two new school readiness indicators. *Dev. Psychol.* **2010**, *46*, 1008–1017. [CrossRef]
227. DeLoache, J.S. Symbolic functioning in very young children: Understanding of pictures and models. *Child Dev.* **1991**, *62*, 736–752. [CrossRef]
228. DeLoache, J.S. Early development of the understanding and use of symbolic artifacts. In *Wiley Blackwell Handbooks of Developmental Psychology*; Goswami, U., Ed.; John Wiley & Sons: Hoboken, NJ, USA, 2011; pp. 312–336. [CrossRef]
229. Troseth, G.L.; Casey, A.M.; Lawver, K.A.; Walker, J.M.T.; Cole, D.A. Naturalistic experience and the early use of symbolic artifacts. *J. Cogn. Dev.* **2007**, *8*, 309–331. [CrossRef]
230. Beeghly, M.; Weiss-Perry, B.; Cicchetti, D. *Beyond Sensorimotor Functioning: Early Communicative and Play Development of Children with Down Syndrome*; Cambridge University Press: Cambridge, UK, 1990; pp. 329–368. [CrossRef]
231. Iverson, J.M. Developing language in a developing body: The relationship between motor development and language development. *J. Child Lang.* **2010**, *37*, 229–261. [CrossRef]
232. Kennedy, M.D.; Sheridan, M.K.; Radlinski, S.H.; Beeghly, M. Play–language relationships in young children with developmental delays: Implications for assessment. *J. Speech Lang. Hear. Res.* **1991**, *34*, 112–122. [CrossRef]
233. LeFevre, J.A.; Fast, L.; Skwarchuk, S.L.; Smith-Chant, B.L.; Bisanz, J.; Kamawar, D.; Penner-Wilger, M. Pathways to mathematics: Longitudinal predictors of performance. *Child Dev.* **2010**, *81*, 1753–1767. [CrossRef]
234. Lewis, J.B.V.; Boucher, J.; Lupton, L.; Watson, S. Relationships between symbolic play, functional play, verbal and non-verbal ability in young children. *Int. J. Lang. Commun. Disord.* **2000**, *35*, 117–127. [CrossRef] [PubMed]
235. McCune, L. A normative study of representational play at the transition to language. *Dev. Psychol.* **1995**, *31*, 198–206. [CrossRef]
236. Miller, E.; Almon, J. *Crisis in the Kindergarten: Why Children Need to Play in School*; Alliance for Childhood: College Park, MD, USA, 2009.
237. Werner, H.; Kaplan, B. *Symbol Formation*; Wiley: New York, NY, USA, 1963.
238. Di Vita, A.; Boccia, M.; Palermo, L.; Guariglia, C. To move or not to move, that is the question! Body schema and non-action oriented body representations: An fMRI meta-analytic study. *Neurosci. Biobehav. Rev.* **2016**, *68*, 37–46. [CrossRef] [PubMed]
239. Murata, A.; Ishida, H. *Representation of Bodily Self in the Multimodal Parieto-Premotor Network*; Springer: New York, NY, USA, 2007; pp. 151–176. [CrossRef]
240. Palermo, L.; Di Vita, A.; Piccardi, L.; Traballesi, M.; Guariglia, C. Bottom-up and top-down processes in body representation: A study of brain-damaged and amputee patients. *Neuropsychology* **2014**, *28*, 772–781. [CrossRef]
241. Coslett, H.B. Body representations: Updating a classic concept. In *The Roots of Cognitive Neuroscience: Behavioral Neurology and Neuropsychology*; Chatterjee, A., Coslett, H.B., Eds.; Oxford University Press: New York, NY, USA, 2014; pp. 221–236.
242. Schwoebel, J.; Coslett, H.B. Evidence for multiple, distinct representations of the human body. *J. Cogn. Neurosci.* **2005**, *17*, 543–553. [CrossRef] [PubMed]
243. Sirigu, A.; Grafman, J.; Bressler, K.; Sunderland, T. Multiple representations contribute to body knowledge processing. *Brain* **1991**, *114*, 629–642. [CrossRef] [PubMed]
244. Berlucchi, G.; Aglioti, S.M. The body in the brain revisited. *Exp. Brain Res.* **2010**, *200*, 25–35. [CrossRef]
245. Buxbaum, L.J.; Coslett, H. Specialized structural descriptions for human body parts: Evidence from autotopagnosia. *Cogn. Neuropsychol.* **2001**, *18*, 289–306. [CrossRef]
246. Crajé, C.; van Elk, M.; Beeren, M.; van Schie, H.T.; Bekkering, H.; Steenbergen, B. Compromised motor planning and motor imagery in right hemiparetic cerebral palsy. *Res. Dev. Disabil.* **2010**, *31*, 1313–1322. [CrossRef]
247. Raimo, S.; Boccia, M.; Di Vita, A.; Iona, T.; Cropano, M.; Ammendolia, A.; Colao, R.; Angelillo, V.; Maiorino, A.; Guariglia, C.; et al. Body representation alterations in patients with unilateral brain damage. *J. Int. Neuropsychol. Soc.* **2021**, *28*, 130–142. [CrossRef]
248. Steenbergen, B.; van Nimwegen, M.; Crajé, C. Solving a mental rotation task in congenital hemiparesis: Motor imagery versus visual imagery. *Neuropsychologia* **2007**, *45*, 3324–3328. [CrossRef] [PubMed]
249. Fontes, P.L.B.; Moura, R.; Haase, V.G. Evaluation of body representation in children with hemiplegic cerebral palsy: Toward the development of a neuropsychological test battery. *Psychol. Neurosci.* **2014**, *7*, 139–149. [CrossRef]
250. Raimo, S.; Iona, T.; Di Vita, A.; Boccia, M.; Buratin, S.; Ruggeri, F.; Iosa, M.; Guariglia, C.; Grossi, D.; Palermo, L. The development of body representations in school-aged children. *Appl. Neuropsychol. Child* **2019**, *10*, 327–339. [CrossRef] [PubMed]
251. Parsons, L.M. Imagined spatial transformations of one's hands and feet. *Cogn. Psychol.* **1987**, *19*, 178–241. [CrossRef]

252. Brownell, C.A.; Nichols, S.R.; Svetlova, M.; Zerwas, S.; Ramani, G. The head bone's connected to the neck bone: When do toddlers represent their own body topography? *Child Dev.* **2010**, *81*, 797–810. [CrossRef]
253. Camões-Costa, V.; Erjavec, M.; Horne, P.J. Comprehension and production of body part labels in 2- to 3-year-old children. *Br. J. Dev. Psychol.* **2011**, *29*, 552–571. [CrossRef]
254. Müller, U.; Sokol, B.; Overton, W. Reframing a constructivist model of the development of mental representation: The role of higher-order operations. *Dev. Rev.* **1998**, *18*, 155–201. [CrossRef]
255. Simons, J.; Dedroog, I. Body awareness in children with mental retardation. *Res. Dev. Disabil.* **2009**, *30*, 1343–1353. [CrossRef]
256. Slaughter, V.; Heron, M.; Jenkins, L.; Tilse, E.I. Levels of human body knowledge in development. *Monogr. Soc. Res. Child Dev.* **2004**, *69*, 1–23. [CrossRef]
257. Auclair, L.; Jambaqué, I. Lexical-semantic body knowledge in 5- to 11-year-old children: How spatial body representation influences body semantics. *Child Neuropsychol.* **2014**, *21*, 451–464. [CrossRef] [PubMed]
258. Parsons, L.M. Temporal and kinematic properties of motor behavior reflected in mentally simulated action. *J. Exp. Psychol. Hum. Percept. Perform.* **1994**, *20*, 709–730. [CrossRef] [PubMed]
259. van Elk, M.; Crajé, C.; Beeren, M.E.G.V.; Steenbergen, B.; van Schie, H.T.; Bekkering, H. Neural evidence for compromised motor imagery in right hemiparetic cerebral palsy. *Front. Neurol.* **2010**, *1*, 150. [CrossRef] [PubMed]
260. Gallagher, S. *How the Body Shapes the Mind*; Oxford University Press: Oxford, UK, 2005.
261. Rizzolatti, G.; Sinigaglia, C. The functional role of the parieto-frontal mirror circuit: Interpretations and misinterpretations. *Nat. Rev. Neurosci.* **2010**, *11*, 264–274. [CrossRef] [PubMed]
262. Serino, A.; De Filippo, L.; Casavecchia, C.; Coccia, M.; Shiffrar, M.; Làdavas, E. Lesions to the motor system affect action perception. *J. Cogn. Neurosci.* **2010**, *22*, 413–426. [CrossRef]
263. Pavlova, M.; Krägeloh-Mann, I.; Sokolov, A.; Birbaumer, N. Recognition of point-light biological motion displays by young children. *Perception* **2001**, *30*, 925–933. [CrossRef]
264. Gobbini, M.I.; Koralek, A.C.; Bryan, R.E.; Montgomery, K.J.; Haxby, J.V. Two takes on the social brain: A comparison of theory of mind tasks. *J. Cogn. Neurosci.* **2007**, *19*, 1803–1814. [CrossRef]
265. Grossman, E.D.; Blake, R. Brain areas active during visual perception of biological motion. *Neuron* **2002**, *35*, 1167–1175. [CrossRef]
266. Grossman, E.; Donnelly, M.; Price, R.; Pickens, D.; Morgan, V.; Neighbor, G.; Blake, R. Brain areas involved in perception of biological motion. *J. Cogn. Neurosci.* **2000**, *12*, 711–720. [CrossRef]
267. Grossman, E.D.; Blake, R.; Kim, C.-Y. Learning to see biological motion: Brain activity parallels behavior. *J. Cogn. Neurosci.* **2004**, *16*, 1669–1679. [CrossRef]
268. Herrington, J.D.; Nymberg, C.; Schultz, R.T. Biological motion task performance predicts superior temporal sulcus activity. *Brain Cogn.* **2011**, *77*, 372–381. [CrossRef]
269. Kaiser, M.D.; Shiffrar, M.; Pelphrey, K.A. Socially tuned: Brain responses differentiating human and animal motion. *Soc. Neurosci.* **2012**, *7*, 301–310. [CrossRef]
270. Krakowski, A.I.; Ross, L.A.; Snyder, A.C.; Sehatpour, P.; Kelly, S.; Foxe, J.J. The neurophysiology of human biological motion processing: A high-density electrical mapping study. *NeuroImage* **2011**, *56*, 373–383. [CrossRef] [PubMed]
271. Pelphrey, K.A.; Morris, J.P.; Michelich, C.R.; Allison, T.; McCarthy, G. Functional anatomy of biological motion perception in posterior temporal cortex: An fMRI study of eye, mouth and hand movements. *Cereb. Cortex* **2005**, *15*, 1866–1876. [CrossRef] [PubMed]
272. Puce, A.; Perrett, D. Electrophysiology and brain imaging of biological motion. *Philos. Trans. R. Soc. B Biol. Sci.* **2003**, *358*, 435–445. [CrossRef] [PubMed]
273. Saygin, A.P. Superior temporal and premotor brain areas necessary for biological motion perception. *Brain* **2007**, *130*, 2452–2461. [CrossRef]
274. Saygin, A.P.; Wilson, S.M.; Hagler, D.J., Jr.; Bates, E.; Sereno, M.I.; Hagler, N.J. Point- light biological motion perception activates human premotor cortex. *J. Neurosci.* **2004**, *24*, 6181–6188. [CrossRef]
275. Vaina, L.M.; Solomon, J.; Chowdhury, S.; Sinha, P.; Belliveau, J.W. Functional neuroanatomy of biological motion perception in humans. *Proc. Natl. Acad. Sci. USA* **2001**, *98*, 11656–11661. [CrossRef]
276. van Kemenade, B.M.; Muggleton, N.; Walsh, V.; Saygin, A.P. Effects of TMS over premotor and superior temporal cortices on biological motion perception. *J. Cogn. Neurosci.* **2012**, *24*, 896–904. [CrossRef] [PubMed]
277. Pavlova, M.A. Biological motion processing as a hallmark of social cognition. *Cereb. Cortex* **2012**, *22*, 981–995. [CrossRef]
278. Pelphrey, K.A.; Morris, J.P.; McCarthy, G. Grasping the intentions of others: The perceived intentionality of an action influences activity in the superior temporal sulcus during social perception. *J. Cogn. Neurosci.* **2004**, *16*, 1706–1716. [CrossRef]
279. Rizzolatti, G.; Destro, M.F. The mirror system and its role in social cognition. *Curr. Opin. Neurobiol.* **2008**, *18*, 179–184. [CrossRef] [PubMed]
280. Guzzetta, A.; Tinelli, F.; Del Viva, M.M.; Bancale, A.; Arrighi, R.; Pascale, R.R.; Cioni, G. Motion perception in preterm children: Role of prematurity and brain damage. *NeuroReport* **2009**, *20*, 1339–1343. [CrossRef] [PubMed]
281. Jakobson, L.; Frisk, V.; Downie, A. Motion-defined form processing in extremely premature children. *Neuropsychologia* **2006**, *44*, 1777–1786. [CrossRef] [PubMed]
282. Goldenberg, G. Defective imitation of gestures in patients with damage in the left or right hemispheres. *J. Neurol. Neurosurg. Psychiatry* **1996**, *61*, 176–180. [CrossRef] [PubMed]

283. Blake, J. *Routes to Child Language: Evolutionary and Developmental Precursors*; Cambridge University Press: Cambridge, UK, 2000.
284. Goldin-Meadow, S. Gesture with speech and without it. In *Gesture and the Dynamic Dimension of Language: Essays in Honor of David McNeill*; Duncan, S.D., Cassell, J., Levy, E.T., Eds.; Benjamins: Amsterdam, The Netherlands, 2007; pp. 31–49.
285. Werker, J.F.; Cohen, L.B.; Lloyd, V.L.; Casasola, M.; Stager, C.L. Acquisition of word-object associations by 14-month-old infants. *Dev. Psychol.* **1998**, *34*, 1289–1309. [CrossRef] [PubMed]
286. Bates, E.; O'Connell, B.; Shore, C. Language and communication in infancy. In *Handbook of Infant Development*; Osofsky, J., Ed.; Willey: Oxford, UK, 1987; pp. 149–203.
287. Iverson, J.M.; Goldin-Meadow, S. Gesture paves the way for language development. *Psychol. Sci.* **2005**, *16*, 367–371. [CrossRef]
288. Iverson, J.M.; Thelen, E. Hand, mouth and brain: The dynamic emergence of speech and gesture. *J. Conscious Stud.* **1999**, *6*, 19–40.
289. Kuhn, L.J.; Willoughby, M.T.; Wilbourn, M.P.; Vernon-Feagans, L.; Blair, C.B. Family Life Project Key Investigators. Early communicative gestures prospectively predict language development and executive function in early childhood. *Child Dev.* **2014**, *85*, 1898–1914.
290. Longobardi, E.; Spataro, P.; Rossi-Arnaud, C. The relationship between motor development, gestures and language production in the second year of life: A mediational analysis. *Infant Behav. Dev.* **2014**, *37*, 1–4. [CrossRef]
291. Shepard, R.N. The mental image. *Am. Psychol.* **1978**, *33*, 125–137. [CrossRef]
292. Shepard, R.N.; Metzler, J. Mental rotation of three-dimensional objects. *Science* **1971**, *171*, 701–703. [CrossRef] [PubMed]
293. Schwarzer, G.; Freitag, C.; Schum, N. How crawling and manual object exploration are related to the mental rotation abilities of 9-month-old infants. *Front. Psychol.* **2013**, *4*, 97. [CrossRef] [PubMed]
294. Slone, L.K.; Moore, D.S.; Johnson, S.P. Object exploration facilitates 4-month-olds' mental rotation performance. *PLoS ONE* **2018**, *13*, e0200468. [CrossRef]
295. Soska, K.C.; Adolph, K.E.; Johnson, S.P. Systems in development: Motor skill acquisition facilitates three-dimensional object completion. *Dev. Psychol.* **2010**, *46*, 129–138. [CrossRef] [PubMed]
296. Bahrick, L.E.; Lickliter, R. Learning to attend selectively: The dual role of intersensory redundancy. *Curr. Dir. Psychol. Sci.* **2014**, *23*, 414–420. [CrossRef]
297. Rusiak, P.; Lachmann, T.; Jaskowski, P.; Van Leeuwen, C. Mental rotation of letters and shapes in developmental dyslexia. *Perception* **2007**, *36*, 617–631. [CrossRef]
298. Rüsseler, J.; Scholz, J.; Jordan, K.; Quaiser-Pohl, C. Mental rotation of letters, pictures, and three-dimensional objects in German dyslexic children. *Child Neuropsychol.* **2005**, *11*, 497–512. [CrossRef]
299. Cheng, Y.-L.; Mix, K.S. Spatial training improves children's mathematics ability. *J. Cogn. Dev.* **2014**, *15*, 2–11. [CrossRef]
300. Cheung, C.-N.; Sung, J.Y.; Lourenco, S.F. Does training mental rotation transfer to gains in mathematical competence? Assessment of an at-home visuospatial intervention. *Psychol. Res.* **2019**, *84*, 2000–2017. [CrossRef]
301. Frick, A. Spatial transformation abilities and their relation to later mathematics performance. *Psychol. Res.* **2018**, *83*, 1465–1484. [CrossRef]
302. Lauer, J.E.; Lourenco, S.F. Spatial processing in infancy predicts both spatial and mathematical aptitude in childhood. *Psychol. Sci.* **2016**, *27*, 1291–1298. [CrossRef] [PubMed]
303. Verdine, B.N.; Golinkoff, R.M.; Hirsh-Pasek, K.; Newcombe, N.S. Links between spatial and mathematical skills across the preschool years. *Mono. Soc. Res. Child Dev.* **2017**, *82*, 1–126.
304. Newcombe, N.S.; Booth, J.L.; Gunderson, E. Spatial skills, reasoning, and mathematics. In *Cambridge Handbook of Cognition and Education*; Dunlosky, J., Rawson, K.A., Eds.; Cambridge University Press: Cambridge, MA, USA, 2019; pp. 100–123.
305. Dutton, G.N. 'Dorsal stream dysfunction' and 'dorsal stream dysfunction plus': A potential classification for perceptual visual impairment in the context of cerebral visual impairment? *DMCN* **2009**, *51*, 170–172. [CrossRef] [PubMed]
306. Dutton, G.N.; McKillop, E.C.; Saidkasimova, S. Visual problems as a result of brain damage in children. *Brit. J. Ophthalmol.* **2006**, *90*, 932–933. [CrossRef]
307. Isaacs, E.B.; Vargha-Khadem, F.; Watkins, K.; Lucas, A.; Mishkin, M.; Gadian, D.G. Developmental amnesia and its relationship to degree of hippocampal atrophy. *Proc. Natl. Acad. Sci. USA* **2003**, *100*, 13060–13063. [CrossRef]
308. Jacobson, L.; Ek, U.; Fernell, E.; Flodmark, O.; Broberger, U. Visual impairment in preterm children with periventricular leukomalacia—Visual, cognitive and neuropaediatric characteristics related to cerebral imaging. *Dev. Med. Child Neurol.* **1996**, *38*, 724–735. [CrossRef] [PubMed]
309. Jacobson, L.; Lundin, S.; Flodmark, O.; Ellström, K.-G. Periventricular leukomalacia causes visual impairment in preterm children. *Acta Ophthalmol. Scand.* **1998**, *76*, 593–598. [CrossRef]
310. Grön, G.; Wunderlich, A.P.; Spitzer, M.; Tomczak, R.; Riepe, M.W. Brain activation during human navigation: Gender-different neural networks as substrate of performance. *Nat. Neurosci.* **2000**, *3*, 404–408. [CrossRef]
311. Maguire, E.A.; Burgess, N.; Donnett, J.G.; Frackowiak, R.S.J.; Frith, C.D.; O'Keefe, J. Knowing where and getting there: A human navigation network. *Science* **1998**, *280*, 921–924. [CrossRef]
312. Wolbers, T.; Hegarty, M. What determines our navigational abilities? *Trends Cogn. Sci.* **2010**, *14*, 138–146. [CrossRef]
313. Pavlova, M.; Sokolov, A.; Krägeloh-Mann, I. Visual navigation in adolescents with early periventricular lesions: Knowing where, but not getting there. *Cereb. Cortex* **2007**, *17*, 363–369. [CrossRef] [PubMed]
314. Steenbergen, B.; Meulenbroek, R.; Rosenbaum, D.A. Constraints on grip selection in hemiparetic cerebral palsy: Effects of lesional side, end-point accuracy, and context. *Cogn. Brain Res.* **2004**, *19*, 145–159. [CrossRef] [PubMed]

315. Rosenbaum, D.A.; Jorgensen, M.J. Planning macroscopic aspects of manual control. *Hum. Mov. Sci.* **1992**, *11*, 61–69. [CrossRef]
316. Rosenbaum, D.A.; van Heugten, C.M.; Caldwell, G.E. From cognition to biomechanics and back: The end-state comfort effect and the middle-is-faster effect. *Acta Psychol.* **1996**, *94*, 59–85. [CrossRef]
317. Crajé, C.; van der Kamp, J.; Steenbergen, B. Visual information for action planning in left and right congenital hemiparesis. *Brain Res.* **2009**, *1261*, 54–64. [CrossRef]
318. Mutsaarts, M.; Steenbergen, B.; Meulenbroek, R.G.J. Assessing the rigidity of the grasping movements of three adolescents with spastic hemiparesis due to a cerebral palsy. *Exp. Brain Res.* **2004**, *156*, 293–304.
319. Mutsaarts, M.; Steenbergen, B.; Bekkering, H. Anticipatory planning of movement sequences in hemiparetic cerebral palsy. *Mot. Control.* **2005**, *9*, 439–458. [CrossRef]
320. Mutsaarts, M.; Steenbergen, B.; Bekkering, H. Anticipatory planning deficits and task context effects in hemiparetic cerebral palsy. *Exp. Brain Res.* **2006**, *172*, 151–162. [CrossRef]
321. Steenbergen, B.; Hulstijn, W.; Dortmans, S. Constraints on grip selection in cerebral palsy: Minimizing discomfort. *Exp. Brain Res.* **2000**, *134*, 385–397.
322. Haaland, K.Y.; Harrington, D.L. Hemispheric asymmetry of movement. *Curr. Opin. Neurobiol.* **1996**, *6*, 796–800.
323. Vingerhoets, G. Knowing about tools: Neural correlates of tool familiarity and experience. *NeuroImage* **2008**, *40*, 1380–1391. [CrossRef]
324. Jeannerod, M.; Frak, V. Mental imaging of motor activity in humans. *Curr. Opin. Neurobiol.* **1999**, *9*, 735–739. [CrossRef]
325. Johnson, S.H. Imagining the impossible: Intact motor representations in hemiplegics. *Neuroreport* **2000**, *11*, 729–732.
326. Johnson, S.H. Thinking ahead: The case for motor imagery in prospective judgments of prehension. *Cognition* **2000**, *74*, 33–70.
327. Babik, I.; Cunha, A.B.; Ross, S.M.; Logan, S.W.; Galloway, J.C.; Lobo, M.A. Means-end problem solving in infancy: Development, emergence of intentionality, and transfer of knowledge. *Dev. Psychobiol.* **2019**, *61*, 191–202.
328. Comalli, D.M.; Keen, R.; Abraham, E.S.; Foo, V.J.; Lee, M.-H.; Adolph, K.E. The development of tool use: Planning for end-state comfort. *Dev. Psychol.* **2016**, *52*, 1878–1892. [CrossRef]
329. Herbort, O.; Büschelberger, J.; Janczyk, M. Preschool children adapt grasping movements to upcoming object manipulations: Evidence from a dial rotation task. *J. Exp. Child Psychol.* **2018**, *167*, 62–77. [CrossRef]
330. Krajenbrink, H.; Lust, J.; Wilson, P.; Steenbergen, B. Development of motor planning in children: Disentangling elements of the planning process. *J. Exp. Child Psychol.* **2020**, *199*, 104945. [CrossRef]
331. Mccarty, M.E.; Clifton, R.K.; Collard, R.R. The beginnings of tool use by infants and toddlers. *Infancy* **2001**, *2*, 233–256. [CrossRef]
332. Sommerville, J.A.; Woodward, A.L. Infants' sensitivity to the causal features of means-end support sequences in action and perception. *Infancy* **2005**, *8*, 119–145. [CrossRef]
333. Willatts, P. Development of means-end behavior in young infants: Pulling a support to retrieve a distant object. *Dev. Psychol.* **1999**, *35*, 651–667.
334. de Lange, F.P.; Helmich, R.C.; Toni, I. Posture influences motor imagery: An fMRI study. *NeuroImage* **2006**, *33*, 609–617. [CrossRef]
335. Heilman, K.M.; Rothi, L.J.G. *Apraxia: The Neuropsychology of Action*; Energy Psychology Press: Fulton, CA, USA, 1997.
336. Helmich, R.C.; Aarts, E.; de Lange, F.; Bloem, B.R.; Toni, I. Increased dependence of action selection on recent motor history in Parkinson's disease. *J. Neurosci.* **2009**, *29*, 6105–6113. [CrossRef]
337. Brizzolara, D.; Pecini, C.; Brovedani, P.; Ferretti, G.; Cipriani, P.; Cioni, G. Timing and type of congenital brain lesion determine different patterns of language lateralization in hemiplegic children. *Neuropsychologia* **2002**, *40*, 620–632. [CrossRef]
338. Bates, E.; Thal, N.; Trauner, D.; Fenson, J.; Aram, D.; Eisele, J.; Nass, R. From first words to grammar in children with focal brain injury. *Dev. Neuropsychol.* **1997**, *13*, 275–343. [CrossRef]
339. Chilosi, A.M.; Cipriani, P.; Bertuccelli, B.; Pfanner, L.; Cioni, G. Early cognitive and communication development in children with focal brain lesions. *J. Child Neurol.* **2001**, *16*, 309–316.
340. Thal, D.J.; Marchman, V.; Stiles, J.; Aram, D.; Trauner, D.; Nass, R.; Bates, E. Early lexical development in children with focal brain injury. *Brain Lang.* **1991**, *40*, 491–527. [CrossRef]
341. Vicari, S.; Albertoni, A.; Chilosi, A.; Cipriani, P.; Cioni, G.; Bates, E. Plasticity and reorganization during language development in children with early brain injury. *Cortex* **2000**, *36*, 31–46. [CrossRef]
342. Bishop, D.V.M. Plasticity and specificity of language localization in the developing brain. *Dev. Med. Child Neurol.* **1981**, *23*, 251–255. [CrossRef]
343. Danguecan, A.N.; Smith, M.L. Re-examining the crowding hypothesis in pediatric epilepsy. *Epilepsy Behav.* **2019**, *94*, 281–287. [CrossRef]
344. Lidzba, K.; Staudt, M.; Wilke, M.; Krägeloh-Mann, I. Visuospatial deficits in patients with early left-hemispheric lesions and functional reorganization of language: Consequence of lesion or reorganization? *Neuropsychologia* **2006**, *44*, 1088–1094.
345. Strauss, E.; Satz, P.; Wada, J. An examination of the crowding hypothesis in epileptic patients who have undergone the carotid amytal test. *Neuropsychologia* **1990**, *28*, 1221–1227. [CrossRef]
346. Mei, C.; Reilly, S.; Reddihough, D.; Mensah, F.; Pennington, L.; Morgan, A. Language outcomes of children with cerebral palsy aged 5 years and 6 years: A population-based study. *Dev. Med. Child Neurol.* **2016**, *58*, 605–611. [CrossRef]
347. Kiessling, L.S.; Denckla, M.B.; Carlton, M. Evidence for differential hemispheric function in children with hemiplegic cerebral palsy. *Dev. Med. Child Neurol.* **1983**, *25*, 727–734. [CrossRef]

348. Downie, A.L.S.; Frisk, V.; Jakobson, L.S. The Impact of periventricular brain injury on reading and spelling abilities in the late elementary and adolescent years. *Child Neuropsychol.* **2005**, *11*, 479–495. [CrossRef]
349. Kurahashi, N.; Futamura, Y.; Nonobe, N.; Ogaya, S.; Maki, Y.; Yoshimura, I.; Suzuki, T.; Hosokawa, Y.; Yamada, K.; Aso, K.; et al. Is hiragana decoding impaired in children with periventricular leukomalacia? *Brain Dev.* **2018**, *40*, 850–856.
350. Vohr, B.R.; Allan, W.C.; Westerveld, M.; Schneider, K.C.; Katz, K.H.; Makuch, R.W.; Ment, L.R. School-age outcomes of very low birth weight infants in the indomethacin intraventricular hemorrhage prevention trial. *Pediatrics* **2003**, *111*, e340–e346. [CrossRef]
351. Peeters, M.; Verhoeven, L.; de Moor, J.; van Balkom, H. Importance of speech production for phonological awareness and word decoding: The case of children with cerebral palsy. *Res. Dev. Disabil.* **2009**, *30*, 712–726. [CrossRef]
352. Kail, R.; Hall, L.K. Processing speed, naming speed, and reading. *Dev. Psychol.* **1994**, *30*, 949–954.
353. Lachmann, T.; van Leeuwen, C. Negative congruence effects in letter and pseudo-letter recognition: The role of similarity and response conflict. *Cogn. Process* **2004**, *5*, 239–248.
354. Lachmann, T.; Khera, G.; Srinivasan, N.; van Leeuwen, C. Learning to read aligns visual analytical skills with grapheme-phoneme mapping: Evidence from illiterates. *Front. Evol. Neurosci.* **2012**, *4*, 8. [CrossRef]
355. Schmitt, A.; Lachmann, T.; van Leeuwen, C. Lost in the forest? Global to local interference depends on children's reading skills. *Acta Psychol.* **2019**, *193*, 11–17.
356. Arp, S.; Taranne, P.; Fagard, J. Global perception of small numerosities (subitizing) in cerebral-palsied children. *J. Clin. Exp. Neuropsychol.* **2006**, *28*, 405–419. [CrossRef]
357. Kaufman, E.L.; Lord, M.W.; Reese, T.W.; Volkmann, J. The discrimination of visual number. *Am. J. Psychol.* **1949**, *62*, 498. [CrossRef]
358. Ashkenazi, S.; Mark-Zigdon, N.; Henik, A. Do subitizing deficits in developmental dyscalculia involve pattern recognition weakness? *Dev. Sci.* **2013**, *16*, 35–46.
359. Mandler, G.; Shebo, B.J. Subitizing: An analysis of its component processes. *J. Exp. Psychol.* **1982**, *111*, 1–22.
360. Wender, K.F.; Rothkegel, R. Subitizing and its subprocesses. *Psychol. Res.* **2000**, *64*, 81–92. [CrossRef]
361. Wolters, G.; Van Kempen, H.; Wijlhuizen, G.-J. Quantification of small numbers of dots: Subitizing or pattern recognition? *Am. J. Psychol.* **1987**, *100*, 225. [CrossRef]
362. Dalrymple, K.A.; Barton, J.J.S.; Kingstone, A. A world unglued: Simultanagnosia as a spatial restriction of attention. *Front. Hum. Neurosci.* **2013**, *7*, 145. [CrossRef]
363. Shakespeare, T.J.; Yong, K.X.X.; Frost, C.; Kim, L.G.; Warrington, E.K.; Crutch, S.J. Scene perception in posterior cortical atrophy: Categorization, description and fixation patterns. *Front. Hum. Neurosci.* **2013**, *7*, 621. [CrossRef]
364. Bloechle, J.; Huber, S.; Klein, E.; Bahnmueller, J.; Moeller, K.; Rennig, J. Neuro-cognitive mechanisms of global Gestalt perception in visual quantification. *NeuroImage* **2018**, *181*, 359–369. [CrossRef]
365. Demeyere, N.; Rotshtein, P.; Humphreys, G.W. The neuroanatomy of visual enumeration: Differentiating necessary neural correlates for subitizing versus counting in a neuropsychological voxel-based morphometry study. *J. Cogn. Neurosci.* **2012**, *24*, 948–964. [CrossRef]
366. Demeyere, N.; Rotshtein, P.; Humphreys, G.W. Common and dissociated mechanisms for estimating large and small dot arrays: Value-specific fMRI adaptation. *Hum. Brain Mapp.* **2014**, *35*, 3988–4001. [CrossRef]
367. He, L.; Zuo, Z.; Chen, L.; Humphreys, G. Effects of number magnitude and notation at 7t: Separating the neural response to small and large, symbolic and nonsymbolic number. *Cereb. Cortex* **2014**, *24*, 2199–2209. [CrossRef]
368. Vuokko, E.; Niemivirta, M.; Helenius, P. Cortical activation patterns during subitizing and counting. *Brain Res.* **2013**, *1497*, 40–52. [CrossRef]
369. Himmelbach, M.; Erb, M.; Klockgether, T.; Moskau, S.; Karnath, H.-O. fMRI of global visual perception in simultanagnosia. *Neuropsychologia* **2009**, *47*, 1173–1177. [CrossRef]
370. Huberle, E.; Karnath, H.-O. The role of temporo-parietal junction (TPJ) in global Gestalt perception. *Brain Struct. Funct.* **2012**, *217*, 735–746. [CrossRef]
371. Rennig, J.; Bilalić, M.; Huberle, E.; Karnath, H.-O.; Himmelbach, M. The temporo-parietal junction contributes to global gestalt perception—evidence from studies in chess experts. *Front. Hum. Neurosci.* **2013**, *7*, 513. [CrossRef]
372. Rennig, J.; Himmelbach, M.; Huberle, E.; Karnath, H.-O. Involvement of the TPJ area in processing of novel global forms. *J. Cogn. Neurosci.* **2015**, *27*, 1587–1600. [CrossRef]
373. Weissman, D.; Woldorff, M. Hemispheric asymmetries for different components of global/local attention occur in distinct temporo-parietal loci. *Cereb. Cortex* **2005**, *15*, 870–876. [CrossRef]
374. Yamaguchi, S.; Yamagata, S.; Kobayashi, S. Cerebral asymmetry of the "top-down" allocation of attention to global and local features. *J. Neurosci.* **2000**, *20*, RC72.
375. Zaretskaya, N.; Anstis, S.; Bartels, A. Parietal cortex mediates conscious perception of illusory Gestalt. *J. Neurosci.* **2013**, *33*, 523–531. [CrossRef]
376. Uvebrant, P. Hemiplegic cerebral palsy aetiology and outcome. *Acta Paediatr.* **1988**, *77*, 1–100. [CrossRef]
377. Noël, M.P. Finger gnosia: A predictor of numerical abilities in children? *Child Neuropsychol.* **2005**, *11*, 413–430.
378. Camos, V.; Fayol, M.; Lacert, P.; Bardi, A.; Laquiere, C. Le dénombrement chez des enfants dysphasiques et des enfants dyspraxiques. *ANAE–Approche Neuropsychologique des Apprentissages de l'Enfant* **1998**, *48*, 86–92.

379. Alibali, M.W.; DiRusso, A.A. The function of gesture in learning to count: More than keeping track. *Cogn. Dev.* **1999**, *14*, 37–56. [CrossRef]
380. Brissiaud, R.; Greenbaum, C.A. A tool for number construction: Finger symbol sets. In *Pathways to Number: Children's Developing Numerical Abilities*; Bideud, J., Meljac, C., Fischer, J.-P., Eds.; Lawrence Erlbaum Associates: Mahwah, NJ, USA, 1992; pp. 41–65.
381. Graham, T.A. The role of gesture in children's learning to count. *J. Exp. Child Psychol.* **1999**, *74*, 333–355. [CrossRef]
382. Jordan, N.C.; Kaplan, D.; Ramineni, C.; Locuniak, M.N. Development of number combination skill in the early school years: When do fingers help? *Dev. Sci.* **2008**, *11*, 662–668.
383. Kaufmann, L. Dyscalculia: Neuroscience and education. *Educ. Res.* **2008**, *50*, 163–175. [CrossRef]
384. VanDevender, E.M. Fingers are good for early learning. *J. Instruc. Psychol.* **1986**, *13*, 182–187.
385. Simon, O.; Mangin, J.-F.; Cohen, L.; Le Bihan, D.; Dehaene, S. Topographical layout of hand, eye, calculation, and language-related areas in the human parietal lobe. *Neuron* **2002**, *33*, 475–487. [CrossRef]
386. Moretto, G.; di Pellegrino, G. Grasping numbers. *Exp. Brain Res.* **2008**, *188*, 505–515.
387. Wiese, H. Iconic and non-iconic stages in number development: The role of language. *Trends Cogn. Sci.* **2003**, *7*, 385–390. [CrossRef]
388. Dehaene, S.; Piazza, M.; Pinel, P.; Cohen, L. Three parietal circuits for number processing. *Cogn. Neuropsychol.* **2003**, *20*, 487–506. [CrossRef]
389. Kleemans, T.; Segers, E.; Verhoeven, L. Cognitive and linguistic precursors to numeracy in kindergarten: Evidence from first and second language learners. *Learn. Individ. Differ.* **2011**, *21*, 555–561. [CrossRef]
390. Jackson, N.; Coney, J. Right hemisphere superiority for subitising. *Laterality* **2004**, *9*, 53–66. [CrossRef]
391. Kimura, D. Dual functional asymmetry of the brain in visual perception. *Neuropsychologia* **1966**, *4*, 275–285. [CrossRef]
392. Pasini, M.; Tessari, A. Hemispheric specialization in quantification processes. *Psychol. Res.* **2001**, *65*, 57–63. [CrossRef]
393. Warrington, E.K.; James, M. Tachistoscopic number estimation in patients with unilateral cerebral lesions. *J. Neurol. Neurosurg. Psychiatry* **1967**, *30*, 468–474. [CrossRef]
394. Dellatolas, G.; Filho, G.N.; Souza, L.G.; Nunes, L.G.; Braga, L.W. Manual skill, hand skill asymmetry, and neuropsychological test performance in schoolchildren with spastic cerebral palsy. *Asymm. Body Brain Cognit.* **2005**, *10*, 161–182.
395. Jenks, K.M.; de Moor, J.; van Lieshout, E.C. Arithmetic difficulties in children with cerebral palsy are related to executive function and working memory. *J. Child Psychol. Psychiatry* **2009**, *50*, 824–833. [CrossRef]
396. Jenks, K.M.; van Lieshout, E.C.; de Moor, J. The relationship between medical impairments and arithmetic development in children with cerebral palsy. *J. Child Neurol.* **2009**, *24*, 528–535.
397. Best, J.R.; Miller, P.H. A Developmental perspective on executive function. *Child. Dev.* **2010**, *81*, 1641–1660. [CrossRef]
398. Olson, E.A.; Luciana, M. The development of prefrontal cortex functions in adolescence: Theoretical models and a possible dissociation of dorsal versus ventral subregions. In *Handbook of Developmental Cognitive Neuroscience*; Nelson, C.A., Luciana, M., Eds.; MIT Press: Cambridge, MA, USA, 2008; pp. 575–590.
399. Schatz, J.; Craft, S.; White, D.; Park, T.; Figiel, G.S. Inhibition of return in children with perinatal brain injury. *J. Int. Neuropsychol. Soc.* **2001**, *7*, 275–284. [CrossRef]
400. Shimamura, A.P. The role of the prefrontal cortex in dynamic filtering. *Psychobiology* **2000**, *28*, 207–218.
401. Corbetta, M. Frontoparietal cortical networks for directing attention and the eye to visual locations: Identical, independent, or overlapping neural systems? *Proc. Natl. Acad. Sci. USA* **1998**, *95*, 831–838. [CrossRef]
402. Qin, Y.; Li, Y.; Sun, B.; He, H.; Peng, R.; Zhang, T.; Li, J.; Luo, C.; Sun, C.; Yao, D. Functional connectivity alterations in children with spastic and dyskinetic cerebral palsy. *Neural Plast.* **2018**, *2018*, 7058953. [CrossRef]
403. White, D.A.; Christ, S.E. Executive control of learning and memory in children with bilateral spastic cerebral palsy. *J. Int. Neuropsychol. Soc.* **2005**, *11*, 920–924. [CrossRef]
404. Anderson, P.J.; Wood, S.J.; Francis, D.E.; Coleman, L.; Anderson, V.; Boneh, A. Are neuropsychological impairments in children with early-treated phenylketonuria (PKU) related to white matter abnormalities or elevated phenylalanine levels? *Dev. Neuropsychol.* **2007**, *32*, 645–668.
405. Kolk, A.; Talvik, T. Cognitive outcome of children with early-onset hemiparesis. *J. Child Neurol.* **2000**, *15*, 581–587. [CrossRef]
406. Bodimeade, H.L.; Whittingham, K.; Lloyd, O.; Boyd, R.N. Executive function in children and adolescents with unilateral cerebral palsy. *Dev. Med. Child Neurol.* **2013**, *55*, 926–933. [CrossRef]
407. Carlsson, G. Memory for words and drawings in children with hemiplegic cerebral palsy. *Scand. J. Psychol.* **1997**, *38*, 265–273. [CrossRef]
408. Christ, S.E.; White, D.A.; Brunstrom, J.E.; Abrams, R.A. Inhibitory control following perinatal brain injury. *Neuropsychology* **2003**, *17*, 171–178.
409. Pirila, S.; Van Der Meere, J.; Korhonen, P.; Ruusu-Niemi, P.; Kyntaja, M.; Nieminen, P.; Korpela, R. A Retrospective neurocognitive study in children with spastic diplegia. *Dev. Neuropsychol.* **2004**, *26*, 679–690. [CrossRef]
410. Nadeau, L.; Tessier, R. Social adjustment of children with cerebral palsy in mainstream classes: Peer perception. *Dev. Med. Child Neurol.* **2006**, *48*, 331–336. [CrossRef]
411. Schonfeld, A.M.; Paley, B.; Frankel, F.; O'Connor, M.J. Executive functioning predicts social skills following prenatal alcohol exposure. *Child Neuropsychol.* **2006**, *12*, 439–452.

412. De Smedt, B.; Janssen, R.; Bouwens, K.; Verschaffel, L.; Boets, B.; Ghesquière, P. Working memory and individual differences in mathematics achievement: A longitudinal study from first grade to second grade. *J. Exp. Child Psychol.* **2009**, *103*, 186–201. [CrossRef]
413. Geary, D.C. Mathematical disabilities: Cognitive, neuropsychological, and genetic components. *Psychol. Bull.* **1993**, *114*, 345–362. [CrossRef]
414. Geary, D.C.; Hamson, C.O.; Hoard, M.K. Numerical and arithmetical cognition: A longitudinal study of process and concept deficits in children with learning disability. *J. Exp. Child Psychol.* **2000**, *77*, 236–263. [CrossRef]
415. Raghubar, K.; Barnes, M.A.; Hecht, S.A. Working memory and mathematics: A review of developmental, individual difference, and cognitive approaches. *Learn. Individ. Differ.* **2010**, *20*, 110–122. [CrossRef]
416. Trick, L.M. Subitizing and counting: Preattentive and attentive processing in visual enumeration. *Diss. Abstr. Int.* **1992**, *52*, 6117.
417. Van Rooijen, M.; Verhoeven, L.; Smits, D.; Dallmeijer, A.; Becher, J.; Steenbergen, B. Cognitive precursors of arithmetic development in primary school children with cerebral palsy. *Res. Dev. Disabil.* **2014**, *35*, 826–832. [CrossRef]
418. Van Rooijen, M.; Verhoeven, L.; Steenbergen, B. From numeracy to arithmetic: Precursors of arithmetic performance in children with cerebral palsy from 6 till 8 years of age. *Res. Dev. Disabil.* **2015**, *45–46*, 49–57. [CrossRef]
419. Van Rooijen, M.; Verhoeven, L.; Steenbergen, B. Working memory and fine motor skills predict early numeracy performance of children with cerebral palsy. *Child Neuropsychol.* **2016**, *22*, 735–747. [CrossRef]
420. Baroody, A.J. *Children's Mathematical Thinking: A Developmental Framework for Preschool, Primary, and Special Education Teachers*; Teachers College Press: New York, NY, USA, 1987.
421. Ginsburg, H. *Children's Arithmetic: The Learning Process*; Van Nostrand: New York, NY, USA, 1977.
422. Locuniak, M.N.; Jordan, N.C. Using kindergarten number sense to predict calculation fluency in second grade. *J. Learn. Disabil.* **2008**, *41*, 451–459. [CrossRef]
423. Torbeyns, J.; van den Noortgate, W.; GhesquieÁre, P.; Verschaffel, L.; van de Rijt, B.A.M.; van Luit, J.E.H. Development of early numeracy in 5- to 7-year-old children: A comparison between Flanders and The Netherlands. *Edu. Res. Eval.* **2002**, *8*, 249–275.
424. Waber, D.P.; Mann, M.B.; Merola, J. Motor overflow and attentional processes in normal school-age children. *Dev. Med. Child Neurol.* **1985**, *27*, 491–497. [CrossRef]
425. Colombo, J. The Development of visual attention in infancy. *Annu. Rev. Psychol.* **2001**, *52*, 337–367. [CrossRef]
426. Richards, J.E.; Casey, B.J. Development of sustained visual attention in the human infant. In *Attention and Information Processing in Infants and Adults: Perspectives from Human and Animal Research*; Campbell, B.A., Hayne, H., Richardson, R., Eds.; Erlbaum: Hillsdale, NJ, USA, 1992; pp. 30–60.
427. Martzog, P.; Stoeger, H.; Suggate, S. Relations between preschool children's fine motor skills and general cognitive abilities. *J. Cogn. Dev.* **2019**, *20*, 443–465. [CrossRef]
428. Smith, L.B. Cognition as a dynamic system: Principles from embodiment. *Dev. Rev.* **2005**, *25*, 278–298. [CrossRef]
429. Babik, I.; Galloway, J.C.; Lobo, M.A. Early exploration of one's own body, exploration of objects, and motor, language, and cognitive development relate dynamically across the first two years of life. *Dev. Psychol.* **2022**, *58*, 222–235. [CrossRef]
430. Cioni, G.; Ferrari, F.; Einspieler, C.; Paolicelli, P.; Barbani, T.; Prechtl, H.F. Comparison between observation of spontaneous movements and neurologic examination in preterm infants. *J. Pediatr.* **1997**, *130*, 704–711. [CrossRef]
431. Barrett, T.M.; Traupman, E.; Needham, A. Infants' visual anticipation of object structure in grasp planning. *Infant Behav. Dev.* **2008**, *31*, 1–9. [CrossRef]
432. Bertenthal, B.I.; Clifton, R.K. Perception and action. In *Handbook of Child Psychology: Cognition, Perception, and Language*; Damon, W., Kuhn, D., Siegler, R.S., Eds.; Wiley: New York, NY, USA, 1998; pp. 51–102.
433. Corbetta, D.; Snapp-Childs, W. Seeing and touching: The role of sensory-motor experience on the development of infant reaching. *Infant Behav. Dev.* **2009**, *32*, 44–58. [CrossRef]
434. Hopkins, B.; Rönnqvist, L. Facilitating postural control: Effects on the reaching behavior of 6-month-old infants. *Dev. Psychobiol.* **2002**, *40*, 168–182. [CrossRef]
435. Lobo, M.A.; Galloway, J.C. The onset of reaching significantly impacts how infants explore both objects and their bodies. *Infant Behav. Dev.* **2013**, *36*, 14–24. [CrossRef]
436. Rochat, P.; Goubet, N. Development of sitting and reaching in 5- to 6-month-old infants. *Infant Behav. Dev.* **1995**, *18*, 53–68. [CrossRef]
437. Thelen, E.; Spencer, J.P. Postural control during reaching in young infants: A dynamic systems approach. *Neurosci. Biobehav. Rev.* **1998**, *22*, 507–514. [CrossRef]
438. von Hofsten, C.; Rosander, K. Development of smooth pursuit tracking in young infants. *Vis. Res.* **1997**, *37*, 1799–1810.
439. Kahrs, B.A.; Lockman, J.J. Building tool use from object manipulation: A perception–action perspective. *Ecol. Psychol.* **2014**, *26*, 88–97. [CrossRef]
440. Keen, S. *Debunking Economics: The Naked Emperor Dethroned?* Zed Books Ltd.: London, UK, 2011.
441. Marcinowski, E.C.; Nelson, E.; Campbell, J.M.; Michel, G.F. The development of object construction from infancy through toddlerhood. *Infancy* **2019**, *24*, 368–391. [CrossRef]
442. Needham, A.; Barrett, T.; Peterman, K. A pick-me-up for infants' exploratory skills: Early simulated experiences reaching for objects using 'sticky mittens' enhances young infants' object exploration skills. *Infant Behav. Dev.* **2002**, *25*, 279–295.

443. Bahrick, L.E.; Lickliter, R.; Flom, R. Intersensory redundancy guides the development of selective attention, perception, and cognition in infancy. *Curr. Dir. Psychol. Sci.* **2004**, *13*, 99–102. [CrossRef]
444. Baumgartner, H.A.; Oakes, L.M. Investigating the relation between infants' manual activity with objects and their perception of dynamic events. *Infancy* **2013**, *18*, 983–1006. [CrossRef]
445. Bushnell, E.W.; Boudreau, J.P. Motor development and the mind: The potential role of motor abilities as a determinant of aspects of perceptual development. *Child Dev.* **1993**, *64*, 1005–1021.
446. Gibson, E.J. Exploratory behavior in the development of perceiving, acting, and the acquiring of knowledge. *Annu. Rev. Psychol.* **1988**, *39*, 1–41. [CrossRef]
447. Jouen, F.; Molina, M. Exploration of the newborn's manual activity: A window onto early cognitive processes. *Infant Behav. Dev.* **2005**, *28*, 227–239. [CrossRef]
448. Lobo, M.A.; Galloway, J.C. Postural and object-oriented experiences advance early reaching, object exploration, and means-end behavior. *Child Dev.* **2008**, *79*, 1869–1890. [CrossRef]
449. Piaget, J. *The Origin of Intelligence in the Child*; Routledge & Kegan Paul: London, UK, 1953.
450. Ruff, H.A.; McCarton, C.; Kurtzberg, D.; Vaughan, H.G. Preterm infants' manipulative exploration of objects. *Child Dev.* **1984**, *55*, 1166. [CrossRef]
451. Smith, L.B.; Sheya, A. Is cognition enough to explain cognitive development? *TiCS* **2010**, *2*, 725–735.
452. Thelen, E. Coupling perception and action in the development of skill: A dynamic approach. In *Sensory-Motor Organizations and Development in Infancy and Early Childhood*; Bloch, H., Bertenthal, B.I., Eds.; Kluwer Academic: Boston, MA, USA, 1990.
453. Wilcox, T.; Woods, R.; Chapa, C.; McCurry, S. Multisensory exploration and object individuation in infancy. *Dev. Psychol.* **2007**, *43*, 479–495. [CrossRef]
454. Zuccarini, M.; Guarini, A.; Savini, S.; Iverson, J.M.; Aureli, T.; Alessandroni, R.; Faldella, G.; Sansavini, A. Object exploration in extremely preterm infants between 6 and 9 months and relation to cognitive and language development at 24 months. *Res. Dev. Disabil.* **2017**, *68*, 140–152. [CrossRef]
455. Campos, J.J.; Anderson, D.I.; Barbu-Roth, M.A.; Hubbard, E.; Hertenstein, M.J.; Witherington, D.C. Travel broadens the mind. *Infancy* **2000**, *1*, 149–219. [CrossRef]
456. Karasik, L.B.; Tamis-LeMonda, C.; Adolph, K.E. Transition from crawling to walking and infants' actions with objects and people. *Child Dev.* **2011**, *82*, 1199–1209. [CrossRef]
457. Karasik, L.B.; Tamis-LeMonda, C.; Adolph, K.E. Crawling and walking infants elicit different verbal responses from mothers. *Dev. Sci.* **2014**, *17*, 388–395. [CrossRef]
458. Atkinson, J.; Braddick, O. Visual and visuocognitive development in children born very prematurely. *Prog. Brain Res.* **2007**, *164*, 123–149. [CrossRef]
459. Mccarty, M.E.; Ashmead, D.H. Visual control of reaching and grasping in infants. *Dev. Psychol.* **1999**, *35*, 620–631. [CrossRef]
460. van Beck, Y.; Hopkins, B.; Hoeksma, J.; Samson, J.F. Prematurity, posture, and the development of looking behavior during early communication. *J. Child Psychol. Psychiatry* **1994**, *35*, 1093–1107.
461. Fayol, M.; Barrouillet, P.; Marinthe, C. Predicting arithmetical achievement from neuro-psychological performance: A longitudinal study. *Cognition* **1998**, *68*, B63–B70. [CrossRef]
462. Araujo, D.; Davids, K. Ecological approaches to cognition and action in sport and exercise: Ask not only what you do, but where you do it. *Int. J. Sport Psychol.* **2009**, *40*, 5–37.
463. Smith, L.B.; Thelen, E. Development as a dynamic system. *TiCS* **2003**, *7*, 343–348.
464. Thelen, E.; Schöner, G.; Scheier, C.; Smith, L.B. The dynamics of embodiment: A field theory of infant perseverative reaching. *Behav. Brain Sci.* **2001**, *24*, 1–34. [CrossRef]
465. Goldfield, E.C. Dynamic systems in development: Action systems. In *Dynamic Approaches to Development: Applications*; Thelen, E., Smith, L., Eds.; MIT Press: Cambridge, MA, USA, 1993.
466. Corbetta, D.; Bojczyk, K.E. Infants return to two-handed reaching when they are learning to walk. *J. Mot. Behav.* **2002**, *34*, 83–95. [CrossRef]
467. Babik, I.; Campbell, J.M.; Michel, G.F. Postural influences on the development of infant lateralized and symmetric hand-use. *Child Dev.* **2014**, *85*, 294–307.
468. Goldfield, E. Transition from rocking to crawling: Postural constraints on infant movement. *Dev. Psychol.* **1989**, *25*, 913–919.
469. Kim, Y.H.; Park, J.W.; Ko, M.-H.; Jang, S.H.; Lee, P.K. Plastic changes of motor network after constraint-induced movement therapy. *Yonsei Med. J.* **2004**, *45*, 241–246. [CrossRef]
470. Schaechter, J.D.; Kraft, E.; Hilliard, T.S.; Dijkhuizen, R.M.; Benner, T.; Finklestein, S.P.; Rosen, B.R.; Cramer, S.C. Motor recovery and cortical reorganization after constraint-induced movement therapy in stroke patients: A preliminary study. *Neurorehabilit. Neural Repair* **2002**, *16*, 326–338. [CrossRef]
471. Wittenberg, G.F.; Schaechter, J.D. The neural basis of constraint-induced movement therapy. *Curr. Opin. Neurol.* **2009**, *22*, 582–588. [CrossRef]
472. Rosenbaum, P.L.; Rosenbloom, L. *Cerebral Palsy: From Diagnosis to Adult Life*; John Wiley & Sons: New York, NY, USA, 2012.
473. Alves-Pinto, A.; Turova, V.; Blumenstein, T.; Lampe, R. The Case for musical instrument training in cerebral palsy for neurorehabilitation. *Neural Plast.* **2016**, *2016*, 1072301. [CrossRef]
474. Buonomano, D.V.; Merzenich, M.M. Cortical plasticity: From synapses to maps. *Annu. Rev. Neurosci.* **1998**, *21*, 149–186. [CrossRef]

475. Cramer, S.C.; Sur, M.; Dobkin, B.H.; O'Brien, C.; Sanger, T.D.; Trojanowski, J.Q.; Rumsey, J.M.; Hicks, R.; Cameron, J.; Chen, D.; et al. Harnessing neuroplasticity for clinical applications. *Brain* **2011**, *134*, 1591–1609. [CrossRef]
476. Johnston, M.V. Plasticity in the developing brain: Implications for rehabilitation. *Dev. Disabil. Res. Rev.* **2009**, *15*, 94–101. [CrossRef]
477. Kleim, J.A.; Jones, T.A. Principles of experience-dependent neural plasticity: Implications for rehabilitation after brain damage. *J. Speech Lang. Hear. Res.* **2008**, *51*, 225–239.
478. Holmefur, M.; Kits, A.; Bergström, J.; Krumlinde-Sundholm, L.; Flodmark, O.; Forssberg, H.; Eliasson, A.C. Neuroradiology can predict the development of hand function in children with unilateral cerebral palsy. *Neurorehabil. Neural Repair* **2013**, *27*, 72–78.
479. Odding, E.; Roebroeck, M.E.; Stam, H.J. The epidemiology of cerebral palsy: Incidence, impairments and risk factors. *Disabil. Rehabil.* **2006**, *28*, 183–191. [CrossRef]
480. Rosenbaum, P.; Paneth, N.; Leviton, A.; Goldstein, M.; Bax, M.; Damiano, D. Definition and classification document. *Dev. Med. Child Neurol.* **2007**, *49*, 8–14.
481. Novak, I.; Hines, M.; Goldsmith, S.; Barclay, R. Clinical prognostic messages from a systematic review on cerebral palsy. *Pediatrics* **2012**, *130*, e1285–e1312. [CrossRef]
482. Rojo, N.; Amengual, J.; Juncadella, M.; Rubio, F.; Camara, E.; Marco-Pallares, J.; Schneider, S.; Veciana, M.; Montero, J.; Mohammadi, B.; et al. Music-supported therapy induces plasticity in the sensorimotor cortex in chronic stroke: A single-case study using multimodal imaging (fMRI TMS). *Brain Inj.* **2011**, *25*, 787–793.
483. Sanger, T.D.; Kukke, S.N. Abnormalities of tactile sensory function in children with dystonic and diplegic cerebral palsy. *J. Child Neurol.* **2007**, *22*, 289–293.
484. O'Brien, G.; Rosenbloom, L. *Developmental Disability and Ageing*; Mac Keith Press: London, UK, 2009.
485. Martin, J.H.; Chakrabarty, S.; Friel, K.M. Harnessing activity-dependent plasticity to repair the damaged corticospinal tract in an animal model of cerebral palsy. *Dev. Med. Child Neurol.* **2011**, *53*, 9–13. [CrossRef]
486. Smorenburg, A.R.; Gordon, A.M.; Kuo, H.C.; Ferre, C.L.; Brandao, M.; Bleyenheuft, Y.; Carmel, J.B.; Friel, K.M. Does corticospinal tract connectivity influence the response to intensive bimanual therapy in children with unilateral cerebral palsy? *Neurorehabil. Neural Repair* **2017**, *31*, 250–260.
487. Michel, G.F.; Tyler, A.N. Critical period: A history of the transition from questions of when, to what, to how. *Dev. Psychobiol.* **2005**, *46*, 156–162. [CrossRef]
488. Chamudot, R.; Parush, S.; Rigbi, A.; Horovitz, R.; Gross-Tsur, V. Effectiveness of modified constraint-induced movement therapy compared with bimanual therapy home programs for infants with hemiplegia: A randomized controlled trial. *Am. J. Occup. Ther.* **2018**, *72*, 7206205010p1–7206205010p9. [CrossRef]
489. Eliasson, A.-C.; Nordstrand, L.; Ek, L.; Lennartsson, F.; Sjöstrand, L.; Tedroff, K.; Krumlinde-Sundholm, L. The effectiveness of Baby-CIMT in infants younger than 12 months with clinical signs of unilateral-cerebral palsy; an explorative study with randomized design. *Res. Dev. Disabil.* **2018**, *72*, 191–201. [CrossRef]
490. Friel, K.; Chakrabarty, S.; Kuo, H.C.; Martin, J. Using motor behavior during an early critical period to restore skilled limb movement after damage to the corticospinal system during development. *J. Neurosci.* **2012**, *32*, 9265–9276.
491. Holmström, L.; Eliasson, A.-C.; Almeida, R.; Furmark, C.; Weiland, A.-L.; Tedroff, K.; Löwing, K. Efficacy of the small step program in a randomized controlled trial for infants under 12 months old at risk of cerebral palsy (cp) and other neurological disorders. *J. Clin. Med.* **2019**, *8*, 1016. [CrossRef]
492. Morgan, C.; Novak, I.; Dale, R.C.; Badawi, N. Optimising motor learning in infants at high risk of cerebral palsy: A pilot study. *BMC Pediatr.* **2015**, *15*, 30. [CrossRef]
493. Morgan, C.; Darrah, J.; Gordon, A.; Harbourne, R.; Spittle, A.; Johnson, R.E.; Fetters, L. Effectiveness of motor interventions in infants with cerebral palsy: A systematic review. *Dev. Med. Child Neurol.* **2016**, *58*, 900–909. [CrossRef]
494. Morgan, C.; Novak, I.; Dale, R.C.; Guzzetta, A.; Badawi, N. Single blind randomised controlled trial of GAME (Goals Activity Motor Enrichment) in infants at high risk of cerebral palsy. *Res. Dev. Disabil.* **2016**, *55*, 256–267. [CrossRef]
495. Hubermann, L.; Boychuck, Z.; Shevell, M.I.; Majnemer, A. Age at referral of children for initial diagnosis of cerebral palsy and rehabilitation: Current practices. *J. Child Neurol.* **2016**, *31*, 364–369. [CrossRef]
496. Novak, I.; Morgan, C.; Adde, L.; Blackman, J.; Boyd, R.N.; Brunstrom-Hernandez, J.; Cioni, G.; Damiano, D.; Darrah, J.; Eliasson, A.C.; et al. Early, accurate diagnosis and early intervention in cerebral palsy: Advances in diagnosis and treatment. *JAMA Pediatr.* **2017**, *171*, 897–907.
497. Boyd, R.N.; Jordan, R.; Pareezer, L.; Moodie, A.; Finn, C.; Luther, B.; Arnfield, E.; Pym, A.; Craven, A.; Beall, P.; et al. Australian Cerebral Palsy Child Study: Protocol of a prospective population based study of motor and brain development of preschool aged children with cerebral palsy. *BMC Neurol.* **2013**, *13*, 57. [CrossRef]
498. Parkinson, K.N.; Gibson, L.; Dickinson, H.O.; Colver, A.F. Pain in children with cerebral palsy: A cross-sectional multicentre European study. *Acta Paediatr.* **2010**, *99*, 446–451. [CrossRef]
499. Booth, A.T.C.; Buizer, A.I.; Meyns, P.; Oude Lansink, I.L.B.; Steenbrink, F.; van der Krogt, M.M. The efficacy of functional gait training in children and young adults with cerebral palsy: A systematic review and meta-analysis. *Dev. Med. Child Neurol.* **2018**, *60*, 866–883.

500. Brandao, M.B.; Mancini, M.C.; Ferre, C.L.; Figueiredo, P.R.P.; Oliveira, R.H.S.; Goncalves, S.C. Does dosage matter? A pilot study of hand-arm bimanual intensive training (HABIT) dose and dosing schedule in children with unilateral cerebral palsy. *Phys. Occup. Ther. Pediatric.* **2018**, *38*, 227–242.
501. Buccino, G.; Arisi, D.; Gough, P.; Aprile, D.; Ferri, C.; Serotti, L.; Tiberti, A.; Fazzi, E. Improving upper limb motor functions through action observation treatment: A pilot study in children with cerebral palsy. *Dev. Med. Child Neurol.* **2012**, *54*, 822–828. [CrossRef]
502. Chen, Y.-P.; Pope, S.; Tyler, D.; Warren, G. Effectiveness of constraint-induced movement therapy on upper-extremity function in children with cerebral palsy: A systematic review and meta-analysis of randomized controlled trials. *Clin. Rehabil.* **2014**, *28*, 939–953. [CrossRef]
503. Ganesh, G.; Das, S. Evidence-based approach to physical therapy in cerebral palsy. *Indian J. Orthop.* **2019**, *53*, 20–34. [CrossRef]
504. Ferre, C.L.; Brandão, M.; Surana, B.; Dew, A.P.; Moreau, N.G.; Gordon, A. Caregiver-directed home-based intensive bimanual training in young children with unilateral spastic cerebral palsy: A randomized trial. *Dev. Med. Child Neurol.* **2017**, *59*, 497–504. [CrossRef]
505. Friel, K.M.; Kuo, H.-C.; Fuller, J.; Ferre, C.L.; Brandão, M.; Carmel, J.B.; Bleyenheuft, Y.; Gowatsky, J.L.; Stanford, A.D.; Rowny, S.B.; et al. Skilled bimanual training drives motor cortex plasticity in children with unilateral cerebral palsy. *Neurorehabilit. Neural Repair* **2016**, *30*, 834–844. [CrossRef]
506. Hoare, B.; Wallen, M.A.; Thorley, M.N.; Jackman, M.L.; Carey, L.M.; Imms, C. Constraint-induced movement therapy in children with unilateral cerebral palsy. *Cochrane Database Syst. Rev.* **2019**, *4*, CD004149. [CrossRef]
507. Inguaggiato, E.; Sgandurra, G.; Perazza, S.; Guzzetta, A.; Cioni, G. Brain reorganization following intervention in children with congenital hemiplegia: A systematic review. *Neural Plast.* **2013**, *2013*, 356275. [CrossRef]
508. Jamali, A.R.; Amini, M. The effects of constraint induced movement therapy on functions of children with cerebral palsy. *Iran. J. Child Neurol.* **2018**, *12*, 16–27.
509. A Kruijsen-Terpstra, A.J.; Ketelaar, M.; Verschuren, O.; Gorter, J.W.; Vos, R.C.; Verheijden, J.; Jongmans, M.J.; Visser-Meily, A. Efficacy of three therapy approaches in preschool children with cerebral palsy: A randomized controlled trial. *Dev. Med. Child Neurol.* **2015**, *58*, 758–766. [CrossRef]
510. Lefmann, S.; Russo, R.; Hillier, S. The effectiveness of robotic-assisted gait training for paediatric gait disorders: Systematic review. *J. Neuroeng. Rehabil.* **2017**, *14*, 1. [CrossRef]
511. Moreau, N.G.; Bodkin, A.W.; Bjornson, K.; Hobbs, A.; Soileau, M.; Lahasky, K. Effectiveness of rehabilitation interventions to improve gait speed in children with cerebral palsy: Systematic review and meta-analysis. *Phys. Ther.* **2016**, *96*, 1938–1954. [CrossRef]
512. Morgan, C.; Novak, I.; Badawi, N. Enriched environments and motor outcomes in cerebral palsy: Systematic review and meta-analysis. *Pediatrics* **2013**, *132*, e735–e746. [CrossRef]
513. Novak, I.; Berry, J. Home program intervention effectiveness evidence. *Phys. Occup. Ther. Pediatr.* **2014**, *34*, 384–389. [CrossRef]
514. Sakzewski, L.; Ziviani, J.; Boyd, R. Efficacy of upper limb therapies for unilateral cerebral palsy: A meta-analysis. *Pediatrics* **2014**, *133*, e175–e204. [CrossRef]
515. Sgandurra, G.; Ferrari, A.; Cossu, G.; Guzzetta, A.; Fogassi, L.; Cioni, G. Randomized trial of observation and execution of upper extremity actions versus action alone in children with unilateral cerebral palsy. *Neurorehabilit. Neural Repair* **2013**, *27*, 808–815. [CrossRef]
516. Toovey, R.; Bernie, C.; Harvey, A.R.; McGinley, J.; Spittle, A.J. Task-specific gross motor skills training for ambulant school-aged children with cerebral palsy: A systematic review. *BMJ Paediatr. Open* **2017**, *1*, e000078. [CrossRef]
517. Hadders-Algra, M. Early diagnosis and early intervention in cerebral palsy. *Front. Neurol.* **2014**, *5*, 185.
518. Novak, I.; Morgan, C.; Fahey, M.; Finch-Edmondson, M.; Galea, C.; Hines, A.; Langdon, K.; Mc Namara, M.; Paton, M.C.; Popat, H.; et al. State of the evidence traffic lights 2019: Systematic review of interventions for preventing and treating children with cerebral palsy. *Curr. Neurol. Neurosci. Rep.* **2020**, *20*, 1–21. [CrossRef]
519. Sakzewski, L.; Ziviani, J.; Boyd, R.N. Delivering evidence-based upper limb rehabilitation for children with cerebral palsy: Barriers and enablers identified by three pediatric teams. *Phys. Occup. Ther. Pediatr.* **2014**, *34*, 368–383. [CrossRef]
520. Lewek, M.D.; Cruz, T.H.; Moore, J.L.; Roth, H.R.; Dhaher, Y.Y.; Hornby, T.G. Allowing intralimb kinematic variability during locomotor training poststroke improves kinematic consistency: A subgroup analysis from a randomized clinical trial. *Phys. Ther.* **2009**, *89*, 829–839. [CrossRef]
521. Prosser, L.A.; Pierce, S.R.; Dillingham, T.R.; Bernbaum, J.C.; Jawad, A.F. iMOVE: Intensive Mobility training with Variability and Error compared to conventional rehabilitation for young children with cerebral palsy: The protocol for a single blind randomized controlled trial. *BMC Pediatr.* **2018**, *18*, 329. [CrossRef]
522. Christensen, M.; Grunbaum, T. Sense of moving: Moving closer to the movement. In *Sensation of Movement*; Routledge: Abingdon, UK, 2017; pp. 64–84.
523. Christensen, M.S.; Grünbaum, T. Sense of agency for movements. *Conscious. Cogn.* **2018**, *65*, 27–47. [CrossRef]
524. Kimberley, T.J.; Novak, I.; Boyd, L.; Fowler, E.; Larsen, D. Stepping up to rethink the future of rehabilitation: IV STEP considerations and inspirations. *J. Neurol. Phys. Ther.* **2017**, *41*, S63–S72. [CrossRef]
525. Ritterband-Rosenbaum, A.; Christensen, M.; Nielsen, J. Twenty weeks of computer-training improves sense of agency in children with spastic cerebral palsy. *Res. Dev. Disabil.* **2012**, *33*, 1227–1234. [CrossRef]

526. Hadders-Algra, M.; Boxum, A.G.; Hielkema, T.; Hamer, E.G. Effect of early intervention in infants at very high risk of cerebral palsy: A systematic review. *Dev. Med. Child Neurol.* **2017**, *59*, 246–258.
527. Crocker, M.D.; MacKay-Lyons, M.; McDonnell, E. Forced use of the upper extremity in cerebral palsy: A single-case design. *Am. J. Occup. Ther.* **1997**, *51*, 824–833. [CrossRef]
528. Ostendorf, C.G.; Wolf, S.L. Effect of forced use of the upper extremity of a hemiplegic patient on changes in function. *Phys. Ther.* **1981**, *61*, 1022–1028.
529. Aarts, P.B.; Jongerius, P.H.; Geerdink, Y.A.; Van Limbeek, J.; Geurts, A.C. Effectiveness of modified constraint-induced movement therapy in children with unilateral spastic cerebral palsy: A randomized controlled trial. *Neurorehabilit. Neural Repair* **2010**, *24*, 509–518. [CrossRef]
530. DeLuca, S.C.; Case-Smith, J.; Stevenson, R.; Ramey, S.L. Constraint-induced movement therapy (CIMT) for young children with cerebral palsy: Effects of therapeutic dosage. *J. Pediatr. Rehabil. Med.* **2012**, *5*, 133–142. [CrossRef]
531. Gordon, A.M.; Charles, J.; Wolf, S.L. Methods of constraint-induced movement therapy for children with hemiplegic cerebral palsy: Development of a child-friendly intervention for improving upper-extremity function. *Arch. Phys. Med. Rehabil.* **2005**, *86*, 837–844. [CrossRef]
532. Gordon, A.M.; Hung, Y.C.; Brandao, M.; Ferre, C.L.; Kuo, H.C.; Friel, K.; Charles, J.R. Bimanual training and constraint-induced movement therapy in children with hemiplegic cerebral palsy: A randomized trial. *NNR* **2011**, *25*, 692–702.
533. Wu, C.Y.; Chuang, L.L.; Lin, K.C.; Chen, H.C.; Tsay, P.K. Randomized trial of distributed constraint-induced therapy versus bilateral arm training for the rehabilitation of upper extremity motor control and function after stroke. *NNR* **2011**, *25*, 130–139.
534. Charles, J.; Gordon, A.M. Development of hand-arm bimanual intensive training (HABIT) for improving bimanual coordination in children with hemiplegic cerebral palsy. *Dev. Med. Child Neurol.* **2006**, *48*, 931–936.
535. Gordon, A.M.; Schneider, J.A.; Chinnan, A.; Charles, J.R. Efficacy of a hand–arm bimanual intensive therapy (HABIT) in children with hemiplegic cerebral palsy: A randomized control trial. *DMCN* **2007**, *49*, 830–838.
536. Gordon, A.M.; Charles, J.; Wolf, S.L. Efficacy of constraint-induced movement therapy on involved upper-extremity use in children with hemiplegic cerebral palsy is not age-dependent. *Pediatrics* **2006**, *117*, e363–e373. [CrossRef]
537. Khare, D.; Soni, R. Effects of constraint-induced movement therapy on hemiplegic cerebral palsy patients. *Int. J. Biomed. Res.* **2016**, *7*, 799–802.
538. Sakzewski, L.; Ziviani, J.; Abbott, D.; MacDonell, R.A.L.; Jackson, G.D.; Boyd, R.N. Randomized trial of constraint-induced movement therapy and bimanual training on activity outcomes for children with congenital hemiplegia. *Dev. Med. Child Neurol.* **2011**, *53*, 313–320. [CrossRef]
539. Cunha, A.B.; Soares, D.A.; Ferro, A.M.; Tudella, E. Effect of training at different body positions on proximal and distal reaching adjustments at the onset of goal-directed reaching: A controlled clinical trial. *Mot. Control.* **2013**, *17*, 123–144. [CrossRef]
540. Cunha, A.B.; Woollacott, M.; Tudella, E. Influence of specific training on spatiotemporal parameters at the onset of goal-directed reaching in infants: A controlled trial. *Braz. J. Phys. Ther.* **2013**, *17*, 409–417.
541. Cunha, A.B.; Lobo, M.A.; Kokkoni, E.; Galloway, J.C.; Tudella, E. Effect of short-term training on reaching behavior in infants: A randomized controlled clinical trial. *J. Mot. Behav.* **2016**, *48*, 132–142. [CrossRef]
542. Heathcock, J.C.; Lobo, M.; Galloway, J.C. Movement training advances the emergence of reaching in infants born at less than 33 weeks of gestational age: A randomized clinical trial. *Phys. Ther.* **2008**, *88*, 310–322. [CrossRef]
543. Lee, H.-M.; Galloway, J.C. Early intensive postural and movement training advances head control in very young infants. *Phys. Ther.* **2012**, *92*, 935–947. [CrossRef]
544. Lobo, M.A.; Galloway, J.C. Enhanced handling and positioning in early infancy advances development throughout the first year. *Child Dev.* **2012**, *83*, 1290–1302. [CrossRef]
545. Lobo, M.A.; Galloway, J.C.; Savelsbergh, G.J.P. General and task-related experiences affect early object interaction. *Child Dev.* **2004**, *75*, 1268–1281. [CrossRef]
546. Lobo, M.; Galloway, J.; Heathcock, J. Characterization and intervention for upper extremity exploration & reaching behaviors in infancy. *J. Hand Ther.* **2015**, *28*, 114–125. [CrossRef]
547. Nakano, H.; Kihara, H.; Nakano, J.; Konishi, Y. The influence of positioning on spontaneous movements of preterm infants. *J. Phys. Ther. Sci.* **2010**, *22*, 337–344. [CrossRef]
548. Soares, D.D.A.; van der Kamp, J.; Savelsbergh, G.J.; Tudella, E. The effect of a short bout of practice on reaching behavior in late preterm infants at the onset of reaching: A randomized controlled trial. *Res. Dev. Disabil.* **2013**, *34*, 4546–4558. [CrossRef]
549. Soares, D.D.A.; Cunha, A.B.; Tudella, E. Differences between late preterm and full-term infants: Comparing effects of a short bout of practice on early reaching behavior. *Res. Dev. Disabil.* **2014**, *35*, 3096–3107. [CrossRef]
550. Dusing, S.C.; Tripathi, T.; Marcinowski, E.C.; Thacker, L.R.; Brown, L.F.; Hendricks-Muñoz, K.D. Supporting play exploration and early developmental intervention versus usual care to enhance development outcomes during the transition from the neonatal intensive care unit to home: A pilot randomized controlled trial. *BMC Pediatr.* **2018**, *18*, 46. [CrossRef]
551. Harbourne, R.T.; Dusing, S.C.; Lobo, M.A.; Westcott-McCoy, S.; Bovaird, J.; Sheridan, S.; Galloway, J.C.; Chang, H.-J.; Hsu, L.-Y.; Koziol, N.; et al. Sitting Together and Reaching to Play (START-Play): Protocol for a multisite randomized controlled efficacy trial on intervention for infants with neuromotor disorders. *Phys. Ther.* **2018**, *98*, 494–502. [CrossRef]

552. Harbourne, R.T.; Dusing, S.C.; Lobo, M.A.; McCoy, S.W.; Koziol, N.A.; Hsu, L.Y.; Willett, S.; Marcinowski, E.C.; Babik, I.; Cunha, A.B.; et al. START-Play physical therapy intervention impacts motor and cognitive outcomes in young children with neuromotor disorders: A multi-site randomized clinical trial. *Phys. Ther.* **2021**, *101*, pzaa232.
553. Libertus, K.; Joh, A.S.; Needham, A.W. Motor training at 3 months affects object exploration 12 months later. *Dev. Sci.* **2016**, *19*, 1058–1066. [CrossRef]
554. Babik, I.; Cunha, A.B.; Lobo, M.A. Assistive and rehabilitative effects of the Playskin Lift$^{TM}$ exoskeletal garment on reaching and object exploration in children with arthrogryposis. *Am. J. Occup. Ther.* **2021**, *75*, 7501205110p1–7501205110p10. [CrossRef]
555. Gaudet, G.; Raison, M.; Achiche, S. Current trends and challenges in pediatric access to sensorless and sensor-based upper limb exoskeletons. *Sensors* **2021**, *21*, 3561. [CrossRef]
556. Lobo, M.A.; Hall, M.L.; Greenspan, B.; Rohloff, P.; Prosser, L.A.; Smith, B.A. Wearables for pediatric rehabilitation: How to optimally design and use products to meet the needs of users. *Phys. Ther.* **2019**, *99*, 647–657. [CrossRef]
557. Libertus, K.; Needham, A. Teach to reach: The effects of active vs. passive reaching experiences on action and perception. *Vis. Res.* **2010**, *50*, 2750–2757. [CrossRef]
558. Nascimento, A.L.; Toledo, A.M.; Merey, L.F.; Tudella, E.; Soares-Marangoni, D.D.A. Brief reaching training with "sticky mittens" in preterm infants: Randomized controlled trial. *Hum. Mov. Sci.* **2019**, *63*, 138–147. [CrossRef]
559. Needham, A.W.; Wiesen, S.E.; Hejazi, J.N.; Libertus, K.; Christopher, C. Characteristics of brief sticky mittens training that lead to increases in object exploration. *J. Exp. Child Psychol.* **2017**, *164*, 209–224. [CrossRef] [PubMed]
560. Wiesen, S.E.; Watkins, R.M.; Needham, A.W. Active motor training has long-term effects on infants' object exploration. *Front. Psychol.* **2016**, *7*, 599. [CrossRef] [PubMed]
561. Herholz, S.C.; Zatorre, R.J. Musical training as a framework for brain plasticity: Behavior, function, and structure. *Neuron* **2012**, *76*, 486–502. [CrossRef] [PubMed]
562. Bangert, M.; Schlaug, G. Specialization of the specialized in features of external human brain morphology. *Eur. J. Neurosci.* **2006**, *24*, 1832–1834. [CrossRef]
563. Bengtsson, S.; Nagy, Z.; Skare, S.; Forsman, L.; Forssberg, H.; Ullén, F. Extensive piano practicing has regionally specific effects on white matter development. *Nat. Neurosci.* **2005**, *8*, 1148–1150. [CrossRef]
564. Bermudez, P.; Lerch, J.P.; Evans, A.C.; Zatorre, R.J. Neuroanatomical correlates of musicianship as revealed by cortical thickness and voxel-based morphometry. *Cereb. Cortex* **2009**, *19*, 1583–1596. [CrossRef]
565. Gaser, C.; Schlaug, G. Brain structures differ between musicians and non-musicians. *J. Neurosci.* **2003**, *23*, 9240–9245. [CrossRef]
566. Herve, P.Y.; Mazoyer, B.; Crivello, F.; Perchey, G.; Tzourio-Mazoyer, N. Finger tapping, handedness and grey matter amount in the Rolando's genu area. *Neuroimage* **2005**, *25*, 1133–1145. [CrossRef]
567. Hutchinson, S.; Lee, L.H.-L.; Gaab, N.; Schlaug, G. Cerebellar volume of musicians. *Cereb. Cortex* **2003**, *13*, 943–949. [CrossRef] [PubMed]
568. Schlaug, G.; Jäncke, L.; Huang, Y.; Staiger, J.F.; Steinmetz, H. Increased corpus callosum size in musicians. *Neuropsychologia* **1995**, *33*, 1047–1055. [CrossRef]
569. Volkmann, J.; Schnitzler, A.; Witte, O.W.; Freund, H.-J. Handedness and asymmetry of hand representation in human motor cortex. *J. Neurophysiol.* **1998**, *79*, 2149–2154. [CrossRef]
570. Alves-Pinto, A.; Turova, V.; Blumenstein, T.; Thienel, A.; Wohlschläger, A.; Lampe, R. fMRI assessment of neuroplasticity in youths with neurodevelopmental-associated motor disorders after piano training. *Eur. J. Paediatr. Neurol.* **2015**, *19*, 15–28. [CrossRef]
571. Chong, H.J.; Cho, S.-R.; Jeong, E.; Kim, S.J. Finger exercise with keyboard playing in adults with cerebral palsy: A preliminary study. *J. Exerc. Rehabil.* **2013**, *9*, 420–425. [CrossRef]
572. Lahav, A.; Boulanger, A.; Schlaug, G.; Saltzman, E. The power of listening: Auditory-motor interactions in musical training. *Ann. N. Y. Acad. Sci.* **2005**, *1060*, 189–194. [CrossRef] [PubMed]
573. Glover, S. Visual illusions affect planning but not control. *Trends Cogn. Sci.* **2002**, *6*, 288–292. [CrossRef]
574. Johnson-Frey, S.H. Stimulation through simulation? Motor imagery and functional reorganization in hemiplegic stroke patients. *Brain Cogn.* **2004**, *55*, 328–331. [CrossRef]
575. Mulder, T. Motor imagery and action observation: Cognitive tools for rehabilitation. *J. Neural Transm.* **2007**, *114*, 1265–1278. [CrossRef]
576. Steenbergen, B.; Crajé, C.; Nilsen, D.M.; Gordon, A. Motor imagery training in hemiplegic cerebral palsy: A potentially useful therapeutic tool for rehabilitation. *Dev. Med. Child Neurol.* **2009**, *51*, 690–696. [CrossRef]
577. Steenbergen, B.; Jongbloed-Pereboom, M.; Spruijt, S.; Gordon, A. Impaired motor planning and motor imagery in children with unilateral spastic cerebral palsy: Challenges for the future of pediatric rehabilitation. *Dev. Med. Child Neurol.* **2013**, *55*, 43–46. [CrossRef]
578. Zacks, J.M. Neuroimaging studies of mental rotation: A meta-analysis and review. *J. Cogn. Neurosci.* **2008**, *20*, 1–19. [CrossRef] [PubMed]
579. Roland, P.E.; Friberg, L. Localization of cortical areas activated by thinking. *J. Neurophysiol.* **1985**, *53*, 1219–1243. [CrossRef] [PubMed]
580. Wilson, P.H.; Thomas, P.R.; Maruff, P. Motor Imagery Training Ameliorates Motor Clumsiness in Children. *J. Child Neurol.* **2002**, *17*, 491–498. [CrossRef] [PubMed]

581. Braun, S.M.; Beurskens, A.J.; Borm, P.J.; Schack, T.; Wade, D.T. The effects of mental practice in stroke rehabilitation: A systematic review. *Arch. Phys. Med. Rehabil.* **2006**, *87*, 842–852. [CrossRef] [PubMed]
582. Sharma, N.; Pomeroy, V.M.; Baron, J.C. Motor imagery: A backdoor to the motor system after stroke? *Stroke* **2006**, *37*, 1941–1952. [CrossRef] [PubMed]
583. Cabral-Sequeira, A.S.; Coelho, D.B.; Teixeira, L.A. Motor imagery training promotes motor learning in adolescents with cerebral palsy: Comparison between left and right hemiparesis. *Exp. Brain Res.* **2016**, *234*, 1515–1524. [CrossRef]
584. Whittingham, K.; Wee, D.; Boyd, R. Systematic review of the efficacy of parenting interventions for children with cerebral palsy. *Child Care Health Dev.* **2011**, *37*, 475–483. [CrossRef]
585. Hielkema, T.; Blauw-Hospers, C.; Dirks, T.; Drijver-Messelink, M.; Bos, A.; Hadders-Algra, M. Does physiotherapeutic intervention affect motor outcome in high-risk infants? An approach combining a randomized controlled trial and process evaluation. *Dev. Med. Child Neurol.* **2011**, *53*, E8–E15. [CrossRef]
586. Lowes, L.P.; Mayhan, M.; Orr, T.; Batterson, N.; Tonneman, J.A.; Meyer, A.; Alfano, L.; Wang, W.; Whalen, C.N.; Nelin, M.A.; et al. Pilot study of the efficacy of constraint-induced movement therapy for infants and toddlers with cerebral palsy. *Phys. Occup. Ther. Pediatr.* **2014**, *34*, 4–21. [CrossRef]
587. Morgan, C.; Novak, I.; Dale, R.C.; Guzzetta, A.; Badawi, N. GAME (Goals-Activity-Motor Enrichment): Protocol of a single blind randomised controlled trial of motor training, parent education and environmental enrichment for infants at high risk of cerebral palsy. *BMC Neurol.* **2014**, *14*, 203. [CrossRef] [PubMed]
588. Libertus, K.; Landa, R.J. Scaffolded reaching experiences encourage grasping activity in infants at high risk for autism. *Front. Psychol.* **2014**, *5*, 1071. [CrossRef] [PubMed]