CE

Understanding Anosognosia for Hemiplegia After Stroke

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Abstract

Background: Anosognosia for hemiplegia (AHP) after stroke is a complex cognitive behavioral disorder that removes awareness of one-sided paralysis (hemiplegia). As a result, stroke survivors afflicted with AHP may be more likely to have unrealistic expectations for stroke rehabilitation, display unsafe behaviors and experience falls, and ultimately suffer the physical and psychological consequences of frequent falling.

Objective: The purpose of this article is to describe AHP by discussing anosognosia within the context of contemporary theoretical understandings, examining current imaging evidence of the disorder, and summarizing emerging interventions designed to reinstate self-awareness in anosognosic patients.

Method: Systematic review with a focus on defining and describing AHP based on human experimental studies was conducted within a 10-year period.

Results: Eleven studies were identified. The content and foci of the 11 studies fell into one of three categories: theory testing, imaging evidence, and interventions for individuals with AHP.

Keywords: Anosognosia; falls; rehabilitation; stroke.

Anosognosia for hemiplegia (AHP) is a phenomenon that was first described in 1914 in an article published by Dr. Joseph Babinski as cited in Langer (2009). He described his observations while attending to two patients after they experienced a stroke. In each of the instances, the patients had a lingering left hemiplegia. The intellectual capacity of the individuals seemed to be preserved, and there was no evidence of confusion, confabulation, or hallucinations. Yet, each of the patients exhibited an unawareness and/or denial of their left hemiplegia. When asked to move the affected limb, the first patient remained silent and reacted as if the question had been addressed to another individual. The second patient, when asked to move the same affected limb, though she was unable to do so, remarked that she had completed the task as directed. Babinski (1914) called this seeming unawareness "anosognosia" and speculated that the phenomenon was due to the combined effects of location of the infracted brain lesion and sensory losses experienced poststroke (as cited in Langer, 2009). The modern definition of anosognosia is a general lack of awareness or the underestimation of a specific deficit in function due to a brain lesion (Kortte & Hillis, 2009). Although this phenomenon has been associated with neglect and can occur in the presence of neglect, anosognosia and neglect are distinct syndromes and should not be confused. With anosognosia, it is theorized that the affected individual is receiving false feedback from a limb that is recognized as belonging to self (Kortte & Hillis, 2009). Neglect, however, is an impairment of the individual to respond to stimuli occurring in the hemispace opposite of the lesion (Kortte & Hillis, 2009).

Today, it is estimated that AHP affects 20%–30% of individuals that suffer a stroke. Patients that experience the typical manifestations of anosognosia tend to have unrealistic expectations of outcomes while in rehabilitation (Orfei, Caltagirone, & Spalletta, 2009) or refuse to participate in rehabilitation activities altogether (Cherney, 2006). More importantly, they are disposed to disregard appropriate safety measures, such as ambulating without assistance, which can lead to falls and serious injury if not addressed early in the rehabilitation stay (Hartman-Maeir, Soroker, & Katz, 2001). But the relationship between AHP after stroke and falling behaviors is not entirely understood. In fact, most of the anosognosia literature stems from neuropsychology journals, whereas nursing and allied health journals have remained silent on the issue. Understanding AHP after stroke and its

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relationship to patient safety events in the stroke rehabilitation setting could potentially lead to a more reliable way to predict stroke patients who will have fall events. Furthermore, a more comprehensive understanding of AHP after stroke would inform the development of interventions to reverse the manifestations and consequences of this syndrome. The purpose of this systematic review article is to describe AHP after stroke by synthesizing findings from human research studies conducted from 2007 through 2017.

Search Strategy

Two databases were used: PsycInfo and PubMed. The search was conducted on June 6, 2017. The following search strategy was used in the PsycInfo databases: the keywords "anosognosia," "hemiplegia," and "stroke" were searched using the "abstract fields." Publications were limited to 2007 through 2017 and to humans aged 18 or older, resulting in 18 articles. For the PubMed database search, the words "hemiplegia," "anosognosia," and "stroke" were searched in both the title and abstract fields. The same limitations (human research only, age 18 or older, research published from 2007 to 2017) were also applied. Twenty-two articles were identified. The results from both searches were combined for a total of 40 articles. After excluding duplicates and review articles, a total of 22 articles remained. Application of further exclusion criteria (research involving apraxia, acquired brain injury, and cognitive anosognosia) resulted in the exclusion of 11 more articles, leaving 11 total articles, which are included in this review.

Results

No qualitative studies were found in the searches. The content and foci of the 11 studies fell into one of three categories: theory testing, imaging evidence, and interventions for individuals with AHP. These articles are reviewed below to produce the most current description of AHP (see Figure 1 and Table 1). Using these categories, the results section is organized so that we first provide an overview of theoretical understandings of anosognosia. Second, we briefly examine current imaging evidence of the disorder. Finally, we summarize the emerging interventions that seek to reinstate self-awareness in anosognosic patients.

Theory Testing

According to Bottini et al. (2009), the motivational and psychodynamic interpretations of AHP after stroke have lost favor with the scientific community. Instead, the contemporary theories concerning the mechanism for the presence of AHP are grounded in neurobiological processes: malfunctions between the motor control system and the accompanying sensory feedback loop (Bottini et al., 2009). There is existing evidence that central nervous system function parallels previously created internal models that mimic and predict dimensions of one's own body in relation to the external world (Frith, Blakemore, & Wolpert, 2000). Movement is based on action intention and motor planning. The success of these actions is attributed to systems within the central nervous system that have been termed predictors and controllers. In healthy (nonstroke) persons, muscles are contracted via stimulation from the central nervous system through a neuronal process known as the predictor, which estimates the end consequence of the movement (see Figure 2). Another neuronal process, the controller, captures the relationship between the desired action and the action that was achieved. Feedback is then used to predict more efficient and effective future movements (Frith et al., 2000). In other words, intentional movements involve the coordination of motor and sensory nerves. The appropriate contraction of specific muscle groups occurs with concurrent processing of sensory information to successfully complete an intended movement. These interacting motor and sensory functions do not only ensure the successful completion of an internal movement but also enable individuals to learn from previous intentional movement experiences to improve efficiency and effectiveness of future movements (Frith et al., 2000). This feedback loop continuously updates so that future movements are optimally efficient. If a movement is not conducted as intended, the comparator will detect the mismatch between the action plan and movement, and that information will be used to inform future motor awareness (Fotopoulou et al., 2008).

The theories discovered in this systematic review all contribute the symptoms of anosognosia to a failure of the feedback loop to update the motor cortex of the success of the intended movement. Where the theories differ is in the mechanism that causes the feedback loop to update (Fotopoulou et al., 2008; Jenkinson, Edelstyn, & Ellis, 2009; Preston & Newport, 2014; Saj, Vocat, & Vuilleumier, 2014; Vocat, Saj, & Vuilleumier, 2013).

According to Frith et al. (2000), in AHP, predictor and controller roles malfunction because relevant areas of the brain have been damaged via infarction. Though there is evidence to suggest that individuals with right-sided stroke are able to activate the motor cortex (Langer, 2009) in order to move the left side of the body, the individual is not able to correctly identify the position of movement of the paralyzed limb because the predictor has estimated, based on previous experience from this command and movement memory, that movement has

Table 1 Matrix table for articles used in synthesis

Author/Date/Article Title	Sample	Procedure and Measures	Data Analysis	Strengths and Limitations
Theory testing				
Vocat et al. (2013) The riddle of anosognosia: Does unawareness of hemiplegia involve a failure to update beliefs?	11 control participants; 9 consecutive patients with a first hemispheric stroke and full left hemiplegia	Global executive and memory function assessed; global cognitive function was measured via MMSE. Riddle Test—Participants were given clues and were asked to come up with the one-word answer and rate their confidence that they had chosen the correct word.	Anosognosic patients were significantly more overconfident in their responses compared with nosognosic (p = .016) and controls (p = .006). Anosognosic patients had significantly fewer correct responses compared to nosognosic (p = .78).	Strengths • Novel study Limitations • Small sample size with low statistical power
Saj et al. (2014) Action-monitoring impairment in anosognosia for hemiplegia	5 control participants; 10 patients with a right-hemispheric stroke and full left hemiplegia, 5 of which were anosognosic	Assessment of AHP using structured interview to assess verbal awareness of ability to perform actions and a composite anosognosia questionnaire. Global cognitive function utilizing MMSE. Phase 1—Participants asked to perform or imagine actions with their right or left arm. Phase 2—Participants are asked whether the prior actions were realized, imagined, or new.	Significant difference among the AHP, HP, and control group for left realized movements (p < .001), left attempted movements (p = .001), left imagined movements (p = .002), and also right realized (p = .004) and right imagined movements (p = .007).	Strengths • Novel study Limitations • Small sample size with low statistical power
Fotopoulou et al. (2008) The role of motor intention in motor awareness: An experimental study on anosognosia for hemiplegia	4 hemiplegic patients with anosognosia and 4 hemiplegic patients without anosognosia	Global cognitive testing including the WTAR, Behavioral Inattention Test, visual field testing, AHP questionnaire, and Cognitive Estimates Test. A life-sized rubber model of a left hand was used to give false visual feedback of movement. Part 1—Participants were asked to raise and lower their arm. Part 2—Participants were told to stay still and that the investigator would move their arm. Part 3—The Participants were told that no movement would be made. Participants were asked to answer in each trial movement detection and confidence in movement.	The AHP group had a decrease in correct responses only in the condition where they had intended to move. Even the non-AHP participants believed they generated movements when presented with false visual feedback of the moving prosthetic hand.	Strengths • Theory testing • Novel study • No differences between groups in global cognitive function or reasoning abilities Limitations • Small sample size, suggestibility of the prosthetic arm should be taken in to account when considering the results

(continues)

Table 1 Matrix table for articles used in synthesis, Continued

Author/Date/Article Title	Sample	Procedure and Measures	Data Analysis	Strengths and Limitations
Jenkinson et al. (2009) Imagining the impossible: Motor representations in anosognosia for hemiplegia	18 patients with dense hemiplegia; 22 age-matched healthy volunteers; 10 control patients	MMSE and National Adult Reading Test. Assessment of AHP using structured interview to measure verbal awareness of ability to perform actions. Grip selection task for motor imagery and motor control.	Congruency between motor imagery and motor control was significantly lower in the anosognosia patients versus the healthy volunteers (left motor imagery, $p = .006$; right motor imagery, $p = .001$).	Strengths • Groups were matched for age, degree of hemiparesis, and length of time between stroke and participation in the study Limitations • Premorbid intellectual function was lower in the patients who experienced a stroke • Small sample size
Preston & Newport (2014) Noisy visual feedback training impairs detection of self-generated movement error: Implications for anosognosia for hemiplegia	22 healthy participants with no history of neurological injury or illness; all right-handed	Participants were asked to reach out and touch a target with one arm; feedback was given using a vBOT robotic manipulandum. Noise Condition—Feedback provided was inaccurate based on the participant's movement. No-Noise Condition—Feedback provided was based on the participant's movement. Participants were asked to give a subjective judgment of their performance.	The condition (noise vs. no noise) had a significant effect on the participants self-judgment ($p = .0008$).	Strengths • Novel study Limitations • Implementation of motor correction during reaching could have been activated at an unconscious level
Imaging evidence				
Fotopoulou et al. (2010) Implicit awareness in anosognosia for hemiplegia: Unconscious interference without conscious re-representation	14 adult patients recruited from an acute stroke rehabilitation center; 7 patients with anosognosia and 7 patients without anosognosia	AHP confirmed utilizing the Berti et al. (1996) scale and the Feinberg et al. (2000) scale. Global cognitive functioning assessed. Patient lesions mapped on slices of the T1-weighted MRI scan template. Lesion anatomical location and volumes estimated.	All lesions located in the right-hemisphere MCA territory. Significant anatomical locations of individuals with AHP include areas extending to the Rolandic operculum and anterior insula to the caudate and putamen nuclei, and inferiorly, lesions extending from the amygdala and superior temporal pole. The supplementary motor area spared in all patients diagnosed with AHP.	Strengths • Balanced sample with no differences between groups in age, education, time of stroke, or global cognitive function Limitations • Small sample size • Lesional analysis is unreliable due to anatomical differences between individuals

(continues)

Table 1 Matrix table for articles used in synthesis, Continued

Author/Date/Article Title	Sample	Procedure and Measures	Data Analysis	Strengths and Limitations
Besharati et al. (2014) The affective modulation of motor awareness in anosognosia for hemiplegia: Behavioral and lesion evidence	16 adult neurological patients with right-hemisphere lesions recruited from a stroke rehabilitation unit 8 classified as having AHP, with the other 8 serving as the non-AHP control group	AHP assessment based on the Berti et al. (1996) scale. AHP confirmed with the Feinberg et al. (2000) scale. Global cognitive function assessed utilizing the WTAR, the MMSE, the Wechsler Adult Intelligence Scale III, the Montreal Cognitive Assessment, the Behavioral Inattention Test, the Frontal Assessment Battery, and the Cognitive Estimates Test. CT and MRI scans obtained from each participant and manually reoriented using statistical parametric mapping then reconstructed onto the Montreal Neurological Institute template. Voxel-based lesion symptom mapping technique utilized as well.	All lesions were from a first-ever stroke, mainly in the MCA territory. The AHP group had overlay of lesions and involvement of cortical and subcortical areas compared to the non-AHP group, which had more focal damage in subcortical areas only. The posterior insula, angular and superior temporal gyri, and inferior frontal gyrus were significantly associated with differences in awareness.	Strengths • Sample did not differ based on age, education, or general cognitive functioning Limitations • Small sample size • Lesional analysis is often unreliable
Baier et al. (2014) Anosognosia for hemiparesis after left-sided stroke	66 participants screened with 1 subject eligible for participation 62-year-old right-handed woman with left-hemisphere stroke participated in the study	AHP confirmed with the Bisiach et al. (1986) scale. Degree of paresis of limbs measured with Likert scale, where 0 = *no movement* and 5 = *normal movement*. Cognitive impairment tested utilizing the Mini-Mental Test. Quotient for handedness assessed according to Edinburgh test. fMRI utilized to assess blood flow during sentence generation.	fMRI confirmed that the language center for this individual was located on the right side. Left hemisphere played a dominant role in self-awareness concerning limb function, which is contradictory to literature that attributes AHP to right-sided lesions only.	Strengths • Procedure and measures used are validated in previous studies Limitations • Case study with only one participant • Aphasia following left-sided stroke is still an obstacle for recruitment in AHP studies

(continues)

Table 1 Matrix table for articles used in synthesis, Continued

Author/Date/Article Title	Sample	Procedure and Measures	Data Analysis	Strengths and Limitations
Interventions				
Fotopoulou et al. (2009) Self-observation reinstates motor awareness in anosognosia for hemiplegia	Case study 67-year-old right-handed individual with a left-sided stroke recruited to participate	AHP confirmed utilizing the Berti et al. (1996) scale. Global cognitive function assessed utilizing the Comb and Razor Test, Hayling Test, Proverbs Test, and Cognitive Estimates Test. The participant was asked if she could perform certain tasks with her plegic limb, was asked to complete the task, and was then asked how she felt she performed. The assessment was filmed, and she was asked if she would like to see the video clip of her during the previous assessment.	The participant had a sudden and complete transformation in awareness when seeing herself from a third-person view via video playback. The participant also had an emotional reaction to realizing her disability.	Strengths • Novel study Limitations • Case study • Larger studies are needed to generalize this finding to the AHP population at large
Besharati et al. (2015) Another perspective on anosognosia: Self-observation in video replay improves motor awareness	2 independent case studies performed by 2 independent research groups in the United Kingdom and Italy 2 participants with right MCA infarcts recruited for participation	AHP confirmed utilizing the Berti et al. (1996) scale, and confirmed with the Feinberg et al. (2000) scale. Participant was asked if they could complete a task, then asked to demonstrate the task, and then asked how they believe they performed. The participant was then asked to view a video of the above procedure.	Self-observation utilizing video playback contributed to the reinstatement of motor awareness of both individuals. Both participants experienced an emotional reaction to realizing their disability.	Strengths • Based on intervention described by Fotopoulou et al. (2009) and had similar findings Limitations • Two independent case studies • Larger trials are needed before these findings can be generalized to the AHP population
Moro et al. (2015) Error-based training and emergent awareness in anosognosia for hemiplegia	4 patients with left-sided hemiplegia and right-hemisphere stroke recruited from a neurological rehabilitation unit	AHP was confirmed utilizing the Bisiach et al. (1986) scale. Global cognitive awareness assessed via the MMSE, the Behavioral Inattention Test, the Comb and Razor Test, visual extinction and verbal memory assessments, and the Frontal Assessment Battery. All patients screened for depression utilizing the Depression Inventory. Participants were asked if they could perform a certain task utilizing their plegic arm, then asked to perform the action, and then asked to reflect upon potential reasons for failure.	Attempts to perform actions followed by a structured analysis of performance can contribute to the recovery of awareness in patients with AHP. All participants improved awareness and maintain their recovery. All participants had an emotional reaction when asked to reflect on their inability to perform tasks.	Strengths • Novel study Limitations • Small sample size

Note. MMSE = Mini-Mental Status Examination; AHP = anosognosia for hemiplegia; WTAR = Wechsler Test of Adult Reading; MCA = middle cerebral artery; fMRI = functional magnetic resonance imaging; HP = hemiplegia; CT = computerized axial tomography.

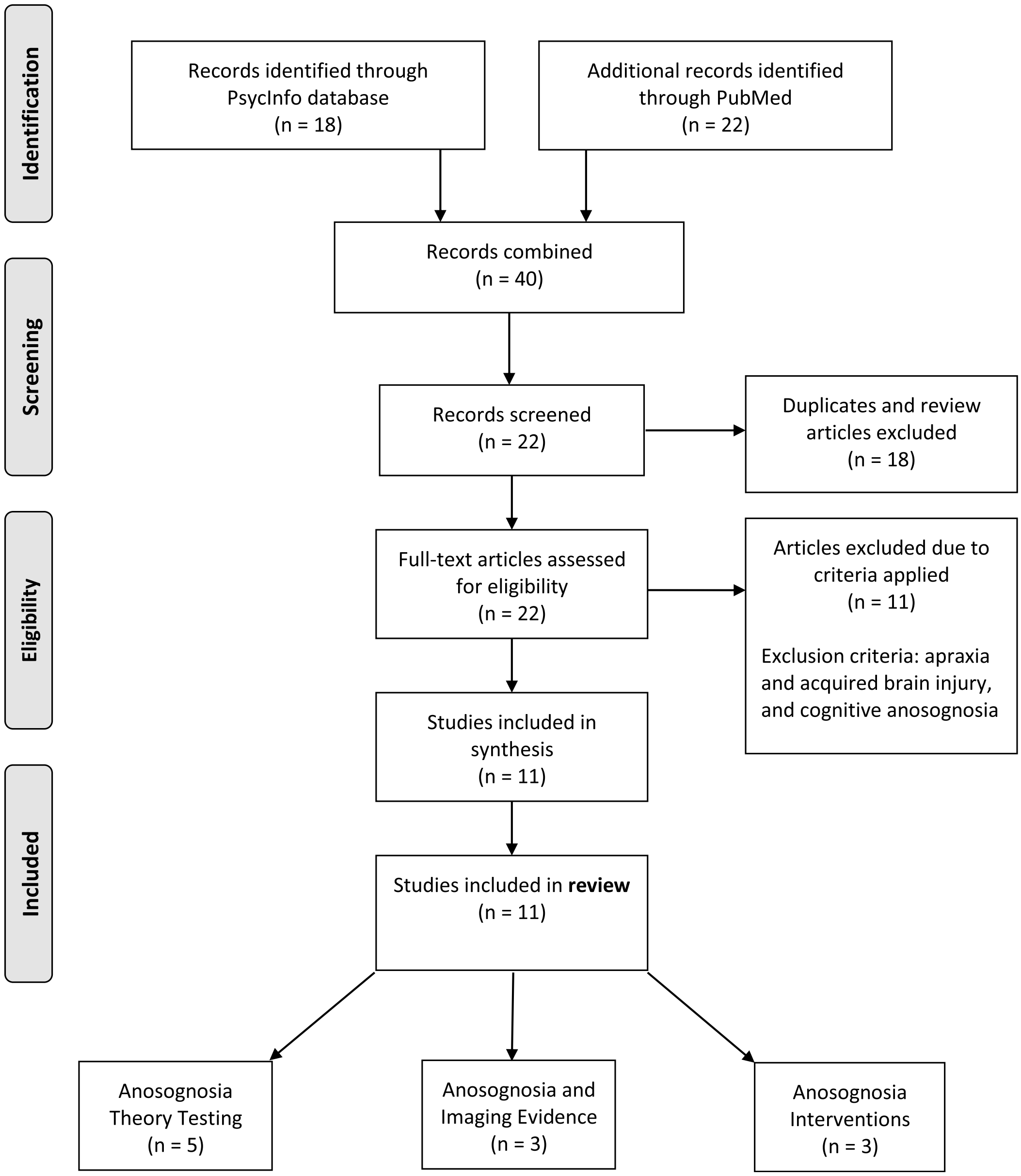

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Figure 1. PRISMA Diagram.

occurred. Over time, the motor cortex should be updated that movement did not occur in the plegic limb; but in the stroke patient, this updating does not occur via the normal feedback loop, and there continues to be a discrepancy between the action initiated by the controller and the feedback produced by the predictor (see Figure 1). The inability to update via a typical feedback loop results in a state of unawareness of deficit or disability (Frith et al., 2000) that manifests itself clinically as an almost delusional denial of deficit. According to this theory, the patient's awareness is dominated entirely by their intention to move versus the failure to process sensory information from the plegic limb that indicates that the movement did not occur (Fotopoulou et al., 2008).

Vocat et al. (2013) have termed the failure of the feedback loop the inability of one to update his or her beliefs. These researchers hypothesized that anosognosic individuals would fail to change their beliefs when confronted with conflicting information when compared to the performance of control participants undergoing the same procedure (Vocat et al., 2013). In Vocat et al.'s experiment, 11 control participants with no evidence of existing neurological injury or disease and nine right-hemispheric stroke patients were given clues that described words that

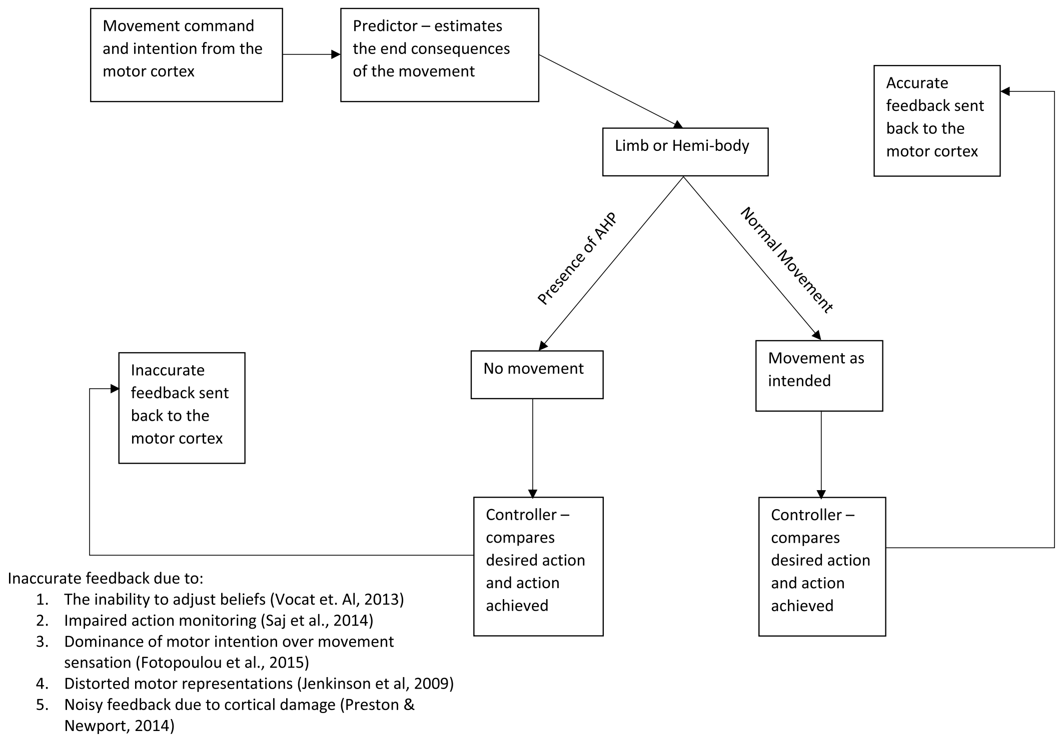

Figure 2. Theoretical Framework for Anosognosia for Hemiplegia after a Stroke.

were progressive in nature and then asked after the introduction of each new clue to guess what the word was. For example, the first clue was ambiguous in detail, with each additional clue providing more precise information regarding the target word. Participants were also instructed to rate their confidence in their answer. Compared to the control group, the anosognosic individuals showed significantly fewer correct responses and were more likely to repeat incorrect responses from a previous clue. This pattern shows that the anosognosic patients were *unable to update their beliefs and modify their responses* even when confronted with a new clue that was incongruent with their previous guess. It should also be noted that there was no difference in the control group and the experimental group in terms of global cognition, general reasoning ability, and semantic knowledge (Vocat et al., 2013). This study suggests that a deficit in the generation of and adjustment of beliefs when confronted with reality is associated with AHP.

In a later study, Saj et al. (2014) utilized an encoding and recognition intervention to investigate the relationship between action intention and the self-monitoring of movements. Five control and 10 first-time right-sided stroke patients were asked to move their arm or imagine moving their arm (if plegic), and then, in the second phase the individual was asked whether the action was realized, or performed as directed, or imagined. Again, as in the prior Vocat et al. (2013) study, there was no difference in neurocognitive testing between groups, which further supports that AHP cannot be explained or accounted for based on global cognitive function. The AHP group produced a higher number of incorrect responses; they also reported movement when no movement occurred at a higher rate than the other groups. Incorrect recall of nonexecuted left-sided motor movement was the most frequent error made by anosognosic patients. The results of this study further support the theory that a disturbance affecting an individual's ability to detect a mismatch between intention and movement realization plays a significant role in AHP (Saj et al., 2014). Fotopoulou and colleagues (2008) used the same method for testing the relationship between motor intention and motor awareness. In this experiment, a prosthetic arm was used to generate false visual feedback to control participants and four anosognosic participants. The control group had a high level of correct responses when confronted with false visual feedback. The AHP group, however, was impaired in detecting movement of the rubber hand only in the condition where they had intended to move their hand. In other words, when the anosognosic patient was asked to move the plegic limb and the prosthetic arm was used to generate false visual feedback of that movement, the anosognosic patients believed they had generated the movement. This theory-testing study also supports the notion that motor intention to move drives motor awareness, and because there is a failure to update the actual position of the limb because of damage to the comparator system, anosognosic patients believe they have moved an impaired limb when they have not (Fotopoulou et al., 2008).

Jenkinson et al. (2009) utilized a grip selection task to test motor imagery and motor control. *Motor imagery* is a mental process by which an individual is asked to visualize completing a certain motor task and then to verbally describe the outcome of the task. *Motor control* is the individual's ability to complete the task as required. Eighteen patients with a dense left hemiplegia were matched with 22 healthy volunteers. In the motor imagery task, the participants were asked to visualize reaching out and grabbing a wooden dowel. One half of the dowel was pink, and the other half was yellow. Participants were asked to verbalize with each grip which color their thumb would face. With each grip task, the dowel was rotated 45° so that the individual would have to imagine how their hand would grip the dowel. For the motor control procedure, the participants were asked to reach out and grip the dowel as it rotated 45° each time. The researcher recorded the orientation of the individual's thumb in relation to the color of the dowel, and the responses between intention and control were compared. The hypothesis of this study was that patients with AHP can generate motor representations concerning both their plegic and functioning limbs. In the anosognosic sample, the motor imagery and the motor control accuracy were significantly lower versus that of the healthy volunteers. Jenkinson et al. (2009) concluded that the predicted sensory consequences of movement form the basis of motor awareness, which is consistent with the previous finding that motor intention informs motor awareness. Both of which overrides sensory feedback in anosognosic patients and indicates a failure of the sensory feedback loop to the motor cortex (Jenkinson et al., 2009).

Lastly, Preston and Newport (2014) hypothesized that the comparators, which are theorized to be active memories of movements and sensations, are not damaged but may be experiencing a pathological slackening of awareness thresholds. Because of the damage left to cortical tissue after a stroke, typical processes, such as the fine-tuning of motor movements, fail to reach conscious awareness. Preston and Newport (2014) tested this theory on 22 neurologically healthy controls and simulated noisy visual feedback of reaching movements using a manipulatable robotic arm. Participants were asked to move a cursor on a computer to a target and were required to complete the task in 1,250 milliseconds. The individuals were presented with screen images that were either an accurate representation of their movement or a noise-induced representation of their movement, meaning that the cursor deviated from the individual's actual course of movement. The results of this study suggest that if noise or deviations of movement were added to visual feedback, participants were less likely to be able to perceive the deviations of movement and attribute the deviations to themselves. These researchers suggested that inducing or adding noise increases the threshold at which one becomes conscious and aware of discrepancies between motor intention and actual motor movement (Preston & Newport, 2014). These researchers argued that the threshold component explains why such large discrepancies can occur between patients with AHP. But, to subscribe to this theory means that a very important assumption must be accepted: That the visual noise that was introduced to the healthy participants mimics that which patients with AHP experience. It is more likely that AHP is an incredibly complex disorder that clinicians and researchers are just beginning to understand, and that its pathogenesis is related to a combination of deficits not yet entirely understood (Vocat, Pourtois, & Vuilleumier, 2011).

Imaging Evidence for AHP

Recent lesion mapping work of anosognosic patients following a stroke has revealed that the majority of patients with a history of AHP had an infarct of the middle cerebral artery and its territory (Baier et al., 2014; Besharati et al., 2014; Fotopoulou, Pernigo, Maeda, Rudd, & Kopelman, 2010). Fotopoulou and colleagues (2010) investigated a sample of 14 patients poststroke. Seven of the patients were confirmed as having AHP per the classical Berti, Ladavas, and Della Corte (1996) scale and verified by the Feinberg, Roane, and Ali (2000) method of identifying anosognosia. Utilizing weighted magnetic resonance imaging (MRI), volumes of affected cerebral tissue and the anatomical location of the lesions were compared to the seven-patient control group who had also experienced a stroke but were nosognosic. All 14 of the patients had either a single ischemic or hemorrhagic stroke that was confined to the right hemisphere, mostly in the territory of the middle cerebral artery. Three of the anosognosic patients had large middle cerebral artery infarcts that affected both cortical and subcortical tissue. Three other anosognosic patients had subcortical damage affecting the basal ganglia, insula, and surrounding white matter. The last patient in the anosognosic group had a large hemispheric lesion that was mostly subcortical but extended to the medial parts of the frontal and occipital cortex.

Compared with the volume of affected tissues experienced by the nonanosognosic group, there were no significant differences. Differences in anatomical location between groups revealed that the anosognosic group had a cluster of lesions that extended from the rolandic operculum and anterior insula to the caudate and putamen nuclei. There was also evidence of some inferior lesion clusters involving the amygdala and the superior temporal pole. The findings of this study conclude that the lesional differences between the groups is the involvement of the insula, inferior motor areas, basal ganglia and surrounding structures, and limbic structure in the anosognosic sample. Also noteworthy is that in this study, as in Berti et al. (2005), the supplementary motor area in the anosognosic patients was spared, lending support to the theory that motor planning is intact in anosognosic patients (Fotopoulou et al., 2010).

Besharti et al. (2014) used the classical voxel-based lesion symptom mapping approach on a sample of 16 patients recruited from a stroke rehabilitation unit. Eight of the patients tested positive for AHP per the Berti et al. (1996) scale, and the other eight patients served as controls. As in the study before, lesion volume and lesion mapping were compared between the groups. All the patients, with and without anosognosia, had right middle cerebral artery infarcts. There was no difference in volume between the groups. Via lesion mapping, the nosognosic sample did not have any lesional involvement that extended into the subcortical areas. Individuals who had damage extending to the putamen, the anterior insula, and the anterior periventricular white matter were more likely to be less aware of their deficit (Besharati et al., 2014).

There is a long-standing debate on whether AHP is a phenomenon that is restricted to a right-hemispheric infarct. Previous data lend evidence that this disorder typically presents after a right-sided stroke, and only a minority of patients with left-sided strokes has been described in the literature (Orfei et al., 2007). There is a concern that potential patients who have suffered a left-sided stroke and who may be anosognosic are excluded from studies because of their inability to participate in the classical interviews used to confirm the presence of the disorder. Left-sided infarcts often infringe on the language center, creating concern that aphasia may obscure the presence of anosognosia (Hartman-Maeir et al., 2001).

Baier et al. (2014) tested 66 acute stroke patients with left-sided infarctions for AHP and then utilized MRI to determine whether the language center of the individual was in the right or left hemisphere (Baier et al., 2014). From the original sample, only 44 could be formally tested for the presence of AHP. Of those 44, only one patient, a 62-year-old right-handed woman, tested positive for AHP after stroke. Like previously mentioned theory-testing literature, though the patient was anosognosic, she did not have cognitive impairment when tested with the Mini-Mental Status Examination. Yet, when asked about her plegic arm, she was grossly anosognosic. To test the hypothesis that her language center was asymmetrically located in the right hemisphere versus the left, the researchers utilized a functional MRI procedure that detected changes in blood flow to different areas of the brain based on activation. The participant was shown a picture and was asked to state a simple sentence describing how the picture appeared. The functional MRI procedure confirmed that this individual's language center was located in the right hemisphere versus the left. This study has implications moving forward in that it is speculated that up to 3% of right-handed individuals have right versus left lateralization of language functions. The assumption that AHP only occurs after a right-sided infarct should be investigated further in larger studies, and research to explore the integration of left-sided stroke survivors into AHP research should be pursued (Baier et al., 2014).

Interventions for AHP

Three researchers reported interventions for AHP based on Vuilleumier's (2004) ABC Model of Updating Beliefs. In each of the three (Besharti, Kopelman, Avesani, Moro, & Fotopoulou, 2015; Fotopoulou, Rudd, Holmes, & Kopelman, 2009; Moro, Scandola, Bulgarelli, Avesani, & Fotopoulou, 2015) studies, the participants were given an opportunity to *Appreciate* their beliefs by being asked to perform a task with the affected limb. Then, the investigator questioned the participant's initial *Belief* on how well they performed the dictated task. Lastly, the participant was allowed the opportunity to *Check* their performance on the task by being asked questions on how they believe they did or by being confronted with video evidence that they did not complete the task (Vuilleumier, 2004). The researchers each thought that the ability to observe oneself from a third person perspective could potentially lead the participants to update their beliefs of their performance by revisiting the question aimed at understanding how they perceived their performance on the task.

The foundational case study by Fotopoulou, Rudd, Holmes, and Kopelman (2009) describes a 67-year-old right-handed woman who presented during the acute stroke phase with a large right middle cerebral artery infarct and a severe left-sided paralysis. The patient maintained that she could move her left side, though it seemed to be weaker than her right side. Though she had a flaccid paralysis of the left side, she adamantly stated that she performed many of the tasks that the investigator asked her to do with the paralyzed limb. She also frequently attempted to get out of the bed unassisted or stand from her wheelchair. Fotopoulou and colleagues video-recorded one of their task assessments of the patient and then asked if she would like to see her performance on the recorded video. They positioned the camera in front of her showing her upper body only and allowed her to watch the 90-second clip of the assessment. Immediately after watching the video, the patient spontaneously stated that her expectations had not been very realistic. The patient experienced a sudden and dramatic new awareness of her paralysis that persisted the following day. When asked why she changed her mind, she stated that she did not realize that she looked like that until she saw the video (Fotopoulou et al., 2009).

Besharati, Kopelman, Avesani, Moro, and Fotopoulou (2015) replicated the methods and intervention of the previous study but applied the interventions to two patients in the chronic phase of stroke recovery to determine the feasibility and effectiveness of the intervention. Instead of focusing on the upper body only, these researchers initiated an intervention on one of the patients that included both the left upper and left lower extremities. Both patients' awareness was tested several times before the video intervention to ensure that there was a presence of AHP. One patient was an 88-year-old right-handed woman with a dense right middle cerebral artery stroke. The second patient to receive the intervention was a 70-year-old right-handed man with a right-sided middle cerebral artery stroke as well. The methods of the experiment mirror the Fotopoulou et al. (2009) experiment in that the participant's awareness and cognitive function was tested; they were asked to perform a task, asked how they think they did on the task, and then confronted with video evidence of failure to perform the task. The 88-year-old woman was the individual who received the intervention for the left lower extremity, which mirrored the intervention for the upper body. Video replay of task performance in both of these participants contributed to significant reinstatement of motor awareness (Besharati et al., 2015).

The final intervention study utilized error-based training to induce awareness of deficits in four patients with damage to the right hemisphere. Much like the interventions above, three steps were followed: the researchers assessed participants' awareness, the participants were asked to judge their ability to perform certain actions, and the participants were asked to perform the action. After these three steps, the investigator invited the patients to discuss their performance and perhaps identify some reasons that the task could not be completed. It is noted in this publication that there were many discussions between the medical staff and the patient and family support system concerning the patient's stroke and subsequent impairment. Even with these conversations, at baseline, all patients were anosognosic and were unaware of their deficits. Though the sample size was small, the intervention outlined above contributed to the recovery of awareness of motor deficits. All the patients in this study improved awareness and maintained recovery of awareness over time (Moro, Scandola, Bulgarelli, Avesani, & Fotopoulou, 2015).

Another consideration for any interventions that seek to reinstate one's self awareness is the potentially upsetting nature that the discovery may have on the patient. In each of the studies above, the researchers were cognizant to build a relationship with their patients and did not seek to intervene until they felt the patients were in a safe place. There were also provisions in the research protocols that allowed the investigator to stop the intervention or the interview if the patient became too upset. At this point, therapeutic communication, understanding, and encouragement were offered to the participant, and the intervention was resumed at a later time. In each of the patient encounters, when self-awareness was realized, there was some form of emotional response. One patient cried and wondered how she would ever live or work again. Another patient withdrew and would not interact with the investigator for a long period of time (Besharati et al., 2015; Fotopoulou et al., 2009; Moro et al., 2015). These emotional reactions should be a point of concern for anyone interested in intervening in the presence of anosognosia. There should always be protocols and additional support built in to any research program to help the individual to cope with their disability in a healthy way.

Discussion

Although the concept of AHP has been in the scientific literature for over 100 years (as cited in Langer, 2009), our understanding of the phenomenon is evolving. Only 11 studies were identified in the systematic review, and the content and foci of the 11 studies fell into one of three categories: theory testing, imaging evidence, and interventions for individuals with AHP. By synthesizing the above results, we can conclude that motor intention in affected individuals is preserved, and they are able to generate an intention to move via the motor cortex (Frith et al., 2000). Though the movement does not occur, sensory feedback is based on previous movement memory rendering the individual unable to update his or her beliefs and know that they are plegic on one side (Vocat et al., 2013). There is also biological evidence from lesion analysis studies that suggests that individuals who suffer from AHP have an infarct at or in the territory of the right middle cerebral artery (Besharati et al., 2014), with more precise locations of damage from the rolandic operculum and anterior insula to the caudate and putamen nuclei, and the amygdala and the superior temporal pole (Fotopoulou et al., 2010). Though AHP is known to be a disorder associated with a right-sided infarct, there is debate on whether the presence of aphasia often associated with a left-sided infarct renders one unable to participate in an AHP test or questionnaire. Aphasia is thought to obscure the presence of AHP in individuals with left-sided infarcts up to 40% (Baier et al., 2014). Future research and studies should seek ways to incorporate and include those with left-sided infarcts into studies concerning AHP.

There were few interventions that reinstated motor awareness in an individual with AHP after stroke. The successful interventions utilized video playback that allowed the participant to view themselves attempting to complete a directed task (Besharati et al., 2015; Fotopoulou et al., 2009). This intervention utilized Vuilleumier's (2004) "ABC" model for updating beliefs. The "Appreciate, Belief, Check" model confronts an anosognosic individual with video evidence that they were unable to perform a task. Viewing this from a third-person point of view was successful in reinstating motor awareness in the studies described above (Besharati et al., 2015; Fotopoulou et al., 2009). Another method successful in reinstating motor awareness utilized the same "ABC" model and gave the individual an opportunity to reflect on why certain actions were not performed as directed. This study used reflective reasoning and initiated the reinstatement of motor awareness to the participants involved (Moro et al., 2015). The intervention studies, however, had very small sample sizes of two or three individuals per intervention. More research, including larger trials with more diverse populations, should be conducted before these interventions are generalized to the anosognosic population.

In each of the intervention studies where an anosognosic patient is confronted with his or her new disability for the first time, there was an emotional response of some sort. Some shed tears, and one participant withdrew from the researchers and refused to participate until he had processed the revelation (Besharati et al., 2015; Fotopoulou et al., 2009; Moro et al., 2015). Any research that seeks to intervene in AHP should consider the emotional consequences of confronting one with their disability for the first time. Measures that offer emotional support and counseling should be part of any study design that seeks to reinstate motor awareness to one who is not aware.

Nursing and Clinical Implications

Anosognosia for hemiplegia after stroke continues to draw attention from scientists because of the profound effect the condition can have on recovery and quality of life of stroke survivors (Orfei et al., 2007). Individuals who have AHP have motor impairments that result in gait and self-care disturbances. The central issue of the phenomenon is that the individual believes that he or she can function in a normal manner. Because of this, common safety precautions are often disregarded by the patient, placing them at risk for an injury both in the hospital and once discharged (Hartman-Maeir et al., 2001). Another consequence of anosognosia is an inability to understand the importance of attending rehabilitation and participating in therapeutic interventions that aid in recovery. Often anosognosic patients will refuse to participate in therapy because they believe they are able to function normally (Kortte & Hillis, 2009). Anosognosia has also been associated with longer rehabilitation stays and with poorer functional outcomes among stroke survivors (Hartman-Maeir et al., 2001). Specifically, this study found that individuals with anosognosia after stroke were deemed unsafe at discharge and never achieved independence in basic activities of daily living as evidenced by significantly lower Functional Independence Measure scores 1 year after discharge from the rehabilitation center.

Conclusion

The majority of the literature concerning AHP is from neuropsychology journals, and the basic understanding and ramifications of the phenomenon are just beginning to be understood. Hartman-Maeir et al. (2001) state that individuals with anosognosia are more likely to disregard safety measures and are therefore more likely to fall, but the relationship between anosognosia and falling has not been properly established through research. Current gaps that must be addressed include studies that investigate whether the presence of anosognosia is a positive and reliable predictor for falls during stroke rehabilitation. The interventions discussed in this article need to be conducted with larger sample sizes. Likewise, utilizing a robust experimental design will aid in building evidence that the confrontation method does, in fact, reinstate awareness and can be used so that anosognostic patients have safer and more effective rehabilitation stays. Likewise, the ethical concerns of utilizing video cameras or cell phones will need to be developed and tested to ensure there are no Health Insurance Portability and Accountability Act (HIPPA) violations and that the confrontation techniques used have resources available to mitigate the emotional distress the patient could experience.

Conflicts of Interest

The authors report no real or perceived vested interest that relate to this article that could be construed as a conflict of interest.

References

Babinski, J. (1914). Contribution to the study of mental disorders in organic cerebral hemiplegia (anosognosia). *Revue Neurologique (Paris)*, *27*, 845–848.

Baier, B., Vucurevic, G., Müller-Forell, W., Glassl, O., Geber, C., Dieterich, M., & Karnath, H.-O. (2014). Anosognosia for hemiparesis after left-sided stroke. *Cortex: A Journal Devoted to the Study of the Nervous System and Behavior*, *61*, 120–126. doi:10.1016/j.cortex.2014.07.017

Berti, A., Bottini, G., Gandola, M., Pia, L., Smania, N., Stracciari, A., … Paulesu, E. (2005). Shared cortical anatomy for motor awareness and motor control. *Science*, *309*(5733), 488–491. doi:10.1126/science.1110625

Berti, A., Ladavas, E., & Della Corte, M. (1996). Anosognosia for hemiplegia, neglect dyslexia, and drawing neglect: Clinical findings and theoretical considerations. *Journal of the International Neuropsychological Society*, *2*(5), 426–440.

Besharati, S., Forkel, S. J., Kopelman, M., Solms, M., Jenkinson, P. M., & Fotopoulou, A. (2014). The affective modulation of motor awareness in anosognosia for hemiplegia: Behavioural and lesion evidence. *Cortex: A Journal Devoted to the Study of the Nervous System and Behavior*, *61*, 127–140. doi:10.1016/j.cortex.2014.08.016

Besharati, S., Kopelman, M., Avesani, R., Moro, V., & Fotopoulou, A. K. (2015). Another perspective on anosognosia: Self-observation in video replay improves motor awareness. *Neuropsychological Rehabilitation*, *25*(3), 319–352. doi:10.1080/09602011.2014.923319

Bisiach, E., Vallar, G., Perani, D., Papagno, C., & Berti, A. (1986). Unawareness of disease following lesions of the right hemisphere: Anosognosia for hemiplegia and anosognosia for hemianopia. *Neuropsychologia*, *24*(4), 471–482. doi:10.1016/0028-3932(86)90092-8

Bottini, G., Sedda, A., Ferrè, E. R., Invernizzi, P., Gandola, M., & Paulesu, E. (2009). Productive symptoms in right brain damage. *Current Opinion in Neurology*, *22*(6), 589–593. doi:10.1097/WCO.0b013e328332c71d

Cherney, L. R. (2006). Ethical issues involving the right hemisphere stroke patient: To treat or not to treat? *Topics in Stroke Rehabilitation*, *13*(4), 47–53.

Feinberg, T. E., Roane, D. M., & Ali, J. (2000). Illusory limb movements in anosognosia for hemiplegia. *Journal of Neurology, Neurosurgery & Psychiatry*, *68*(4), 511.

Fotopoulou, A., Pernigo, S., Maeda, R., Rudd, A., & Kopelman, M. A. (2010). Implicit awareness in anosognosia for hemiplegia: Unconscious interference without conscious re-representation. *Brain: A Journal of Neurology*, *133*(Pt. 12), 3564–3577. doi:10. 1093/brain/awq233

Fotopoulou, A., Rudd, A., Holmes, P., & Kopelman, M. (2009). Self-observation reinstates motor awareness in anosognosia for hemiplegia. *Neuropsychologia*, *47*(5), 1256–1260. doi:10.1016/j.neuropsychologia.2009.01.018

Fotopoulou, A., Tsakiris, M., Haggard, P., Vagopoulou, A., Rudd, A., & Kopelman, M. (2008). The role of motor intention in motor awareness: An experimental study on anosognosia for hemiplegia. *Brain: A Journal of Neurology*, *131*(Pt. 12), 3432–3442. doi:10.1093/brain/awn225

Frith, C. D., Blakemore, S. J., & Wolpert, D. M. (2000). Abnormalities in the awareness and control of action. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *355*(1404), 1771–1788.

Hartman-Maeir, A., Soroker, N., & Katz, N. (2001). Anosognosia for hemiplegia in stroke rehabilitation. *Neurorehabilitation & Neural Repair*, *15*(3), 213–222. doi:10.1177/154596830101500309

Jenkinson, P. M., Edelstyn, N. M., & Ellis, S. J. (2009). Imagining the impossible: Motor representations in anosognosia for hemiplegia. *Neuropsychologia*, *47*(2), 481–488. doi:10.1016/j.neuropsychologia.2008.10.004

Kortte, K., & Hillis, A. E. (2009). Recent advances in the understanding of neglect and anosognosia following right hemisphere stroke. *Current Neurology and Neuroscience Reports*, *9*(6), 459–465.

Langer, K. G. (2009). Babinski's anosognosia for hemiplegia in early twentieth-century French neurology. *Journal of the History of the Neurosciences*, *18*(4), 387–405. doi:10.1080/09647040802537064

Moro, V., Scandola, M., Bulgarelli, C., Avesani, R., & Fotopoulou, A. (2015). Error-based training and emergent awareness in anosognosia for hemiplegia. *Neuropsychological Rehabilitation*, *25*(4), 593–616. doi:10.1080/09602011.2014.951659

Orfei, M. D., Caltagirone, C., & Spalletta, G. (2009). The evaluation of anosognosia in stroke patients. *Cerebrovascular Diseases*, *27*(3), 280–289. doi:10.1159/000199466

Orfei, M. D., Robinson, R. G., Prigatano, G. P., Starkstein, S., Rüsch, N., Bria, P., … Spalletta, G. (2007). Anosognosia for hemiplegia after stroke is a multifaceted phenomenon: A systematic review of the literature. *Brain: A Journal of Neurology*, *130*(Pt. 12), 3075–3090.

Preston, C., & Newport, R. (2014). Noisy visual feedback training impairs detection of self-generated movement error: Implications for anosognosia for hemiplegia. *Frontiers in Human Neuroscience*, *8*, 456.

Saj, A., Vocat, R., & Vuilleumier, P. (2014). Action-monitoring impairment in anosognosia for hemiplegia. *Cortex: A Journal Devoted to the Study of the Nervous System and Behavior*, *61*, 93–106. doi:10.1016/j.cortex.2014.10.017

Vocat, R., Pourtois, G., & Vuilleumier, P. (2011). Parametric modulation of error-related ERP components by the magnitude of visuo-motor mismatch. *Neuropsychologia*, *49*(3), 360–367. doi:10.1016/j.neuropsychologia.2010.12.027

Vocat, R., Saj, A., & Vuilleumier, P. (2013). The riddle of anosognosia: Does unawareness of hemiplegia involve a failure to update beliefs? *Cortex: A Journal Devoted to the Study of the Nervous System and Behavior*, *49*(7), 1771–1781. doi:10. 1016/j.cortex.2012.10.009

Vuilleumier, P. (2004). Anosognosia: The neurology of beliefs and uncertainties. *Cortex*, *40*(1), 9–17. doi:10.1016/S0010-9452(08)70918-3

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