Running head: Anosognosia as a Delusion

Anosognosia for Motor Impairments as a Delusion: Anomalies of Experience and Belief Evaluation

Martin Davies\textsuperscript{a, b, c}, Caitlin L. McGill\textsuperscript{d}, and Anne M. Aimola Davies\textsuperscript{b, d}

\textsuperscript{a} University of Oxford, Faculty of Philosophy, United Kingdom

\textsuperscript{b} University of Oxford, Department of Experimental Psychology, United Kingdom

\textsuperscript{c} Monash University, Department of Philosophy, Australia

\textsuperscript{d} Australian National University, Research School of Psychology, Australia
Abstract

Anosognosia is a patient’s lack of knowledge of his or her illness or impairment. Patients who lack knowledge of their motor impairments believe that they can still move limbs that are now paralysed. This belief fits the *DSM-5* definition of delusions as “fixed beliefs that are not amenable to change in light of conflicting evidence”. Thus, anosognosia for motor impairments is both a lack of knowledge and a delusion.

In the aetiology of a delusion, one factor is an anomaly of experience. In anosognosia for motor impairments, this phenomenological first factor – arising from impairment of the motor control system – is the anomalous absence of immediate bodily experience of movement failure.

In this chapter, a distinction is drawn between three kinds of knowledge that may be lacking in patients with anosognosia for motor impairments: knowledge of movement failure when it occurs, more lasting knowledge of motor impairments, and knowledge of the consequences of those motor impairments for everyday activities. The first factor blocks a direct experiential route to concurrent knowledge of movement failure and, thence, to knowledge of motor impairments. Alternative experiential routes may be blocked by proprioceptive loss or unilateral visuospatial neglect.

Even without immediate experience of movement failure, other evidence of the patient’s motor impairments would be available. A cognitive second factor is needed to explain why the patient is unable to use this evidence to reject the delusional belief and achieve knowledge of his or her true condition. The patient might be unable to remember the evidence for long enough to make use of it, or unable to recognise that the evidence is incongruent with current beliefs, or unable to carry out the cognitively demanding task of belief evaluation. Consequently, impairments of memory, error detection, executive function or working memory are candidate second factors in anosognosia for motor impairments.

Keywords: anosognosia, belief evaluation, concurrent awareness, delusion, error detection, executive function, experience of movement failure, memory, motor impairment, right hemisphere, stroke, two-factor theory, working memory.
Anosognosia as a Delusion

Anosognosia is a patient’s lack of knowledge of his or her illness or impairment: a- (without); -noso- (disease); -gnosia (knowledge). The French neurologist Joseph Babinski (1914) introduced the term as applying to patients’ lack of knowledge of their hemiplegia but the term has a more inclusive use (as the etymology would suggest). Patients may be described as having anosognosia for their visual impairments, memory impairments, cognitive impairments, and so on. In this chapter, we shall focus on “the anosognosia of Babinski” (see Langer, 2009, p. 390), anosognosia for hemiplegia or, more generally, for motor impairments. Anosognosia for motor impairments may follow a left-hemispheric or right-hemispheric stroke but we shall mainly discuss anosognosia for left-side motor impairments – specifically, impairment of the left arm – following a right-hemispheric stroke.

Anosognosia is usually assessed by a structured interview. Interviews typically begin with general questions about the patient’s health and why the patient is in hospital, and then move on to more specific questions about the motor impairment, and whether the patient is able to move the left arm. A patient who claims to be able to move the paralysed left arm may be asked to raise the left arm.

Patients are classified as having no anosognosia, or mild, moderate, or severe anosognosia, using scoring criteria such as the Bisiach Anosognosia Scale (Bisiach, Vallar, Perani, Papagno, & Berti, 1986):

0 The disorder is spontaneously reported or mentioned by the patient following a general question about his complaints (No anosognosia)

1 The disorder is reported only following a specific question about the strength of the patient’s left limbs (Mild anosognosia)

2 The disorder is acknowledged only after its demonstration through routine techniques of neurological examination (Moderate anosognosia)

3 No acknowledgement of the disorder can be obtained (Severe anosognosia).

---

1 See Aimola Davies, White and Davies (2010, Table 23.2) for a review of the questions used in nine structured interviews for anosognosia for motor impairments published between 1952 and 2008; also see Nurmi and Jehkonen (2014, Table 2) for a review of assessment methods published between 1978 and 2013.
Many studies classify patients as having anosognosia only if they have a score of 2 or 3 on the Bisiach Anosognosia Scale. If a patient’s left-side motor impairment is not total and some movement of the arm is possible then an affirmative answer to the question, “Can you move it?”, is actually true. For this reason, some studies include only patients whose motor impairment is total. An alternative approach is to modify the interview questions to assess whether the patient is, nevertheless, underestimating the degree of impairment (see Vocat, Staub, Stroppini, & Vuilleumier, 2010).

In the interview used by Berti, Làdava and Della Corte (1996), the first group of questions includes both general questions and questions specifically about the motor impairment: “Where are we? Why are you in hospital? How is your left arm? Can you move it?” (p. 429). If the patient claims to be able to move the left arm then he or she is asked: “Please, touch my hand with your left hand. ... Have you done it? ... Are you sure? It is very strange because I have not seen your hand touching my hand” (pp. 429–32). The patient is classified as having no anosognosia, or mild or severe anosognosia, using the following criteria:

0 The patient answered correctly to the first group of questions (No anosognosia)

1 The patient acknowledged being in the hospital and/or being affected by a stroke, but denied his or her upper limb impairment. However, the patient acknowledged that the left arm did not reach the examiner’s hand (Mild anosognosia)

2 The patient claimed that he or she had reached the examiner’s hand (Severe anosognosia).

Reported rates of occurrence of anosognosia for motor impairments vary quite widely. In one recent study of fifty-eight patients with left-arm motor impairment (Vocat et al., 2010), fifty patients were assessed within five days following a right-hemispheric stroke and sixteen (32%) had a score of 2 or 3 on the Bisiach Anosognosia Scale. Eight (18%) of forty-four patients assessed in the second week following stroke had a score of 2 or 3, and one (5%) of nineteen patients examined six months after stroke still had a score of 3 (none had a score of 2).

---

2 See Aimola Davies et al. (2010, Table 23.3) for occurrence rates in 21 studies published between 1952 and 2009.
Outline

In this chapter, a distinction is drawn between three kinds of knowledge that may be lacking in patients with anosognosia for motor impairments: knowledge of movement failure when it occurs, more lasting knowledge of motor impairments, and knowledge of the consequences of those motor impairments for everyday activities (Section 2).

Patients who lack knowledge of their motor impairments believe that they can still move limbs that are, in reality, paralysed. This belief fits the definition of delusions, and anosognosia for motor impairments can be considered within a generic two-factor framework for understanding monothematic delusions. In the aetiology of a delusion, one factor is an anomalous experience that prompts the delusional idea or hypothesis. This first factor is not sufficient, by itself, to explain the delusion and a second factor is needed to account for the fact that the delusional belief is not rejected, despite its implausibility and the evidence against it (Section 3).

In anosognosia for motor impairments, the phenomenological first factor – arising from impairment of the motor control system – is the anomalous absence of immediate bodily experience of movement failure. However, even without immediate experience of movement failure, other evidence of the patient’s motor impairments would be available (including evidence from everyday mishaps consequent on the motor impairments). A cognitive second factor is needed to explain why the patient is unable to use this evidence to reject the delusional belief and achieve knowledge of his or her true condition. The patient might be unable to remember the evidence for long enough to make use of it, or unable to recognise that the evidence is incongruent with current beliefs, or unable to carry out the cognitively demanding task of belief evaluation. Consequently, impairments of memory, error detection, executive function or working memory are candidate second factors in anosognosia for motor impairments (Sections 4 and 5).

The chapter begins (Section 1) with phenomenology – the patient’s experience, or absence of experience, of trying but failing to move a paralysed limb – and its underpinnings in the motor control system.
1. Experience of Movement Failure

Definitions of anosognosia often mention *unawareness* of impairment and, indeed, the translation of Babinski’s original paper uses that term: “the patients are *unaware* of ... the existence of the paralysis which affects them” (1914/2014, p. 6; emphasis added).³ The term “unawareness” is certainly used to express a lack of knowledge but “awareness” and “unawareness” also suggest the presence or absence of conscious experience (sensation and perception). We regard anosognosia as a failure or pathology at the level of knowledge and belief. The patient fails to know about his or her left-arm motor impairment and believes, instead, that he or she does not have the impairment and can still move the left arm. The patient may also sometimes believe that he or she *is moving* the left arm – for example, in response to a request to reach and touch the examiner’s hand. It is important to distinguish between failure to *know* about one’s own motor impairments and failure to *experience* one’s own movement failures. (Throughout this chapter, we shall use the terms “awareness” and “unawareness” only for the presence or absence of conscious experience, and not for the presence or absence of knowledge.)

1.1 A model of motor control

The experience of movement failure (and the absence of such experience) can be understood in terms of a well-established model of motor control (Frith, Blakemore, & Wolpert, 2000; Wolpert, 1997; Wolpert & Flanagan, 2001). The key components in the model of motor control are *predictors* and *comparators*. Predictors or forward models capture the relationship between actions and their consequences. They use information about the current state of the system and about motor commands to predict the future state of the system and the resulting sensory feedback. Comparators detect any mismatch between the predicted sensory feedback and the actual feedback and generate *prediction error signals*.

³ In the original French: “les malades ignorent ... l’existence de la paralysie dont ils sont atteints” (Babinski, 1914, p. 845).
Consider, first, a hypothetical case of hemiplegia without anosognosia. The patient wants to raise her left arm (the arm being in the raised position is the desired state); and she tries to raise her arm. A motor command is issued. A predictor within the motor control system uses an efference copy of the motor command to generate a representation of the predicted position of the arm when the attempted movement is complete (predicted state) and a representation of the predicted proprioceptive feedback. The paralysed arm does not move but remains by the patient’s side (actual state). A comparator detects the substantial disparity between the predicted position of the arm, as represented by the predicted proprioceptive feedback, and the actual position of the arm, as represented by proprioception, and a prediction error signal is generated. Consequently, the patient has an immediate bodily experience of trying, but failing, to raise her arm – “concurrent awareness” of the specific movement failure (Marcel, Tegnér, & Nimmo-Smith, 2004, p. 34).

Now consider, in contrast, a hypothetical case of hemiplegia in which additional impairments of the motor control system are present. As a result of these impairments, no disparity between a predicted state and an actual state is detected and no prediction error signal is generated. Consequently, the patient does not have an immediate experience of failing to raise his arm – “concurrent unawareness” of the specific movement failure. Several proposals have been made about impairments of the motor control system that would have this consequence.

1.2 Explaining the absence of experience of movement failure

Heilman (1991; Heilman, Barrett, & Adair, 1998; Heilman & Harciarek, 2010; Heilman, 2014) has proposed that, in at least some cases of anosognosia for motor impairments, there is a motor intention deficit. The patient desires to move his left arm but a motor command is not issued. Without an efference copy of a motor command, even an intact predictor will generate neither a representation of a predicted raised position of the arm, nor a representation of predicted proprioceptive feedback consequent on that new position. The comparator may have access to information from proprioception about the actual position of the immobile left arm, but it has no
information about a predicted different position. Without two represented positions to compare, the comparator detects no disparity, and no prediction-error signal is generated. Consequently, the patient does not have an immediate experience of failing to move his left arm.

This motor intention theory may account for some cases of absence of experience of movement failure, but an increasing body of evidence supports the claim that at least some patients with anosognosia are able to generate motor intentions (e.g. Berti, Spinazzola, Pia, & Rabuffetti, 2007; Garbarini et al., 2012; Jenkinson & Fotopoulou, 2010; Pia et al., 2013; Piedimonte et al., 2015). In some cases, the patient has an illusory bodily experience of successful movement – a kinaesthetic hallucination or illusory limb movement (Feinberg, Roane, & Ali, 2000; Marcel et al., 2004; Vocat et al., 2010). These illusory movements of the paralysed limb are not well accounted for by Heilman’s motor intention theory because the experience of moving the arm depends primarily on the motor commands and consequent predictions of movement, and on the match between the desired state and the predicted state (Blakemore & Frith, 2003; Frith et al., 2000).

Suppose now that motor intentions are intact and that the comparator receives information about the predicted position of the left arm. There are at least two circumstances in which the comparator would not generate a prediction error signal and so the patient would not have an immediate experience of movement failure. One possibility is that, because of impaired proprioceptive feedback, the comparator may not receive information about the actual position of the left arm. In such a case, the comparator would not have two represented positions – predicted and actual – to compare. A second possibility is that no prediction error signal is generated, despite the fact that information about the predicted and actual positions of the left arm is available. There may be damage to the comparator itself (Berti et al., 2005, p. 490; Berti & Pia, 2006, p. 247; Berti et al., 2007, p. 169; also see Garbarini et al., 2019) or the comparator’s threshold for generating a (conscious) prediction error.
signal might be pathologically raised as a result of increased inherent noise in the motor system (Preston, Jenkinson & Newport, 2010; Preston & Newport, 2014).

Proprioceptive loss often co-occurs with anosognosia for motor impairments, and so it might not be straightforward to provide clear cases of the second possibility described in the previous paragraph. However, predictors in the motor control system predict, not only the proprioceptive feedback, but also the visual feedback that will result from the predicted state; and this predicted visual feedback is compared with actual visual feedback. Thus, there is an opportunity to test the hypothesis that, in at least some patients with anosognosia, motor intentions and predictions of movement are generated and visual feedback is available, yet no disparity between predicted and actual state is detected. In a seminal experiment, Fotopoulou, Tsakiris, Haggard, Vagopoulou, Rudd and Kopelman (2008) provided evidence that, in anosognosia for motor impairments, predictions flowing from motor intentions “dominate over sensory feedback” (p. 3433).

In this study, four patients with anosognosia for a motor impairment of the left arm following a right-hemispheric stroke and four control patients (with the left arm paralysed, but without anosognosia) were provided with false visual feedback from a realistic prosthetic hand that could be moved (unbeknown to the patient) by an assisting experimenter. The prosthetic hand was positioned (aligned with body midline) on a table in front of the patient, and was accepted by the patient as being his or her own hand. In the critical condition (12 trials), patients were asked to raise their left hand. On six trials, the prosthetic hand moved as if the patient had succeeded in raising it, and on the other six trials, the prosthetic hand did not move. Patients were asked whether their hand moved. Patients

---

4 Preston and colleagues suggest that, in anosognosia, “the raising of the comparator thresholds is such that all movements are treated as both self-produced and accurate. Thus, when a movement is intended, and, importantly, a motor programme produced, the movement is treated as self-produced, even though no actual movement has taken place” (2010, p. 3449).

5 A suitable rubber hand was selected for each patient, so that the rubber hand resembled the patient’s own hand. The patients’ belief that the rubber hand was their own hand was confirmed before, during, and after the experiment, and patients “did not doubt the rubber hand was theirs” (Fotopoulou et al., 2008, p. 3437).
with anosognosia reported that the hand moved, not only when it did move, but also on a substantial majority of trials when it did not move. In contrast, patients without anosognosia were able to discriminate between movement and no movement of the prosthetic hand. In two other conditions, patients were instructed not to move their left hand. In one condition (12 trials), patients were told that the assisting experimenter would passively lift their left hand for them; in the other condition (12 trials), they were told that the assisting experimenter would not attempt to lift their left hand. In each of these two conditions, the prosthetic hand moved on six of the 12 trials and both groups of patients were reliably able to discriminate between movement and no movement. Thus, anosognosia patients failed to detect a substantial disparity between predicted and actual visual feedback from the prosthetic left hand, but only when they themselves attempted to move their left hand.

1.3 From experience to knowledge of movement failure

Experience, or absence of experience, of movement failure is likely to have consequences for a patient’s knowledge of movement failure at the time it occurs, or beliefs about successful movement. First, an immediate experience of trying, but failing, to raise the left arm will normally provide a patient with knowledge of the movement failure when it occurs. The patient will know that she has just now failed to move her left arm. Conversely, a patient’s knowledge that she just now failed to move her arm is naturally interpreted as evidence that she had an experience of movement failure. Nevertheless, experience of movement failure and knowledge of movement failure are conceptually dissociable in both directions. A patient having a bodily experience of movement failure might be sceptical about the veridicality of this experience and might still believe that her arm moved (experience of movement failure without knowledge of movement failure). Equally, a patient who was well informed about her condition but did not have a bodily experience of movement failure might still know that her arm did not move (knowledge of movement failure without experience of movement failure).
Second, a patient who does not have an immediate experience of failing to move the left arm when he tries may have a concurrent belief in successful movement, especially if he experiences an illusory movement of the paralysed limb. The patient may believe that he is at this moment moving his left arm. Conversely, a patient’s belief that he is at this moment moving his arm is naturally interpreted as evidence that he is experiencing an illusory limb movement. Nevertheless, the experience of successful movement and the belief in successful movement are conceptually dissociable in both directions. A well-informed patient experiencing an illusory limb movement might still know that his arm was not really moving (experience of successful movement without belief in successful movement). Equally, a patient with anosognosia might conceivably believe, not only that he can move his left arm, but also that he is actually moving his arm at this very moment, even without an illusory limb movement (belief in successful movement without experience of successful movement).

2. Knowledge: A Threefold Distinction

In this section, we introduce a distinction between three kinds of knowledge that may be lacking in anosognosia for motor impairments. The knowledge of movement failure at the time it occurs, which is normally provided by an immediate experience of trying but failing to raise the left arm, is distinguished from more lasting knowledge of motor impairments themselves, and knowledge of the consequences of motor impairments for everyday activities.

2.1 Concurrent knowledge of movement failure and knowledge of motor impairments

Knowledge of movement failure at the time it occurs may naturally lead to revision of long-held – but now false – beliefs, so that a patient comes to know that she is no longer able to move her left arm. But there is a clear distinction between concurrent knowledge of a movement failure and the relatively stable state of knowing about one’s motor impairment. A patient who sometimes

---

experiences movement failure and concurrently knows that she has failed to move her left arm might not be able to consolidate that information and might not achieve a lasting state of knowledge of her impairment. Equally, a patient who never concurrently knows that he has tried, but failed, to move his left arm may, on the basis of other available evidence, achieve a stable state of knowledge that he can no longer move his left arm.

This distinction is not a merely conceptual one. Marcel and colleagues (2004) assessed concurrent knowledge of movement failure by asking patients to raise each limb with vision precluded and, immediately afterwards, to evaluate their own motor performance. They also assessed knowledge of motor impairments by asking questions such as “Can you move your arms normally?” and “Is either of your arms weak?” (2004, p. 40), without asking patients actually to attempt any movement. More patients “overevaluated” their left-arm motor performance (demonstrating lack of concurrent knowledge about their failure to move the arm with vision precluded) than failed to acknowledge their motor impairment of the left arm (p. 26). In fact, Marcel and colleagues reported a double dissociation between lack of concurrent knowledge of movement failure and lack of knowledge of motor impairments, although the two conditions were highly associated (p. 32).

2.2 Knowledge of motor impairments and knowledge of the consequences

There is also an important distinction between knowledge of motor impairments themselves and knowledge of the consequences of those motor impairments for activities of daily living, such as washing, dressing and eating, and for other everyday tasks, such as tying a knot or carrying a large tray of glasses requiring two hands. Here, we consider the failure to appreciate the consequences of motor impairments as a further failure at the level of knowledge and belief, which can be assessed by asking patients to rate their abilities to perform everyday tasks. For example, in the interview used

---

7 We do not equate this anosognosia for the consequences of motor impairments with the indifference, or lack of concern, for which Babinski (1914/2014) introduced the term “anosodiaphoria” (p. 7): “I have also observed some hemiplegics who, without being unaware of the existence of their paralysis, seemed not to attach any importance to it, as if it were a matter of an insignificant discomfort” (also see Langer, 2009, p. 391).
by Berti and colleagues (1996), the patient is asked to assess his or her ability to perform ten bimanual tasks (e.g. tie a knot, open a bottle), and five unimanual tasks (e.g. eat with a fork) assessed separately for the left and the right hand. Berti and colleagues found a double dissociation between anosognosia for the upper-limb motor impairment itself and anosognosia for the consequences of this motor impairment.

Marcel and colleagues (2004) asked patients questions about activities of daily living (e.g. “In your current state do you have any problems with dressing?”; 2004, p. 40) and about bimanual tasks (e.g. “In your present state how well, compared with your normal ability, can you tie a knot?”; p. 24). While twelve of forty-two patients failed to acknowledge their left-arm motor impairment, many more overestimated their ability to engage in activities of daily living and to carry out everyday bimanual tasks. Twenty-two patients failed to acknowledge their problems with two or more of four activities of daily living and twenty-four overestimated their ability for at least five of eight bimanual tasks. Thus, a substantial number of patients who explicitly acknowledged their motor impairment failed to appreciate the consequences of the impairment; they explicitly overestimated their ability to engage in activities of daily living and to perform everyday bimanual tasks (p. 27). These patients had anosognosia for the consequences of their motor impairment persisting longer than anosognosia for the impairment itself. While Marcel and colleagues did not describe patients with the reverse dissociation, Berti and colleagues (1996) reported two patients with anosognosia for their upper-limb motor impairment itself without anosognosia for the consequences of the impairment (1996, pp. 434–5, patients M.E. and M.A.). We shall return to this reverse dissociation, anosognosia for the impairment itself without anosognosia for the consequences, in Section 6.

---

8 The procedure for assessing anosognosia for the consequences of motor impairments was attributed to a 1994 poster presentation by Marcel and Tégner. Della Sala, Cocchini, Beschlin, and Cameron (2009) have since developed the Visual-Analogue Test for Anosognosia for motor impairment (VATA-m), which assesses anosognosia for the consequences of a motor impairment and provides normative data for diagnosis, as well as being suitable for patients with language impairments.
2.3 The threefold distinction and assessment of anosognosia

Aimola Davies and colleagues (2010, Table 23.4) present an anosognosia interview that is structured in accordance with this threefold distinction. In their assessment of concurrent knowledge of movement failure, the patient is requested, with vision precluded, to raise each arm, and then both arms, to shoulder level and is first asked questions such as, “Did it feel to you as if your arm was rising?” This initial stage of the assessment provides information about the patient’s immediate experience of movement failure, or illusory experience of successful movement, as he or she tried to move the affected limb. If the patient reports an illusory limb movement then the examiner continues with questions such as, “Do you believe that, when it felt as if it [this arm] was moving, it really did move?” (see Table 23.4, Q5, Step 2 ‘Experience’ and Step 3 ‘Post-Performance Evaluation’).

In the assessment of anosognosia for motor impairments, the patient is asked to perform the same actions again – that is, to raise each arm, and then both arms – but now with vision permitted, so that evidence of success or failure is maximally available. The patient is asked to rate his or her ability to perform the action both before (prior belief) and after (posterior belief) each attempt (see Table 23.4, Q6 and Q7). An unrealistic prior belief but a realistic posterior belief is similar to a score of 2 (moderate anosognosia) on the Bisiach Anosognosia Scale; an unrealistic prior belief and posterior belief is similar to a score of 3 (severe anosognosia).

In the assessment of anosognosia for the consequences of motor impairments, patients are asked to rate their ability to carry out everyday tasks, including bimanual tasks such as tying a knot. In some cases, patients are asked to describe how they would perform the task. Patients are asked actually to perform some tasks for which clear evidence of success or failure will be available (e.g. attaching a handkerchief to a ring by tying a knot; using the affected foot to push a ball toward the examiner) and to provide ratings of their ability both before (prior belief) and after (posterior belief) their attempt (see Table 23.4, Q8 and Q9).
3. Delusion: A Two-Factor Explanatory Framework

In this chapter, we conceptualise anosognosia as a delusion, in accordance with the DSM-5 definition: “Delusions are fixed beliefs that are not amenable to change in light of conflicting evidence” (APA, 2013, p. 87). Our strategy (Aimola Davies, Davies, Ogden, Smithson, & White, 2009; Davies, Aimola Davies, & Coltheart, 2005) will be to consider anosognosia within a generic two-factor framework that was offered, in the first instance, as a schema for explanations of monothematic delusions of neuropsychological origin. We begin with a brief account of the two-factor framework for understanding delusions.

3.1 The two-factor framework

A starting point for understanding monothematic delusions is provided by Maher’s (1974, 1992) anomalous experience hypothesis: a delusion arises as a normal response to an anomalous experience. The two-factor theory of delusions (Coltheart, 2007, 2010; Davies & Coltheart, 2000; Davies, Coltheart, Langdon, & Breen, 2001; Langdon & Coltheart, 2000) agrees with Maher that an anomalous experience is one factor in the aetiology of a delusion, and that the anomalous experience arises from a neuropsychological deficit or anomaly (Maher, 1999); but it disagrees with Maher’s implied claim that the anomalous experience is normally sufficient to produce the delusion. According to the two-factor theory, even if the anomalous experience prompts a delusional idea or hypothesis, this idea or hypothesis normally could be, and normatively should be, rejected. So a second departure from normality, an impairment of belief evaluation, is needed to account for the fact that the delusional belief is adopted and maintained despite its implausibility and despite the evidence against it.

The two-factor theory has been applied to a wide range of monothematic delusions such as:

- Capgras delusion – “This [e.g. the patient’s mother] is not my mother. My mother has been replaced by an impostor” (Capgras & Reboul-Lachaux, 1923; Edelstyn & Oyebode, 1999; Ellis & Young, 1990);
- Cotard delusion – “I am dead” (Cotard, 1882; Young & Leafhead, 1996);
• Mirrored-self misidentification – “The person I see in the mirror is not really me” (Breen, Caine, Coltheart, Hendy, & Roberts, 2000; Breen, Caine, & Coltheart, 2001);

• Somatoparaphrenia – “This [body part; e.g. the patient’s left arm] is not mine” (Halligan, Marshall & Wade, 1995; Vallar & Ronchi, 2009); and

• The delusion of alien control – “Someone else is able to control the movements of my body” (Frith, 1992; Stirling, Hellewell & Quraishi, 1998).9

The leading idea of the two-factor theory is that an explanation of a delusion can be achieved by answering two questions (Coltheart, 2007, p. 1044):

Where did the delusion come from? – that is, what is responsible for the content of the delusional belief?

Why does the patient not reject the belief? … – that is, what is responsible for the persistence of the delusional belief?

Each of the two factors provides at least the beginning of an answer to the corresponding question. First, the delusional idea or hypothesis is prompted by an anomalous experience. Because the first-factor anomalous experience prompts the delusional idea or hypothesis, it varies from delusion to delusion; it may also vary between patients with the same delusion. Second, the delusional belief is not rejected because belief evaluation is impaired. There is no obvious requirement that the second-factor impairment of belief evaluation should vary from delusion to delusion. The boldest proposal is that “this impairment is the same in all people with monothematic delusion” (Coltheart, 2005, p. 154).

The strength of the two-factor theory is that, for a wide range of monothematic delusions, there is evidence that an anomalous experience (underpinned by a neuropsychological anomaly) is present in patients with the delusion, and also evidence that it is not sufficient to explain the delusion. Because the first factor is not sufficient by itself, there must be (at least) a second factor (a second departure

---

9 For reviews, see e.g. Aimola Davies & Davies, 2009; Coltheart, 2007, 2010; Coltheart, Langdon, & McKay, 2011; Davies & Egan, 2013; McKay, 2012.
from normality) in the aetiology of delusions. Coltheart (2007, 2010; Coltheart et al., 2011) has suggested that this second factor results from damage to right lateral prefrontal cortex, but a weakness of the two-factor theory has been the relatively underdeveloped characterisation of the cognitive nature of the second factor. It has proved difficult to move beyond the truistic point that the second factor is an impairment of cognitive processes on which belief evaluation depends.

3.2 The cognitive nature of the second factor in delusions

A proposal about belief formation made by Stone and Young (1997) provides a starting point for further reflection on the cognitive nature of the second factor in delusions:

The belief formation system contains within it a permanent tension between two principles that can come into conflict: a tension between forming beliefs that require little readjustment to the web of belief (conservatism) and forming beliefs that do justice to the deliverances of one’s perceptual systems [observational adequacy]. (p. 349)

A balance needs to be struck between these two cognitive imperatives: conservatism, that is, minimising adjustment of the pre-existing web of belief, and observational adequacy, that is, doing justice to one’s own perceptual experience. In delusions, the balance tips too far toward observational adequacy, at the expense of conservatism.10 The delusional hypothesis may have arisen as an urgently needed explanation of an anomalous experience. But the imperative to do justice to one’s own perceptual experience needs to be inhibited, so that account can be taken of more conservative considerations of plausibility given one’s existing web of background knowledge and beliefs.

The belief evaluation that would allow a patient to reject a delusion seems to require two kinds of resources. First, it requires taking control of the balance between competing cognitive imperatives; it requires “suspending automatic biases in order to critically evaluate different hypotheses, ‘re-

10 The Bayesian analogue of the balance tipping too far toward observational adequacy is giving too much weight to likelihoods at the expense of prior probabilities (Davies & Egan, 2013; McKay, 2012). The predictive coding analogue of the balance tipping too far toward observational adequacy is giving too much weight to prediction errors at the expense of prior beliefs, understood as internal predictive models of the world (Fotopoulou, 2012, 2014).
initialized’ as having equal priority” (Langdon & Coltheart, 2000, p. 204). Second, belief evaluation requires assessing hypotheses in the light of evidence and plausibility – weighing up evidence and plausibility considerations and working out what to believe. This weighing up and working out should take account of the anomalous experience, a mass of other recent evidence, the patient’s pre-existing background knowledge and beliefs, and other knowledge available from family, friends, and medical staff.

Thus, on general theoretical grounds, it is plausible that the belief evaluation that would allow a patient to reject a delusion requires executive processes, including some inhibitory processes, and also working memory resources for the maintenance and manipulation of information. In short, belief evaluation seems to be a good example of an executive working memory task (Engle, 2002; see also Smith & Kosslyn, 2007, p. 259: “The central executive is what does the ‘work’ in working memory.”). It is for this reason that we propose that the second factor in the two-factor framework for understanding delusions may involve impairments of executive function or working memory (Aimola Davies & Davies, 2009).

4. Explaining Anosognosia as a Delusion

Anosognosia for motor impairments, especially in its severe form, fits the DSM-5 definition of delusions as “fixed beliefs that are not amenable to change in light of conflicting evidence” (APA, 2013, p. 87). However, there is an important difference between anosognosia and other monothematic delusions such as Capgras delusion, Cotard delusion, mirrored-self misidentification, somatoparaphrenia, and the delusion of alien control. In those familiar examples of monothematic delusion, the delusional belief is newly adopted and somewhat exotic but, in anosognosia, the delusional belief is long held and commonplace. Patients with anosognosia have believed for many decades that they can move their left arm, and that they can tie a knot or carry a large tray of glasses. Following a right-hemispheric stroke, however, these beliefs are no longer true.
Anosognosia for motor impairments is a continued-belief delusion; Capgras delusion and the other examples are, in contrast, new-belief delusions. Anosognosia is not the only continued-belief delusion; another example is “a delusional belief in the fidelity of a romantic partner” (reverse Othello syndrome; Butler, 2000, p. 85). In cases of continued-belief delusion, reality has changed in a way that would normally lead to substantial revisions to long-held beliefs but, instead, the beliefs persist.11

When we say that we conceptualise anosognosia as a delusion, our point is not that anosognosia is sometimes accompanied by new-belief delusions such as somatoparaphrenia – although that is true (Moro et al., 2016). Our point is that the core belief in anosognosia, “I can move my left arm”, is itself a delusion – a continued-belief delusion rather than a new-belief delusion.

4.1 Anosognosia in the two-factor framework

The difference between anosognosia and more familiar monothematic delusions poses a potential problem for our project of considering anosognosia in the two-factor framework for understanding delusions. In the case of anosognosia, Coltheart’s first question, “Where did the delusion come from?”, simply does not arise and only the second question needs to be answered. Nevertheless, it turns out to be theoretically illuminating to answer the second question about anosognosia – “Why does the patient not reject the belief, ‘I can move my left arm’?” – by appeal to two factors: an anomaly of experience and an impairment that prevents the patient from carrying out the task of belief evaluation.

Consider a case of Capgras delusion and two other cases, one a case of hemiplegia without anosognosia for motor impairments and the other a case of hemiplegia with anosognosia for motor impairments. The Capgras patient has set aside an old, commonplace, and still true belief (“The

11 The distinction between new-belief delusions and continued-belief delusions does not coincide with the distinction between bizarre and nonbizarre delusions. According to DSM-5, “Delusions are deemed bizarre if they are clearly implausible and not understandable to same-culture peers and do not derive from ordinary life experiences” (APA, 2013, p. 87). Many familiar examples of monothematic delusion are bizarre, whereas anosognosia is not a bizarre delusion. Indeed, the belief that one can move one’s left arm is a good deal more ordinary even than DSM-5’s example of a nonbizarre delusion: “the belief that one is under surveillance by the police, despite a lack of convincing evidence” (ibid.). But, unlike anosognosia, this example of a nonbizarre delusion is a new-belief delusion. Another example of a nonbizarre new-belief delusion would be delusional jealousy (Othello syndrome).
Anosognosia as a Delusion

A woman who looks just like my mother and says that she is my mother is, indeed, my mother”) and has adopted a new, exotic, and false belief (“My mother has been replaced by an impostor”). The patient has adopted this new belief in response to an anomalous experience when looking at the woman who is, in fact, her mother. Consider now the two cases of hemiplegia. The patient with hemiplegia but without anosognosia has replaced an old, commonplace, but now false belief (“I can move my left arm”) with a new, unwelcome, but true belief (“I cannot move my left arm”). The patient has adopted this new belief in response to an immediate experience of movement failure when trying to move the left arm (Section 1.1). In contrast, in the case of hemiplegia with anosognosia, because of additional impairments of the motor control system, the patient does not have an immediate experience of movement failure (Section 1.2). As a result of this anomalous absence of experience, his old, commonplace, but now false belief has not been immediately rejected and a new, true belief has not been adopted.

Both the Capgras patient and the anosognosia patient have made errors of belief adoption and, in both cases, the error is the result of an anomaly of experience – an anomalous experience, in one case, and an anomalous absence of experience, in the other. The Capgras patient has made an error of commission – adopting a new and false belief about her mother although reality has not changed (her mother has not been replaced by an impostor). The anosognosia patient has made an error of omission – failing to reject an old and false belief and adopt a new and true belief about his motor abilities although reality has changed (his motor abilities are now severely impaired).

4.2 Candidate first factors in anosognosia for motor impairments

When anosognosia for motor impairments is considered in the two-factor framework, a leading candidate for the first-factor role is an anomalous absence of immediate experience of movement failure – perhaps accompanied by illusory experience of successful movement. As described earlier (Section 1.2), this anomalous absence of experience in anosognosia arises from one or another of
several possible impairments of the motor control system – a motor intention deficit, impaired proprioceptive feedback, damage to, or abnormal functioning of, the comparator.

Two other candidate first factors are proprioceptive loss (now considered independently of the motor control system) and unilateral visuospatial neglect (unilateral neglect). Proprioceptive loss – long considered a possible factor in the aetiology of anosognosia (Babinski, 1914, 1918; Levine, 1990; Levine et al., 1991) – could give rise to an anomaly of experience that would make an independent contribution to the aetiology of anosognosia. Consider a patient who did not have immediate bodily experience of movement failure, because no prediction error signal was generated in the motor control system. But suppose that the patient’s proprioception was intact. Such a patient could still have conscious bodily experiences of the position of her left arm, immobile at her side. Proprioceptive loss would block this experiential route to knowledge of her motor impairment.

In a similar way, a left-side attentional deficit – unilateral neglect – would obstruct the route to knowledge of motor impairments that is provided by a patient’s visual experience of her paralysed limbs. Vuilleumier (2004, p. 10) describes unilateral neglect as “a notable suspect in anosognosia” and anosognosia persisting more than three months after stroke is almost invariably accompanied by unilateral neglect (e.g. Aimola Davies et al., 2009; Cocchini, Beschin, & Della Sala, 2002). Interestingly, in the study by Vocat and colleagues (2010), patients with both severe proprioceptive loss and severe unilateral neglect in the first twelve days following a right-hemispheric stroke were found to be significantly more likely to have anosognosia than patients with only one or neither of those two deficits.

Among candidate first factors, we also include memory impairments that are specific to information about the movements or locations of parts of the patient’s body. Patients with a specific memory impairment of this kind might have immediate bodily experience of movement failure, and perhaps also fleeting concurrent knowledge of movement failure, but might be unable to consolidate this information into more lasting knowledge of their motor impairments (House & Hodges, 1988). In
Anosognosia as a Delusion

terms of its effects on lasting knowledge, a specific memory impairment of this kind would be functionally similar to an anomalous absence of experience of movement failure.\textsuperscript{12}

4.3 Arguments for a second factor in anosognosia for motor impairments

In the case of anosognosia, as with new-belief delusions, there are arguments in favour of the claim that the first factor is not normally sufficient to explain the delusion, so that there must be a second factor.

First, there is an empirical argument. There are patients who have the leading candidate first factor – absence of experience of movement failure, or even illusory experience of successful movement – but do not have anosognosia. For example, patient EM (Chatterjee & Mennemeier, 1996) was asked, “Can you raise both arms? ... Can you raise the left one?” and responded: “It feels like it’s rising, but, it’s not” (p. 229).

Second, there is a more theoretical argument for a second factor. Even without immediate experience of movement failure, other evidence of motor impairments is available:

[I]t is not just that they fail \textit{motorically}. The consequence of such failures is that, in trying to get out of bed to go to the toilet or to lift an object, they fall over or incur a similar accident, often lying helpless or hurting themselves. Unless such patients have some other problem, it is unlikely that they are unaware of these incidents (even if they are unaware of the reason

\textsuperscript{12} Some support for this suggestion is provided by a study of epilepsy patients undergoing the Wada test (intracarotid sodium amobarbital procedure, ISAP) in preparation for temporal-lobe surgery (Carpenter, Berti, Oxbury, Molyneux, Bisiach, & Oxbury, 1995). During the Wada test, patients receive a barbiturate injection, leading to weakness on the side of the body opposite to the injection. Nine patients were questioned about their left-arm weakness during the first three minutes following a right-side barbiturate injection while the effects of the barbiturate were still present (early questioning), and again about fifteen minutes after the injection when the effects had resolved (later questioning). Five of these nine patients denied their left-arm weakness early, and also later. Importantly for our purposes, three of the four patients who acknowledged their left-arm paralysis early, at the time when it occurred, failed to recall it when questioned later, even though the barbiturate did not induce more general memory impairments in these patients. Carpenter and colleagues conclude (p. 249): “[I]n some patients, failure to recall left arm weakness can be attributed to unawareness at the time. In others it seems to be due to a specific memory deficit.”
for them), or that they rapidly forget them, or that they hallucinate the success of the intended action (as opposed to the movement). (Marcel et al., 2004, p. 35)

Patients with AHP [anosognosia for hemiplegia] do not express mere uncertainty regarding the perception of sensations or movement from the left limbs, nor do they just complain of movement illusions. They instead ignore the wealth of evidence that they are paralysed (e.g. their disabilities, occasional accidents, others’ feedback) and adhere to the ‘delusional’ belief that they have functional limbs. The explanation of the latter belief ... requires the postulation of another dysfunction. (Besharati, Forkel, Kopelman, Solms, Jenkinson, & Fotopoulou (2016, p. 982)

So – even without immediate experience of movement failure – patients normally would, and normatively should, come to reject the long-held belief that they can move their left limbs. There must be a second factor that explains why anosognosia patients are unable to make appropriate use of this evidence – including evidence from everyday mishaps consequent on the motor impairment (e.g. the glasses – on the tray that they were carrying – are now on the floor).

**4.4 Candidate second factors in anosognosia for motor impairments**

In principle, there could be at least four kinds of case in which a patient who did not have immediate experience of movement failure might also be unable to make use of other evidence to achieve realistic beliefs about his or her motor impairments.

**Option 0. No relevant evidence:** There might not be any relevant evidence for the patient to use. This might be the situation of a patient, perhaps sedated, lying in bed and not trying to engage in any everyday activities. Having mentioned this kind of case, we set it aside. If such a case of anosognosia were possible then it would not fit the definition of delusion and the two-factor theory would not obviously be applicable.

**Option 1. Unable to remember the evidence:** There might be relevant evidence available, but the patient might be unable to remember it for long enough to make use of it.
Option 2. Unable to recognise that the evidence calls for evaluation of current beliefs:

There might be relevant evidence available and remembered by the patient. But the patient might be unable to recognise that the evidence provides a reason to evaluate current beliefs.

Option 3. Unable to carry out the task of belief evaluation: There might be relevant evidence available and remembered, and the patient might recognise that the evidence provides a reason to evaluate current beliefs. But the patient might be unable to carry out the cognitively demanding task of belief evaluation.

Option 1 highlights the fact that a general memory impairment is a candidate second factor in anosognosia. Such an impairment could help explain why a patient is unable to use evidence and clues of many kinds to reject old beliefs that are now false and to adopt new beliefs that are more realistic.\textsuperscript{13} Patient NS is a good example of such a case, in which anosognosia for motor impairments persisted a year after a severe closed head injury (Cocchini et al., 2002). Patient NS had left-side paralysis and unilateral neglect, and he also suffered from “anterograde amnesia for self-related information ... he regularly failed to recall what he was doing or whom he had met a few minutes earlier” (p. 2031).

Because of his unilateral neglect (a first factor) and associated allochiric movements,\textsuperscript{14} patient NS did not have immediate experience of motoric failure unless his left limbs were repositioned on the right side of space and he attempted to move them. Even when Patient NS did momentarily acknowledge his hemiplegia, the anterograde memory impairment meant that he was unable to retain this information for long enough to achieve more realistic beliefs about his changed circumstances. He continued to believe that he could move his left limbs, that he could go surfing, and that he could

\textsuperscript{13} Vocat and colleagues (2010) found that, in the second week after stroke, anosognosia was significantly associated with memory impairment (assessed by a simple three-word recall task) (see p. 3587, Table 1).

\textsuperscript{14} Patient NS moved his right limbs when asked to move his left limbs – allochiric movements (Cocchini et al., 2002, p. 2036). When he was asked to move the left limb, a motor command was issued for the right limb, which did, indeed, move, so that there was no mismatch between the predicted and the actual state, and no prediction error signal was generated.
jump out of the car to buy a newspaper. (We shall provide a substantive account of Option 2 in Section 5.1.)

Our own proposal, in line with Option 3, is that at least some patients may have difficulty with the cognitively demanding task of belief evaluation. Although anosognosia is a continued-belief delusion, the anosognosia patient’s belief evaluation task is similar in outline to the task for a patient with a new-belief delusion (Section 3.2). It requires taking control of the balance between cognitive imperatives of conservatism and observational adequacy. Specifically, the imperative to do justice to pre-existing background knowledge and beliefs needs to be inhibited, so that account can be taken of new evidence.\(^\text{15}\)

Belief evaluation requires assessment of hypotheses in the light of plausibility and evidence – evidence that may not all point in the same direction, especially if the patient experiences illusory limb movements. It requires weighing up these competing considerations and working out what to believe. Crosson and colleagues (Crosson et al., 1989) point out that the transition, from concrete pieces of evidence about specific difficulties in particular situations, to a more abstract and general belief about having a motor impairment, may present an additional challenge. The patient needs to recognise “some common thread in the activities with which [he] has trouble” (1989, p. 47).

Thus, we propose that the second factor in anosognosia for motor impairments (as in new-belief delusions) may involve impairments of executive function or working memory (Aimola Davies et al., 2009). Support for this proposal comes from our study of patients with unilateral neglect persisting at least three months following stroke (Aimola, 1999; Maguire & Ogden, 2002), of whom five (3 to 22 months post-stroke) had anosognosia for their motor impairments and four (4 to 14 months post-stroke) did not. A detailed neuropsychological assessment of all nine patients was conducted, followed by a statistical investigation of the seven patients with results on all the neuropsychological

\(^{15}\) The Bayesian analogue of the balance tipping too far toward conservatism is giving too much weight to prior probabilities at the expense of likelihoods. The predictive coding analogue of the balance tipping too far toward conservatism is giving too much weight to prior beliefs at the expense of prediction errors (Fotopoulou, 2012, 2014).
tests for which the score was the number of correct responses out of a fixed total. Thus, the statistical analysis included seven patients (four with anosognosia and three without) and fifteen scores from neuropsychological tests of visuoperceptual function, sustained attention, memory, executive function, and working memory. In brief, the statistical analysis demonstrated that only three (of fifteen) test scores were significantly predicted by the overall anosognosia scores for upper and lower limbs. One was the Elevator Counting with Distraction subtest of the Test of Everyday Attention (Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994). This subtest is described by the authors as a test of working memory, but it also has a clear inhibitory component. The other two test scores were Categories Achieved and Perseverative Errors from the computerised version of the Wisconsin Card Sorting Test (WCST), which was administered using standardised instructions (Heaton, Chelune, Talley, Kay, & Curtiss, 1993). The WCST is a demanding test of executive function, involving set-shifting, complex working memory operations, error detection, and feedback utilisation (Lie, Specht, Marshall, & Fink, 2006). For an account of the neuropsychological assessment that includes the statistical analysis, see Aimola Davies and colleagues (2009).

5. The Two-Factor Framework and the ABC Model of Anosognosia

In the two-factor framework for understanding anosognosia as a delusion, the first factor is an anomalous absence of immediate experience of movement failure, which prevents the patient from gaining knowledge of movement failure when it occurs. Alternative experiential routes to concurrent knowledge of movement failure (and, thence, to more lasting knowledge of motor impairments) may be blocked by proprioceptive loss or unilateral neglect (Section 4.2). There are empirical and theoretical arguments for the claim that the first factor is not sufficient, by itself, to account for

---

16 In a mathematical model of the WCST (Bishara, Kruschke, Stout, Bechara, McCabe, & Busemeyer, 2010), one of the parameters, sensitivity to punishment, controls the rate at which beliefs about the current card sorting rule are updated in response to negative feedback. Gläscher, Adolphs and Tranel (2019) conducted a model-based lesion-mapping study of 328 patients with focal brain damage. They found that lower values of the sensitivity to punishment model parameter were associated with elevated Perseverative Errors scores on the WCST and with lesions “located primarily in the right PFC [prefrontal cortex] reaching from dorsolateral PFC to the frontal pole and mostly focused in the underlying white matter” (2019, p. 5).
anosognosia (Section 4.3). A second factor must explain why patients are unable to make appropriate use of available evidence to achieve knowledge of their true condition. The boldest conjecture about the second factor is that it is the same in all cases of delusion, but the two-factor framework allows that the second factor may vary, and we have mentioned impairments of anterograde memory, executive function, or working memory as candidate second factors in anosognosia (Section 4.4).

The two-factor framework is similar in structure to Levine’s (1990; Levine et al., 1991) discovery theory of anosognosia (for discussion, see Davies et al., 2005). According to Levine, proprioceptive loss prevents the patient from having immediate knowledge of whether the affected limb is moving, but discovery of paralysis would still be straightforward for cognitively healthy individuals. Thus, Levine proposed that patients with motor impairments who suffered a proprioceptive loss (a first factor) would have anosognosia for their motor impairments only if they also had a second factor, “cognitive defects impairing the ability to observe and to infer” (1990, p. 254). The structure that is shared by the two-factor framework and the discovery theory is well described by Vuilleumier (2004, p. 11) “[A]ny neurological dysfunction susceptible to alter the phenomenal experience of a defect might provide the ground out of which anosognosia can develop when permissive cognitive factors are also present.”

Vuilleumier’s ABC (Appreciation, Belief, Check) model of anosognosia (Vocat, Saj, & Vuilleumier, 2013; Vocat & Vuilleumier, 2010; Vuilleumier, 2004; Vuilleumier, Vocat, & Saj, 2013) conforms to the same structure. Understood as the (A + BC) model, it offers a two-factor account of anosognosia. Impaired Appreciation operations (e.g. impairments of the motor control system, proprioceptive loss, or unilateral neglect) alter the patient’s conscious experience and prevent the patient from gaining “direct first-person knowledge” about his or her motor impairments (Vuilleumier, 2004, p. 15). But impaired Appreciation operations are not sufficient to explain anosognosia and so additional impairments are required. These are grouped under the Belief and Check headings and can be summarised as “an inability to question beliefs or knowledge [Belief] ... or an inability to trigger
reactions of doubt or verification in case of uncertainty [Check]” (Vuilleumier et al., 2013, pp. 204–5).

5.1 Belief updating in anosognosia for motor impairments

Vocat, Saj and Vuilleumier (2013) investigated belief updating in anosognosia for motor impairments, testing patients in the second week after a right-hemispheric stroke – four patients with anosognosia and five without – and healthy control participants. They used a riddle task that required the participant to guess ten target words (AIRPLANE, TOOTH, CARROT, KEY, COW, HEART, SHADOW, GARDEN, MATCHES, BROOM). For each word, five successively more informative clues were offered and participants were asked to guess the word, and to indicate their level of confidence, after each clue. Neither the target words nor the clues were related to motor abilities or impairments.

The first clue allowed many possible answers and was sufficiently uninformative to create doubt in healthy participants. For example, the first clue for the target word HEART was “My weight is approximately 300 grams”. The fifth clue was intended to leave no doubt about the correct answer; for example, “Lovers often draw me” for HEART. Anosognosia patients were no less able than participants in the other two groups to solve the riddle by giving the correct response after the fifth clue. However, patients with anosognosia gave significantly higher confidence ratings than other participants after the first three clues. Thus, it appeared “as if the anosognosics could not experience ‘doubt’ anymore” (Vocat et al., 2013, p. 1777). In the terms that we have used earlier (Section 3.2), it seemed that the patients with anosognosia could not suspend or inhibit judgement and consider their first guess as a hypothesis having only “equal priority [with other] possible hypotheses” (Langdon & Coltheart, 2000, p. 206).

17 The two-factor structure is also evident in a recent structural neuroimaging study (Pacella et al., 2019): “We thus postulate that deficits in motor monitoring [first factor], associated with a compromised premotor network, need to be combined with other salience and belief updating deficits [second factor], collectively leading to a multifaceted syndrome in which premorbid beliefs and emotions about the non-paralysed self dominate current cognition about the paralysed body” (p. 6).
Most interestingly, given the character of anosognosia as a continued-belief delusion, the patients with anosognosia showed clear evidence of failure to update their beliefs. They were significantly more likely than the other two groups – indeed, more than twice as likely – to produce the same incorrect guess to two consecutive clues in the same riddle. Vocat and colleagues (2013) proposed that the anosognosia patients’ impairment of belief updating resulted from a problem with error detection – in this case, detection of mismatch or incongruence between the presented clue (evidence) and the patient’s guess (current belief). The anosognosia patients “required a repeated signal of errors, or a larger incongruence between a new clue and the previous guess, in order to prompt a re-appraisal of their preceding responses and to trigger a new solution” (p. 1778).

This proposed connection between impaired belief updating and a difficulty in detecting mismatch, incongruence or error fits well with recent formulations of the ABC model in which first factors (A) disrupt “direct appreciation of motor losses” and second factors (BC) damage “the capacity to monitor and detect error in performance” (Vuilleumier et al., 2013, p. 208). Hence, Vocat and colleagues (2013) suggest: “anosognosics might be unable to change their past beliefs ... simply because they have no grounds to do so at both the sensory-motor and [cognitive]-affective-motivational levels” (p. 1778; emphasis added).

If Vocat and colleagues’ (2013) suggestion is correct, it makes a difference to our understanding of the second factor in the two-factor framework. Earlier in this chapter (at the beginning of Section 4.4), we considered ways in which a patient with a first factor (absence of immediate experience of movement failure) might also be unable to make use of available evidence (including evidence from everyday mishaps) to achieve realistic beliefs about his or her motor impairments. The patient might be unable to remember the evidence for long enough to make use of it (option 1), unable to recognise that the evidence calls for evaluation of current beliefs (option 2), or unable to carry out the cognitively demanding task of belief evaluation (option 3). We discussed impairments of anterograde memory (Cocchini et al., 2002), executive function or working memory (Aimola, 1999; Maguire & Ogden, 2002) as candidate second factors in line with options 1 and 3.
We can now add impaired error detection as a candidate second factor in line with option 2. We can also provide a fuller account of option 2 and some further articulation of option 3. (*Italics* indicate changes from the earlier versions of options 2 and 3.) Option 1 remains unchanged, but for convenience it is repeated here.

**Option 1. Unable to remember the evidence:** There might be relevant evidence available, but the patient might be unable to remember it for long enough to make use of it.

**Option 2. Unable to recognise that the evidence calls for evaluation of current beliefs:** There might be relevant evidence available and remembered by the patient. But the patient might be unable to recognise that the evidence provides a reason to evaluate current beliefs because the patient does not recognise that the evidence is incongruent with current beliefs.

**Option 3. Unable to carry out the task of belief evaluation:** There might be relevant evidence available and remembered, and the patient might recognise that the evidence provides a reason to evaluate current beliefs because the patient recognises that the evidence is incongruent with current beliefs. But the patient might be unable to carry out the cognitively demanding task of belief evaluation.

### 5.2 Impaired error detection and reality monitoring: Further evidence

Contemporary theories of anosognosia for motor impairments appeal to a domain-specific failure of error detection. A comparator within the motor control system fails to detect a substantial disparity between predicted and actual feedback from the left arm and fails to generate a (conscious) prediction error signal. As a result, the patient has no immediate experience of movement failure (Section 1.2). Vocat and colleagues’ (2013) results using the riddle task, with materials that were not related to motor abilities or impairments, suggest a more general problem with detection of mismatch or error. Is there evidence to support the proposal that an impairment of error detection – extending beyond motor control for the paralysed limbs – might play a second-factor role in the explanation of anosognosia? Several studies have suggested that this problem with detection of mismatch or error
extends to actions performed using the unimpaired limbs (Ramachandran, 1995; Preston, Jenkinson, & Newport, 2010; Saj, Vocat, & Vuilleumier, 2014; Jenkinson, Edelstyn, Drakeford, & Ellis, 2009, Experiment 2), while the results of another experiment by Jenkinson et al. (2009, Experiment 1) suggested that the problem extends even beyond the domain of movement and action.

Patient FD (Ramachandran, 1995) experienced illusory movements of her paralysed left arm. When asked to point to the examiner’s nose with her left hand, she said that she could clearly see her hand pointing: “it is about two inches from your nose” (p. 32). Ramachandran investigated error detection related to patient FD’s unimpaired right hand by using a mirror box to provide false visual feedback. Patient FD placed her right hand in the box and moved it up and down. Vision of her right hand was precluded by a mirror, in which she viewed the reflection of a stationary (left) hand positioned so as to appear to be a (right) hand at the location of her moving right hand. Patient FD apparently failed to detect the disparity between the predicted and actual visual feedback; that is, movement of the felt hand versus no movement of the seen hand. She reported that “she could clearly see the hand move up and down” (p. 33).

A different visuomotor error detection paradigm (cf. Fourneret & Jeannerod, 1998; Nielsen, 1963) was used by Preston et al. (2010). Subjects reached with their unimpaired right hand toward target locations directly in front of them. False visual feedback introduced an angular perturbation (leftward or rightward in the horizontal plane) from the hand’s actual movement. An anosognosia patient, GG, failed to detect disparities of up to 20 degrees between the false visual feedback and the actual trajectory of his unimpaired right hand movement (while healthy control participants easily detected disparities of 8 degrees).

Saj and colleagues (2014) also investigated “whether self-monitoring deficits for movements in patients with [anosognosia for motor impairments] are selective for the affected limb” (p. 95). In the first (encoding) phase of the experiment, five patients with, and five without, anosognosia and five healthy control participants were instructed either to perform or to imagine actions (e.g. rub shoulder, wave goodbye) using either the left or the right arm (twenty actions in total, five in each of four
conditions). In the second (recognition) phase (when five new actions were included), participants were asked, for each of the twenty-five actions, whether it was new, or had been successfully executed, only attempted, or imagined, and which arm had been used. The performance of the patients with motor impairments following a right-hemispheric stroke, but without anosognosia, was essentially the same as that of the healthy control participants, save that the patients without anosognosia acknowledged their failure to execute actions with the left arm. In contrast, patients with anosognosia never classified actions as having been only attempted. They classified actions attempted or imagined using the left arm—and even some executed using the right arm—as having been executed using the left arm (thirteen of twenty-five actions on average). They also classified some actions imagined using the right arm as having been executed. Saj and colleagues concluded:

Patients with [anosognosia for their motor impairments] ... often misattributed movements previously executed with the right arm to the left arm, and generally showed greater confusion between executed and imagined for both sides, rather than strictly unilateral deficits concerning the left arm. (p. 103)

These results built on an earlier study of reality monitoring for actions by Jenkinson and colleagues (2009, Experiment 2). In the first (acquisition) phase of their experiment, three patients with anosognosia were presented with short phrases for actions that were to be performed, imagined, or observed (twenty action phrases in each of three conditions). In the second (test) phase (when twenty new actions were included), they made source attributions: performed, imagined, observed, or new. The anosognosia patients’ source attribution performance was significantly less good than patients without anosognosia and healthy volunteers.

---

18 Jenkinson and colleagues (2009) distinguish (a) reality monitoring, which is discrimination between remembered information that had an internal origin and remembered information that had an external origin, from (b) reality testing, which is online discrimination between information with an internal origin and information with an external origin.
Patients with anosognosia fail to distinguish between internally represented and externally perceived movements of their limbs – both the impaired and the unimpaired limbs. Is there evidence to support the proposal that impaired detection of mismatch or error extends even beyond the domain of movement and action. Jenkinson and colleagues (2009, Experiment 1) investigated whether patients with anosognosia are impaired in distinguishing between imagined (internally represented) and externally perceived visual stimuli that are unrelated to limb movement. In the acquisition phase, ten anosognosia patients were presented with words for visual objects and, immediately after each word, either perceived or imagined a drawing of the corresponding object (twenty words in each of two conditions). In the test phase, patients were presented with the same words (along with twenty new words) and made a source attribution: perceived, imagined, or new. Anosognosia patients reported imagined visual stimuli as having been perceived and their source attribution performance was significantly less good than patients without anosognosia and healthy volunteers. (The latter two groups did not differ significantly.)

Taken together, these experimental studies provide evidence that, in patients with anosognosia, impairments of error detection and reality monitoring extend to actions performed using unimpaired limbs, and even to domains beyond movement and action. This might indicate “a more global deficit for motor awareness” (Preston et al., 2010, p. 3449), “more global monitoring difficulties” (Saj et al., 2014, p. 103), “a breakdown of reality monitoring processes for information not directly related to movement” (Jenkinson et al., 2009, p. 468), or even damage to a domain-general “anomaly detector” (Ramachandran, 1995, p. 39).

A difficulty in detecting disparities between what is internally represented – intended, imagined, or antecedently believed – and external reality could contribute to a patient’s inability to make appropriate use of available evidence to achieve realistic beliefs about his or her motor impairments. It might also help to explain the performance of some patients with anosognosia in Berti and colleagues’ (1996) study. Patients were asked to assess their potential ability to perform bimanual tasks, such as opening a bottle or a jam tin, and were then asked actually to perform the tasks. Some
patients not only claimed, hypothetically, that they would be able to perform these tasks well, but also gave themselves high scores after attempting the action with real objects – despite the fact that an unopened bottle or jam tin would provide clear evidence of failure (see Berti et al., 1996, p. 435, Table 6).  

6. Conclusion

Anosognosia for motor impairments fits the DSM-5 definition of delusions as “fixed beliefs that are not amenable to change in light of conflicting evidence” (APA, 2013, p. 87). In this chapter, we have considered anosognosia in the two-factor framework for understanding delusions. Anosognosia is a continued-belief delusion, rather than a new-belief delusion, and the first factor in its aetiology is not an anomalous experience but the anomalous absence of immediate bodily experience of movement failure. Patients with motor impairments, but without immediate experience of their movement failure, could – if they had no additional impairments – readily use other available evidence to achieve knowledge of their true condition. So there must be at least a second factor in the aetiology of anosognosia. There must be additional impairments that prevent anosognosia patients from making appropriate use of available evidence.

We agree with Cocchini and colleagues (2002) that some patients might be unable to make appropriate use of available evidence because of a general memory impairment (option 1). And we agree with Vocat and colleagues (2013) that some patients might have evidence available and remembered, but might still be unable to recognise the incongruence between the evidence and their current beliefs because of an error detection impairment (option 2). We, ourselves, propose that

---

19 Fotopoulou (2014, pp. 13–14) describes several ways in which failures of error detection and belief updating might be explained in a predictive coding framework. (i) Updating of prior beliefs (learning) is driven by prediction error signals and, following brain injury, some prediction error signals might be weakened or absent. (ii) The learning process itself might be affected by brain injury. (iii) When prior beliefs are updated, less weight is attached to prediction error signals that are expected to be noisy (low precision). Impaired expectations about precision might result in ‘suboptimal gain’ being applied to prediction error signals. (iv) The effects of brain injury might be exacerbated by individual differences in the pre-morbid balance between prediction errors and prior beliefs: “the weakening of prediction errors ... may have particularly strong effects in a brain system that pre-morbidly requires large and sustained prediction errors to update its priors” (p. 14).
some patients might have evidence available and remembered, and might recognise the incongruence between the evidence and their current beliefs. But some of these patients might still be unable to carry out the cognitively demanding task of belief evaluation because of impairments of executive function or working memory (option 3).

Patients with no general memory impairment and no error detection impairment might use the evidence from everyday mishaps to reject the current beliefs with which the evidence is most obviously incongruent. They might adopt new and more realistic beliefs about activities of daily living, such as washing, dressing and eating, and about other everyday tasks, such as tying a knot or carrying a large tray of glasses. In short, they might overcome their anosognosia for the consequences of their motor impairment – but, crucially, they would still have anosognosia for the motor impairment itself. (See Section 2.2. for the double dissociation between anosognosia for the impairment itself and anosognosia for the consequences of the impairment.) So the patients would still need to evaluate and reject the core belief in anosognosia for a motor impairment. Belief evaluation is a cognitively demanding task (Sections 3.2. and 4.4) and there are particular challenges in the case of anosognosia.

As Crosson and colleagues (1989) observe, it is not a straightforward matter to proceed from evidence about specific mishaps in particular situations (e.g. getting dressed, tying a knot, carrying a large tray of glasses) to the new general belief, “I cannot move my left arm” (Section 4.4). The task would be even less straightforward if illusory experiences of successful movement were to provide (misleading) evidence in support of the to-be-rejected belief. Thus, some patients with impairments of executive function or working memory might still fail to achieve full knowledge of their true condition.

Support for our proposal comes from a neuropsychological study of patients with unilateral neglect persisting at least three months following stroke, five of whom also had chronic anosognosia for motor impairments persisting for up to 22 months post-stroke (Aimola Davies et al., 2009; Maguire & Ogden, 2002). Chronic anosognosia for motor impairments is rare, but even if one takes account of studies of anosognosia for motor impairments at earlier time points following stroke, relatively few studies include a full neuropsychological investigation. By revealing both strengths and deficits in the
areas of orientation, attention and working memory, sensation and perception, memory and learning, concept formation, reasoning and executive function, there is the possibility of developing individual neuropsychological profiles of series of cases of anosognosia. We might hope that these neuropsychological profiles would shed light on the patterns of co-occurrence of cognitive impairments of memory, error detection, executive function and working memory, with anosognosia for motor impairments.
Anosognosia as a Delusion

References


Anosognosia as a Delusion


Anosognosia as a Delusion


