Spatial Perspective and Coordinate Systems in Autoscopy: A Case Report of a "Fantome de Profil" in Occipital Brain Damage

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Abstract

■ Autoscopic phenomena refer to complex experiences involving the illusory reduplication of one's own body. Here we report the third long-lasting case of autoscopy in a patient with right occipital lesion. Instead of the commonly reported frontal mirror view (fantôme spéculaire), the patient saw her head and upper trunk laterally in side view (fantôme de profil). We found that the visual appearance and completeness of the autoscopic image could be selectively modulated by active and passive movements, without being influenced by imagining the same movements or by tactile and auditory stimulation. Eyes closure did not disrupt either the perception of the autoscopic body or the effects of the motor stimulation. Moreover, the visual body reduplication was coded neither in purely eye-centered nor in head-centered frames of reference, suggesting the involvement of egocentric coordinate systems (eyes and head centered). A follow-up examination highlighted the stability of the visual characteristics of the body reduplication and its shift induced by displacement of both head and eyes. These findings support the view that autoscopic phenomena have a multisensory motor origin and proprioceptive signals may play an important role in modulating the illusory visual reduplication of the patient's own body, most likely via cross-modal modulation of extrastriate areas involved in body and face perception. ■

INTRODUCTION

Autoscopic phenomena (AP) encompass a range of perceptual experiences involving the illusory reduplication of one's own face or body in the extrapersonal space. Three main forms of AP have been identified in neurological patients (Blanke & Mohr, 2005; Brugger, 2002): out-of-body experience (OBE), autoscopic hallucination (AH), and heautoscopy (HAS). Basically, they differ with respect to (1) the phenomenological characterization of disembodiment (apparent location of the self outside one's body), (2) perspective (the presence of a distanced and an elevated visuospatial perspective from which the world and the body are seen), and (3) autoscopy (the seeing of one's own body). Common to all AP there is the impression of seeing one's own body; however, OBE is characterized by the presence of disembodiment and extracorporeal visuospatial perspective, whereas in AH there is no disembodiment and the observer's perspective from which the autoscopic self is seen stays within the physical body. At an intermediate state, subjects with HAS do not usually feel disembodiment but they report seeing in an alternating or simultaneous fashion from both the physical and the double's body. Another distinguishing feature is that the hallucinatory origin of the visual experience is immediately realized only during AH, whereas OBE and HAS are usually described as highly realistic experiences. Vestibular and body schema dysfunctions represent the core characteristic of OBEs; they are moderate and variable in HAS, but they are usually absent or weak in AH, in which the deficient visual processing is thought a prominent factor (Blanke, Arzy, & Landis, 2008). With respect to their underlying anatomy, AP of focal origin primarily implicate posterior brain regions, with a prominent involvement of the temporal, parietal, or occipital areas. Some authors have proposed different anatomical substrates for the different AP (Blanke & Mohr, 2005).

In most reported cases, AP are ephemeral, lasting only few minutes to days. Conrad (1953) reported the first case of chronic mirror hallucination in a patient who became blind because of a hypophysary tumor. This case was characterized by the presence of echopraxic imitation (i.e., the reduplication of the patient's movements by the autoscopic double) and by the fact that the location and the characteristics of the autoscopic image were modified when the patient turned or tilted the head. In addition, the examiner's touches on the patient's cheek were visualized in the autoscopic percept. The patient reported by Conrad was blind, and the onset of the autoscopic percept was temporally associated to his blindness. Owing to the stable nature of the percept, Conrad suggested to name

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this phenomenon "phantom" ("fantôme" in French) instead of hallucination by analogy with the phantom limb phenomenon, which is more stable with regard to time (Conrad, 1953, p. 351).

More recently, Zamboni, Budriesi, and Nichelli (2005) reported a case of chronic autoscopy in a patient who suffered from lesion of the occipital cortex and BG bilaterally. Similarly to what reported by Conrad, this second case was characterized by echopraxia, and the touches by the experimenter (e.g., on the patient's front or shoulder) were visualized in the autoscopic image. Quite differently, however, the patient reported by Zamboni et al. did not have any primary visual deficit. In both previous cases, the autoscopic phantom was described by the patients like a mirror image located in front of them.

Here we investigated another case of long-lasting hallucinatory phenomena, associated with a right occipital lesion, although of possible iatrogenic etiology (see next section). The distinctive feature of this patient is that her autoscopic self was not seen in her hemianopic field frontally, but laterally as a side view of her profile. This phenomenon was first investigated with a clinical interview, and then we experimentally examined the original symptom of persistent autoscopy by assessing (1) whether the visual appearance of the phantom was modulated by eyelid closure and by sensory and motor stimulations, (2) the frame of reference of the autoscopic percept, and (3) whether the characteristics were stable and consistent over time. This investigation allowed the conceptualization of the body reduplication as primarily characteristic of the AH, although some peculiar features more representative of HAS also emerged.

METHODS

Case Report

The patient (M.M.) is a right-handed, 48-year-old woman (8 years of education) who was referred to our attention by a neurosurgeon for a neuropsychological evaluation and a possible rehabilitation treatment of hemianopia. Seven months before the neuropsychological assessment, the patient underwent a surgical intervention to remove a neoplasm. Before the surgical intervention, the MRI scan showed an intraparenchymal neoplastic lesion in the right medial occipital region, at the cortico-subcortical junction, without involvement of the cortex but infiltrating the ependyma of the occipital part of the right lateral ventricle. M.M. underwent a right paramedial occipital craniotomy to remove the tumor. The MRI scan performed after the intervention showed a right occipital lesion (see Figure 1), without residual components of the tumor.

At the time of the neuropsychological assessment, the patient had a stabilized, dense left-side homonymous hemianopia, as assessed by means of Goldmann perimetry (see Figure 2).

The patient was alert, cooperative, and well oriented in space and time, as documented by the Milan Overall Dementia Assessment (Brazzelli, Capitani, Della Sala, Spinnler, & Zuffi, 1994) on which the patient obtained a normal score. The presence of visual neglect was assessed by a standard battery of clinical tests: letter cancellation (Diller & Weinberg, 1977), line cancellation (Albert, 1973), and line bisection, on which the patient scored within normal range (omissions, letter cancellation, <5; line cancellation, <2). A detailed examination was carried out to assess the presence

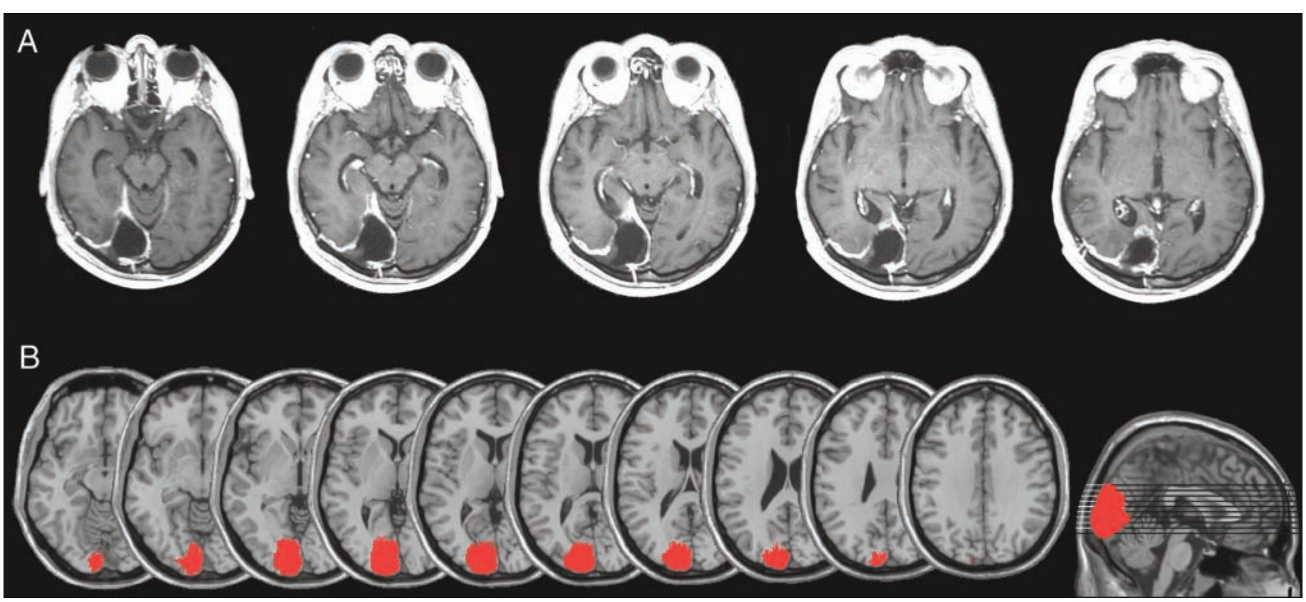

Figure 1. (A) Original MRI scans and (B) reconstruction of the patient's brain lesion drawn from MRI T1-weighted template (Montreal Neurological Institute) using MRIcro software (http://www.psychology.nottingham.ac.uk/staff/cr1/mricro.html).

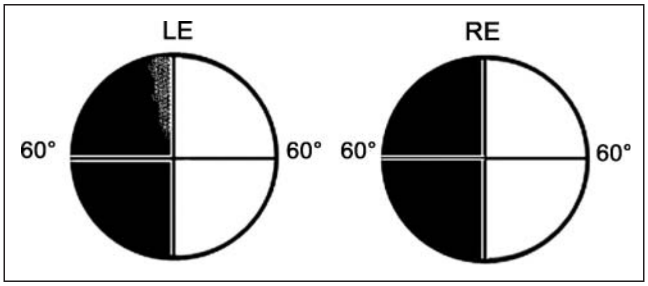

Figure 2. The figure depicts the reconstruction of the visual field on the basis of the computerized perimetry. LE = left eye; RE = right eye. Black areas: regions of lost vision; dotted areas: amblyopic regions; white areas: intact regions.

and extent of visual deficits. Visual field defects and visual exploration impairments were evaluated by using different visual search paradigms and different visual field tests (for details, see, Bolognini, Rasi, Coccia, & Ladavas, 2005). In addition, "visual field" and "visual exploration" subtests from the Testbatterie zur Aufmerksamkeitsprüfung (Zoccolotti, Pizzamiglio, Pittau, & Galati, 1994; Zimmerman & Fimm, 1992) were also used. The examination confirmed the presence of left homonymous hemianopia and the presence of visual exploration impairments. The patient showed a normal hearing threshold as measured by audiometric test in each ear, with no sign of asymmetry between ears. An evaluation of optic ataxia was also carried out by asking the patients to point with her right index finger to different visual stimuli presented in central and peripheral vision; no disturbance of pointing movements emerged.

One week after the neuropsychological assessment, the patient started a multisensory audiovisual rehabilitation training for the visual field defects (Passamonti, Bertini, & Làdavas, 2009; Passamonti, Frissen, & Làdavas, 2009; Bolognini et al., 2005). A few days afterward, M.M. reported she started seeing an image of herself in the left (hemianopic) field since the second treatment session. To clarify the origin of the AP, the patient underwent another MRI scan, which excluded the tumor recurrence. Worth mentioning, at the end of the rehabilitation, at about the time of the follow-up investigation, there was an improvement of the visual exploration disorders, whereas the size of the visual field loss remained stable. No other neurological/neuropsychological changes were observed.

Vestibular functions were not formally tested as the patient did not complained about vestibular problems by the time of the investigation, which started a few weeks after she first reported the presence of the autoscopy to us, when the phenomenon had appeared rather stable. Proprioception was not assessed clinically but emerged to be spared from the experimental investigation (see Results section).

Procedure

On consecutive days, we carried out an examination to collect detailed phenomenological information about the visual details of the image and the sensory and motor components related to the autoscopic percept. The examination included a semistructured interview, the empirical testing of sensory and motor factors contributing to the phenomenal features of the autoscopic double, and the experimental assessment of the frames of reference of the autoscopic percept (see next section). Two months later, a second examination was conducted to evaluate the stability of the phenomenon. Each examination was videotaped for further off-line analysis. The patient gave informed consent to have the nature of her autoscopic phenomenon experimentally investigated.

Semistructured Interview: Patient's Report of the Autoscopic Phenomenon

During the interview, we specifically inquired for sensory and motor characteristics of the AH the visual-spatial perspective, the presence of additional sensory hallucinations, and the emotional feelings related to autoscopy. On the basis of the information obtained during the interview, we developed several experimental paradigms to further analyze the main phenomenological features reported by the patient.

Experimental Investigation: Motor and Sensory Influences on Autoscopy

Motor Stimulation

Because movements of the patient's body were found to profoundly modify the autoscopic percept (e.g., arm movements made the autoscopic arm to appear), we investigated whether motor stimulation could affect AH and which kind of movement was most efficient in inducing its appearance and in modulating the visual aspect of the image. Thus, in different sessions, we tested whether moving the head, the arm, or the leg differentially affected the double body image in a body part–selective way. To establish the possible role played by proprioceptive inputs and motor planning and execution in the genesis of the autoscopic percept, we compared the effect of active movements (i.e., the patient performed the requested movement) versus passive movements (i.e., the patient's body parts were moved by the examiner while she kept herself relaxed) for each of the three body parts. We also investigated the potential role of motor imagery (Jeannerod, 1994); that is, whether the imagining of the movement, without a corresponding movement, could be effective in modulating the appearance and/or the movement of the autoscopic body. To test the possible role played by concurrent visual inputs from the retina in the modulation of the autoscopic image, each movement was additionally tested under two different conditions: M.M. was asked to keep her eyes open while staring in front of her (open-eyes condition) or she had to maintain her eyes closed (closed-eyes condition).

There were six trials for each experimental condition for each body part (see next section) presented in a pseudorandom order (i.e., no more than two consecutive repetitions of the same body part movement). For each trial, M.M. was asked to describe which parts of the autoscopic body she could see, the vividness of the image, and whether the autoscopic image replicated her movement (i.e., echopraxia). She was also asked to judge whether the autoscopic movement extent was comparable with the patient's real movement and whether its execution was simultaneous or delayed relative to the patient's execution.

Head movement. M.M. was asked (1) to rotate her head (active movement condition), or the head was rotated by the examiner, while she was asked to keep relaxed (passive movement condition) and (2) to mentally imagine the active and passive movements (imagery conditions). The movements started from a straight-ahead position and consisted of successive leftward–rightward rotations along the vertical axis.

Leg movement. The patient was asked to describe the autoscopic percept, focusing on the legs, while standing up steadily, during walking, and while she only imagined walking (the condition with passive walking movements could not be done from the standing position). In another session, M.M. sat on a chair, and the movement consisted in flexing (back and forth) the left or the right leg.

Arm movement. On the basis of pilot investigation showing that right arm movement and tactile stimulations were ineffective, the motor and the somatosensory tests (see next section) were conducted only for the left, contralesional arm. M.M.'s left arm laid on the table, in front of her. The movement consisted in flexing the forearm upward by 45° with respect to the table surface (by abducting the lower arm while the elbow laid on the table surface). After each movement, she was asked to indicate on a panel, positioned on her right side on the wall, the amount of flexion of either her arm or the autoscopic arm in separate sessions. Differently oriented lines were depicted on the panel as reference for her judgment (measured off-line in degrees).

Tactile Stimulation

We investigated whether the tactile stimulation of the cheeks and arms could modify the appearance of the autoscopic image (i.e., brightness, movement of the autoscopic forearm, sharing of tactile feelings). The investigation was conducted in open- and closed-eyes conditions. Six trials for each type of tactile stimulation were given in a pseudorandom order.

Cheek stimulation. The examiner touched the patient's left or right cheek with the index finger. The touch could be static, or the finger could be rubbed in a vertical direction or in a horizontal direction. For each trial, M.M. was instructed to report whether she felt to be touched and which cheek had been stimulated (left vs. right one); she also had to describe whether the autoscopic image changed during the tactile stimulation.

Arm stimulation. The patient's left arm laid on the table. The experimenter rubbed M.M.'s forearm or grasped the patient's wrist. Care was taken by the experimenter to reproduce the same kind of grasping of the patient's wrist that was used to passively displace the patient's arm in the arm movement condition described earlier. M.M. was asked to report possible changes in the autoscopic percept.

Auditory Stimulation

The effect of auditory stimulation on the appearance of the AH was tested by asking M.M. to describe any change in it, while the experimenter, standing outside the patient's view, made different noises such as pounding, clapping, and dropping objects on the floor and walking. M.M. was asked to report possible changes in the autoscopic percept.

Frames of Reference of the Autoscopic Percept

To establish in which frames of references (head or eye centered) the autoscopic image was coded, two experiments were conducted in which the patient was always asked to localize the spatial position of the nose of the autoscopic image by manually pointing to it.

In Experiment 1, M.M. sat on a chair at approximately 120 cm from a panel on which three fixation points were marked (centrally at 0° and 32° leftward and rightward). M.M. was instructed to always maintain her eyes at 0°, looking at the central fixation point. At the experimenter verbal command, she had to turn her head (i.e., the tip of her nose) toward one of the three fixation points (i.e., at 0° or 32° left or right), and immediately after, she was asked to point with her left index finger to the nose of the autoscopic percept. The task was performed both with eyes open (binocular view) and closed. In the closed-eyes condition, M.M. was instructed to keep her eyes as if she was looking at the 0° location in front of her. Fixation in open-eyes condition was visually monitored by one experimenter sitting in front of the patient below her line of sight, while the patient's head position was controlled by a second experimenter, standing behind the patient. There were six trials for each condition. The experimenter stood behind the patient and recorded the location, expressed in degrees, of the final finger position with respect to the patient's midline with a medical goniometer (Plastic 360° 12″ ISOM STFR Goniometer).[1] Larger negative values indicate that the nose of the autoscopic image was localized further leftward in the blind hemifield, and smaller negative values indicate a comparatively rightward location in the left hemifield.

In Experiment 2, the setup and the procedures were identical, except that the patient was asked to keep her head still (her nose pointing toward the frontal 0° location) while she was prompted by the experimenter to shift her eyes at one of the three fixation points from trial to trial. An experimenter stood in front of the patient, below her line of sight, to check the maintenance of fixation during the testing conditions. The order of the experiments was reversed in the follow-up evaluation, 2 months afterward.

RESULTS

Semistructured Interview

The first appearance of the autoscopic image was approximately 7 months after the surgical intervention; it is noteworthy that the sudden appearance coincided in time with the audiovisual training to which M.M. was submitted to promote compensatory exploratory saccades toward the hemianopic field (Passamonti, Bertini, et al., 2009; Passamonti, Frissen, et al., 2009; Bolognini et al., 2005). M.M. was alone at home, dressing herself in front of a mirror, and bent forward to put on tights when, for the first time, she suddenly perceived the auscopic image in the left hemifield (i.e., the hemianopic one): As the patient, the image was bending forward, copying each patient's movement in real time. Since this first appearance, M.M. continued experiencing the autoscopic phenomenon, although its vividness and completeness could vary (see later). M.M. never reported its presence during night dreams. At first, she was reluctant to mention the autoscopy because she was worried "to be considered crazy." M.M. immediately recognized the hallucinatory nature of the experience.

She never experienced any other sensory hallucinations. No emotional state was associated with the image, and no sharing of words or thoughts were reported. She declared to prefer the presence of the image compared with the "black hole" of the hemianopic field, and she wondered whether the image was a sign that vision in the left hemifield was recovering.

From a physical visual-spatial perspective, she always saw the autoscopic percept next to her, in the left hemianopic field. When the patient remained immobile, the autoscopic image was life-sized and usually included head and shoulders. The autoscopic image was seen in side view, as a profile on her left side, the nose of the autoscopic head being oriented frontally, as the patient's nose (see Figure 3). The patient could not make out the details of the image (e.g., the eyes and the mouth), but she clearly saw the silhouette. She was indeed able to precisely delineate the contour of the image, including the nose, with her index finger and to point to its "exact" position, located approximately 10 cm from the patient's left cheek. The image was uniformly gray, except for the presence of a pink hat on the head that was sometimes reported.

When M.M. was asked about who the image could represent, she described it as a person, "I call her 'person' since the silhouette is clearly defined… Probably she is me since she replicates all my movements: she does exactly what I do. She's like a 'doll.'" Since then, M.M. always referred to the image as "my dolly." The image was always in the blind field, nearby the patient's left cheek and shoulder. If the examiner stood on the left side of the patient, that is, in the hemianopic hemifield, M.M. was unable to see him, although she still perceived the image. In the same way, when M.M. was asked to point to the image with her left hand while looking straight ahead, she could not see her hand, located in the hemianopic field, but the image could be clearly seen. The autoscopic percept in the external space could move, and M.M. reported that it changed depending upon where she was gazing (see Experiments 1 and 2).

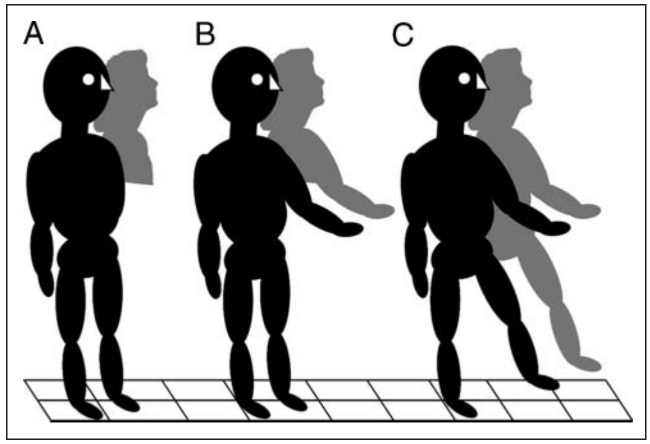

Figure 3. Schematic illustration of the location, orientation, and visual appearance of the autoscopic image (gray) according to body part movement of the patient (black). (A) The autoscopy was limited to the head and the upper trunk when the patient was still, but (B) arm movements and (C) walking rendered the corresponding body parts of the autoscopic double visible to the patient.

The autoscopic image was life-sized and despite the fact that M.M. usually perceived only the head and the upper trunk, she could extend her perception to the entire doll's body whenever she moved. For example, when she walked around, she could see the leg and the feet of the autoscopic body, that is, a life-sized image located next to the respective body parts of the patient. Moreover, M.M. reported that the vividness of the image as well as the chance of seeing different autoscopic body parts was closely related to her own movements. For instance, the most helpful movement for inducing a more vivid view of the autoscopic body was the movement of the head: left–right rotation and tilting the head were the most effective movements for the modulation of the visual aspect of the image. However, if M.M. wanted to clearly perceive the image's arm, she had to move her left, contralesional arm. Similarly, for the perception of the autoscopic leg, she had to move her left leg. As shown in Figure 3, the movement of the contralesional part of the body evoked the visibility of the corresponding left body part of the autoscopic image, whereas moving the ipsilesional side was overall ineffective.

As if it were reflected in a mirror located laterally, the "doll" replicated every M.M.'s movements in real time (i.e., echopraxia). If M.M. stayed in front of a mirror, she could see the image doing the same, similarly looking directly toward the mirror. However, only M.M. could be mirrored (i.e., reflected in he mirror), whereas the autoscopic image remained "single," that is, there was not an appearance of an additional autoscopic body reflected in the mirror. When M.M. was asked to hold a 70-cm-long plastic tube in her left hand and to move it, she could see the doll doing the same movement, but without holding any tube in her left hand.

M.M. also noticed that the salience of the image was modulated by the amount of attention paid to it and by lightening conditions being more vivid in dimness. She reported that the image was visible also when she lied supine in bed before falling asleep and did not disappear when the patient closed her eyes, although it became somewhat less vivid. She did not report any vertical displacement of the autoscopic image during eye closure. The patient spontaneously reported to have sometimes experienced gravitational disturbances with rotational components. In the past, M.M. felt difficult to keep her balance while standing up, having the sensation of swinging backward and forward. When this occurred, she saw that the doll was rocking too.

Two months after the first interview, the autoscopic percept was still present, with the same characteristics described before, except for what follows: Now the image, still life-sized, appeared to be more distant in the extrapersonal space (at approximately 24 cm, when asked to point to the doll's nose), less lateralized in the left hemifield, and somewhat lighter than before. Moreover, she could no longer see the lower part of the autoscopic body or the arms when she moved her legs and arms, respectively. In contrast, head and eye movements were still effective in modulating the image location in space.

Experimental Investigation: Motor and Sensory Influences on AH

Motor Activity

The experimental assessment overall confirmed patient's subjective description. First, we confirmed the critical influence induced by *head* movements on the visual appearance of the autoscopic body. Indeed, both active and passive head movement increased the brightness of the autoscopic image, relative to when the head stood still (100% of trials). Moreover, the autoscopic head replicated the patient's head movements in real time. This occurred both when M.M. kept her eyes open and closed (100% of trials in both conditions). In contrast, the imagining of head movement was completely ineffective (0%). The same findings were observed at the second testing sessions, 2 months later.

Active and passive movements of the *arm* were also able to induce a corresponding displacement of the arm of the autoscopic image (100% of trials); there was a strict correspondence between the movement of the patient's arm and the autoscopic arm, as measured in the degree of flexion of patient's arm and the autoscopic arm, although M.M. was more accurate in estimating the degrees of her arm flexion during the active movement than during the passive movement of the forearm, as assessed by a t test comparing the two conditions. The significant effect was observed either in the patient's arm or in the autoscopic arm conditions, irrespective of the presence of concurrent visual inputs [open-eyes condition, active movement (patient's forearm = 44.6°, autoscopic arm = 44.6°) vs. passive movement (patient's forearm = 42.5°, autoscopic arm = 42.5°), $t = 5$, $p < .001$; closed-eyes condition, active movement (patient's forearm = 44°, autoscopic arm = 44°) vs. passive movement (patient's forearm = 40.4°, autoscopic arm = 40.4°), $t = 7.6$, $p < .0001$]. Such a performance clearly indicates that the patient's proprioceptive sense was well preserved. Noteworthy, passive movements cannot completely exclude some tonic muscular activity. The finding that passive leg movement did not alter the autoscopic percept (see next section) limits the role possibly played by muscular tonus per se. Moreover, the patient was more accurate in open-eyes than in closed-eyes condition, with a significant difference between these two conditions only for passive movements, as assessed by a t test ($t = 5$, $p < .0005$). By contrast, the mere imagination of the forearm movements had overall no effect in making the autoscopic arm to appear (0% of trials). At the 2-month follow-up, M.M. could still perceive the upper body of the autoscopic image, from face to shoulders included, although the phantom was no longer modulated by the patient's arm movements.

Relative to the *legs*, only walking could induce the appearance of the lower autoscopic body parts, which were usually not perceived; indeed, the patient could see entirely the autoscopic body, including the legs, only during the walking task. The autoscopic body replicated M.M.'s movements (i.e., if she walked, the autoscopy image walked). This echopraxic phenomenon did not occur when M.M. only imagined walking. Closing the eyes rendered the lower part of the image less vivid compared with the open-eyes condition, but it was still present and congruent with the action of walking. When M.M. was sitting, both passive and active leg movements were overall ineffective in modulating the appearance autoscopic body.

Overall, the movement-evoked completion of the autoscopic percept was transient because it was no longer present in the follow-up examination performed 2 months later. At that time, however, autoscopy was still present and very consistent in its visual appearance. At this later stage, spontaneous and passive head movements were still effective in brightening the doll's face (and shoulder), and echopraxia was also still present, although the whole autoscopic body could not be perceived anymore, even when M.M. moved herself actively.

Tactile Stimulation

Relative to the role of sensory stimulations, we found that tactile stimulation delivered to the patient's cheeks and grabbing the arms did not have any effect on the autoscopic image (0% of trials); after being touched, M.M. never reported to see or feel that the corresponding part of autoscopic body was being touched. However, during the testing, an interesting case of visual and tactile allesthesia emerged (for similar occurrence, see Conrad, 1953; Zamboni et al., 2005). When the patient's right cheek was touched by the experimenter, M.M. perceived the touching finger as it was projected into the hemianopic field: During the stimulation of the right cheek, M.M. indeed described a finger in the blind hemifield, approaching her autoscopic cheek and touching it.[2] This phenomenon was not present at the follow-up evaluation.

Auditory Stimulation

Auditory stimulation, presented behind the patient, was completely ineffective in modulating the autoscopic body, and the patient never experienced auditorily induced sensory hallucinations. It should be noted, however, that only some of the sounds used here were body specific (e.g., walking), and future work should include a frontal presentation of bodily sounds (i.e., use of coughs, sneezes, voice of patient), which was not possible here due clinical reasons.

Frames of Reference of the Autoscopic Percept

To assess in which frames of reference the autoscopic percept was coded, we statistically analyzed the location of the autoscopic image in the visual field; we conducted two separate analyses, one for the head position (Experiment 1) and one for the eyes' position (Experiment 2), by using a three-way ANOVA with the following main variables: Session (first and second evaluation), Vision (open and closed eyes), and Location (32° left, 0°, and 32° right). Post hoc comparisons were conducted using the Newman–Keuls test.

When the head was shifted in space, a significant effect of Vision, $F(1, 5) = 9.67, p < .03$, and Location, $F(2, 10) = 40.18, p < .00002$, and a significant Session × Location interaction, $F(2, 10) = 5.7, p < .03$, were observed. Indeed, there was a significant, although modest, difference between the open-eyes condition (−47.6°) and the closed-eyes condition (−48.7°, $p < .03$). More interesting, the main effect of the location showed that the position of autoscopic percept in the hemianopic hemifield was significantly modulated by head direction (see Figure 4A). When compared with the condition in which the patient's head was oriented straight ahead at 0° (i.e., aligned with the body midline), the autoscopic image was shifted leftward when the patient's head pointed to the left (−46.9° vs. −58.2°, $p < .0005$), whereas it was shifted rightward when the patient's head pointed to the right (−39.3°, $p < .005$). The Session × Location interaction showed a significant difference in the location of the autoscopic image when the head was turned to the right between the first and the second evaluations (−44.01° vs. −34.5°, $p < .0007$), therefore indicating a rightward shift of the autoscopic image toward the body midline at the second evaluation as compared with the first evaluation, which was present only when the head was turned to the right.

Because eye movements were not recorded, the occurrence of ocular movements when the patient was tested with eyes closed cannot be completely ruled out; this possibility seems unlikely, however, because the closed-eyes condition brought shifts of the autoscopic image that were comparable with those observed in the open-eyes condition, during which eye-fixation was monitored throughout.

In Experiment 2 when the eyes, but not the head, were shifted in space, a significant effect of Session, $F(1, 5) = 10.88, p < .02$, and Location, $F(2, 10) = 97.82, p < .000001$, was similarly found. First, the variable Location indicated that the position of the autoscopic image was

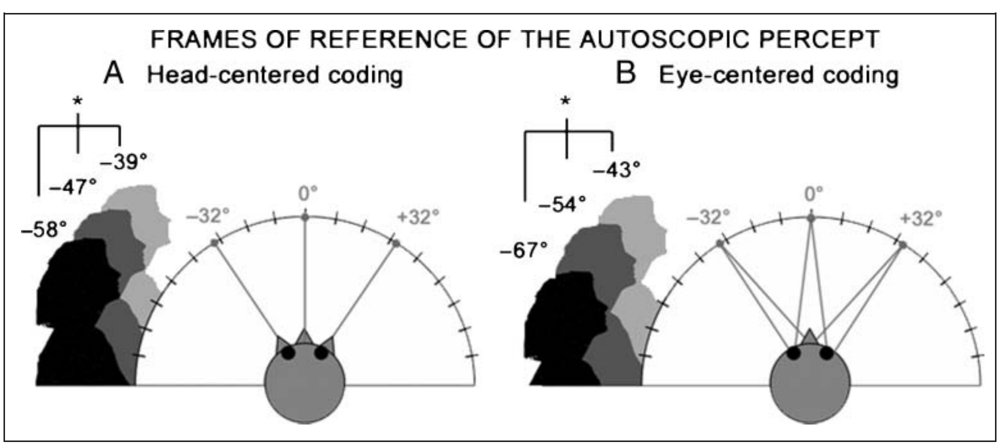

Figure 4. Schematic view of the patient and the experimental setting in eyes-open condition. (A) The patient maintained her eyes at 0° looking in front of her while orienting the nose toward one of three possible fixation points (0° or 32° left or right). (B) The patient maintained the head oriented toward 0° and shifted her eyes toward one of the three possible fixation points. The nose of the gray-scale silhouette represents the location of the autoscopic image, as indicated by the patient pointing to the nose of her autoscopic percept, as a function of head orientation (A) or eyes orientation (B). The gray-scale fading of the silhouettes represents the rightward shift of the autoscopic percept as a function of the patient's left-to-tight orientation of the head and eyes.

significantly modified by eyes direction: When compared with the condition in which the patient fixated centrally (−54.1°), the autoscopic image was shifted leftward when M.M. looked to the left (−67°, $p < .0002$), whereas it was shifted rightward when the patient looked to the right (−43.1°, $p < .0002$) (see Figure 4B). Second, the variable Session showed that, overall, the position of the autoscopic image changed between the evaluations: At the follow-up session, the autoscopic image was localized significantly more rightward (−47.1°), toward the body midline, as compared with the first evaluation (−62.4°). This effect thus upheld the spontaneous report made by M.M. about her sensation that the autoscopic image was more distant from her body and less lateralized in the left hemifield at the second evaluation. No other changes in the AH were reported (e.g., no vertical displacement).

DISCUSSION

The neuroscientific approach to the study of AP is quite recent (Blanke & Mohr, 2005; see also Blanke & Metzinger, 2009; Cheyne & Girard, 2009; Blanke et al., 2008), partly because subjects usually experience AP in the range of a few seconds. Here we conducted an extensive examination of a neurological patient with a persistent autoscopy associated to occipital brain damage by collecting detailed data about her phenomenological experience and experimental data assessing modulatory effects of sensory, motor, and mental stimulations on AP. This is the third reported case of a long lasting autoscopic phenomenon (Zamboni et al., 2005; Conrad, 1953). Here, the autoscopic phenomenon was persistent in two respects: It lasted several months and, in contrast to the case reported by Zamboni et al. (2005), it was not suppressed by closing the eyes (Bhaskaran, Kumar, & Nayar, 1990; Genner, 1947). To the best of our knowledge, it is the first report of an AH that is seen as a lateral profile on the contralesional side of the patient's external space.

The symptoms shown by M.M. correspond to most of the typical manifestations of the AH: limitation of the AH to the upper body, presence of hemianopia, lateralization of the phenomenon to the hemianopic field, body-centered visuospatial perspective, acknowledgement of the hallucinatory origin of the experience by the patient, and no sharing behavior with the double nor any kind of sign of depersonalization or "double consciousness" (Blanke & Mohr, 2005). However, some features do not allow for a full nosological labeling of this case as a typical AH case (see Table 1). First, a peculiar feature of the present case was the seeing of the autoscopic body in profile, whereas usually AH is represented as mirror hallucinations ("hallucinations spéculaires"; Brugger, 2005; Brugger, Regard, & Landis, 1997).

Instead, patients with HAS often see the autoscopic body in side or back views. Second, the presence of echopraxia and the colorless, pale, and misty appearance of the autoscopic body are also compatible with HAS (Brugger, 2005; Brugger et al., 1997), although the patient reported to see a pink hat on the head of the autoscopic image (which was not actually worn by the patient). However, it is worth noting that figures wearing hats and moving in a realistic way are frequent phenomenological variables of visual hallucination associated to the pathological hyperactivity of the ventral occipito-temporal cortex (Santhouse, Howard, & ffytche, 2000).

This complex nosological picture might indicate that HAS and AH are still to be considered as different entities, but on a continuum on which, as suggested by Blanke, Landis, Spinelli, and Seeck (2004), the degree of vestibular impairment might differ. It has been proposed that

Table 1. Summary of the Main Features of M.M.'s Autoscopy

Neurological Features	
Cerebral lesion	Right occipital lobe
Hemianopia	Left hemianopia
Neglect	Absent
Sensory hallucinations	Absent
Other neuropsychological disorders	Visual/tactile allesthesia
Clinical Features	
Location	Lateralized to the hemianopic hemifield
Orientation	Matching patient's orientation
Disembodiment	Absent
Body partialness (whole/partial)	Head and trunk
Body details	Gray silhouette, with a pink hat
Dimension	Life-sized
Position (upright, supine)	Matching patient's position
View	Side view (profile)
Action	Echopraxia
Patient's emotions	Neutral
Reality	Autoscopy experienced as hallucinatory
Experimental Features	
Sensory (tactile/visual) modulation	Absent
Motor modulation	Present for active and passive movements
Eyes closure modulation	Absent
Frames of reference	Eyes and head centered

abnormal activation of extrastriate visual areas induced by multisensory information regarding body perception and self-representation may result in the long-lasting visual phenomenon of autoscopy (Zamboni et al., 2005): The hyperactivity of high-order cortical visual areas, deprived of their visual input, might establish or strengthen abnormal cross-modal connections with multisensory cortical areas involved in bodily representations. This aberrant cross-modal plasticity might be responsible of the transformation of self-related sensory information into the visual percept of the AH. A multisensory interpretation of the AP has been suggested by the review of clinical observations by Blanke et al. (2004). On the basis of these accounts, we experimentally explored the role of different sensory and motor stimulations in the modulation of the autoscopic experience. Our findings extend the knowledge about long-lasting AP by body part movements and give some experimental support to the idea that perceptual characteristics of the autoscopic image can be enhanced by body proprioceptive information.

Indeed, some of the most fascinating features of M.M.'s autoscopic percept emerged from the experimental investigation. First of all, we found that the visual appearance of the autoscopic body could be profoundly modulated (i.e., completed) only by the physical displacement of the patient's body parts, whereas the mere motor imagery of the action and the auditory or tactile stimulations were ineffective. As often reported in the literature (but see Zamboni et al., 2005; Bhaskaran et al., 1990), eyes closure did not disrupt the perception of the autoscopic body but made it less vivid. Here we additionally found that eye closure did not prevent any of the effects of the motor stimulation. Indeed, almost all movements of the patient's body parts induced a corresponding movement of the autoscopic body, independently of whether they were actively or passively performed. In contrast, mere motor imagery of the same body parts was ineffective, suggesting that motor planning did not represent a causal factor. More intriguing is the observation that motor stimulation literally generated the perception of autoscopic body parts, as the arm or leg, which were usually not seen by the patient when the body remained still. This finding reveals not only that sensorimotor inputs were able to modulate the percept (e.g., increasing brightness) but also that proprioceptive input played a crucial role in completing the manifestation of the hallucinatory percept itself: Arm movement made the previously lacking autoscopic arm visible and moving congruently. The role played by proprioceptive inputs is strengthened by the fact that this phenomenon, that we suggest to call "autoscopic generative echopraxia," was body part selective: Head movements rendered the autoscopic image of the moving head more vivid, without extending the autoscopic percept to other body parts. Arm movements made the autoscopic arm visible and moving congruently but did not change the visual appearance of the autoscopic head nor made the autoscopic leg visible. A full autoscopic body, including legs, became visible only when M.M. was walking, whereas active leg movements while sitting were not translated into the autoscopic experience. Noteworthy, when the legs were moved and the entire body was instantly seen, the apparent distance of the double remained constant and approximately life-sized, although there was an extension (downward) of the size of the autoscopic image, which now included the lower part of the body. This pattern of selectivity, highly consistent across time and a variety of tasks, indicates that the patient is quite reliable in her description of the phenomena. As another example of this selectivity, it is important to underline that the patient was clearly able to distinguish between her autoscopic percept (her "dolly") and her own mirror reflection (her own face or the long tube she moved, which made the doll's arm visible but not holding the same tube).

Another interesting aspect of the modulation of motor activity on perception of autoscopic body parts is that only the movement of the contralesional part of the body evoked the appearance of the corresponding left body part of the autoscopic image, whereas moving the ipsilesional side was ineffective. This finding points to an interaction between the visual and the motor representations. In this regard, postlesional proprioceptive-visual plasticity might have occurred. It has been shown that humans can recognize a right-facing body view of human motion better when presented in the right visual hemifield than in the left; the opposite being true for left-facing body views. Such behavioral facing effect appears to be associated with the contralateral intrahemispheric activity of the primary somatosensory cortex (BA 2) and inferior frontal gyrus (BA 44) (de Lussanet et al., 2008). As a result, interactions between the visual system and the motor-somatosensory system may be crucial for the perception of body movements (de Lussanet et al., 2008), likely playing a role in autoscopic echopraxia.

The fact that the autoscopic legs were induced only by walking, but not by moving the legs from a sitting position, suggests that vestibular processing also contributes to the emergence of autoscopic experience. This idea is further supported by the finding that the rotation of the head was the most successful movement in getting a better perception of the "dolly." The experimental manipulation of head and eye position showed that the autoscopic body moved in space according with movements of both the eyes and the head. The susceptibility of the phenomenon to both eye- and head-centered coding of space suggests that the hallucinatory percept could be ascribed to dysfunction of parietal areas containing representations of space in multiple reference frames (Avillac, Denève, Olivier, Pouget, & Duhamel, 2005; Colby, 1998). Moreover, here the autoscopic body was located at approximately 10 cm from the patient's left cheek. Autoscopic and heautoscopic doubles are generally experienced in the near peripersonal space and less frequently localized at a distance far beyond grasping space (Brugger, Blanke, Regard, Bradford, & Landis, 2006; Blanke et al., 2004). This spatial location further suggests a causal role of parietal areas involved in the multisensory representation of the peripersonal space (Makin, Holmes, & Zohary, 2007; Avillac et al., 2005; Farne, Dematte, & Ladavas, 2005; Maravita, Spence, & Driver, 2003; Rizzolatti, Fadiga, Fogassi, & Gallese, 1997). In this regard, the disintegration in personal space (due to conflicting tactile, proprioceptive, kinesthetic, and visual information) has been proposed as a critical factor in the genesis AP (Blanke et al., 2004).

Moreover, an inverse relationship seems to exist between the autoscopic echopraxia and the spatial distance of the autoscopic body because the extent of echopraxia decreases as a function of the perceived spatial distance of the autoscopic body from the patient's body (Brugger et al., 2006). Here we found that at the follow-up evaluation the autoscopic body was seen more distant from the patient's own body, and the movement of the lower parts of the autoscopic body could no longer be induced. This association between the distance of the autoscopic body and the strength of echopraxia corroborates previous observations of associations between spatial and psychological phenomenologies during AP (Brugger et al., 2006; Brugger, 2002).

On the basis of the present experimental observations, we would speculate that abnormal feedback from high-order extrastriate areas onto the damaged visual areas might be responsible of the complexity of the visual hallucination of patient's own body. The hallucinatory visual appearance of the autoscopic body might depend upon pathological activity from the extrastriate body area (EBA; see Blanke & Mohr, 2005), an area that responds to vision of human body parts (Downing, Chan, Peelen, Dodds, & Kanwisher, 2006) in which activity is strongly modulated by limb (arm and foot) movements, even without any visual feedback from the movement (Astafiev, Stanley, Shulman, & Corbetta, 2004). Recent data suggest that EBA is also critical for the sense of embodiment (Arzy, Thut, Mohr, Michel, & Blanke, 2006). Collectively, this evidence underlies the role of EBA in multisensory body perception and integration: Body movement signals might thus enhance the aberrant activation of EBA, possibly reinforcing the perception of the autoscopic body.

The movement-evoked completion of the autoscopic percept was transient: It was no longer present in a follow-up examination performed 2 months later, despite the fact that autoscopy was still present (for the head and the shoulder) and very consistent in its visual appearance. At this later stage, active and passive head movements were still effective in brightening the doll's face (and shoulder), and echopraxia was also still present, although the whole autoscopic body could not be perceived anymore, even when M.M. moved herself actively. This upper/lower dissociation has been previously mentioned as a distinction between "fantômes spéculaires" and phantom limbs (Brugger, 2006). Along this line, experimental investigations in healthy participants have shown that the perception of changes in another person's limbs is influenced in a limb-specific way by the simultaneous movement of the observer's own limbs (Reed & Farah, 1995). Worth mentioning, it has been shown that changes in the arm position were easier detected than those in the leg position. Together with present findings, this evidence suggests an intimate link between the action-induced limb visualization and action execution.

Notably, the AH only occurred 7 months after the surgical intervention, and more importantly it appeared soon after enrollment in a multisensory-based rehabilitation intervention, aimed at reinforcing the retino-collicular–extrastriate cortex pathway in patients with a lesion in the retino-geniculo–striate pathway (see Passamonti, Bertini, et al., 2009; Passamonti, Frissen, et al., 2009; Bolognini et al., 2005). This might suggest a causal role played by the treatment in the genesis of the autoscopy, perhaps through the inducement of a cross-modal reactivation of the cortical areas spared by the lesion. However, it is worth noting that none of the several patients submitted to the same rehabilitation training ever reported an autoscopic experience (Passamonti, Bertini, et al., 2009; Passamonti, Frissen, et al., 2009; Bolognini et al., 2005), thus indicating that the multisensory-based treatment might be necessary but not sufficient alone (i.e., without a specific lesion pattern) to let autoscopy emerge.

To conclude, our data support a multisensorimotor account for the AP, including its visual variant of AH: Body-related sensory information may cross-modally modulate spontaneous and aberrant hyperactivity of extrastriate visual areas involved in body and face perception, giving rise to the appearance of AH. Although the illusory duplication of one's own body appears to be restricted to the visual modality, the multimodal character of AH can emerge under multiple sensory and motor stimulations. Hopefully, the examination presented here could contribute to differentiate the different forms of AP in future cases: Meticulous procedures seem definitely necessary for disentangling conflicting intersensory factors, multiple coordinate systems, and proprioceptive-motor contributions that determine body-related hallucination contents.

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Notes

1. The goniometer head had three scales calibrated to be used with the International Standards of Measurement (ISOM) system. One arm has a linear scale in inches and centimeters. Scale reads 1/2° increments (http://www.nexgenergo.com).
2. As suggested by an anonymous reviewer, it would be interesting to test the presence of face–hand extinction (see Farnè, Roy, Giraux, Dubernard, & Sirigu, 2002; Bender, 1952) in future case studies.

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