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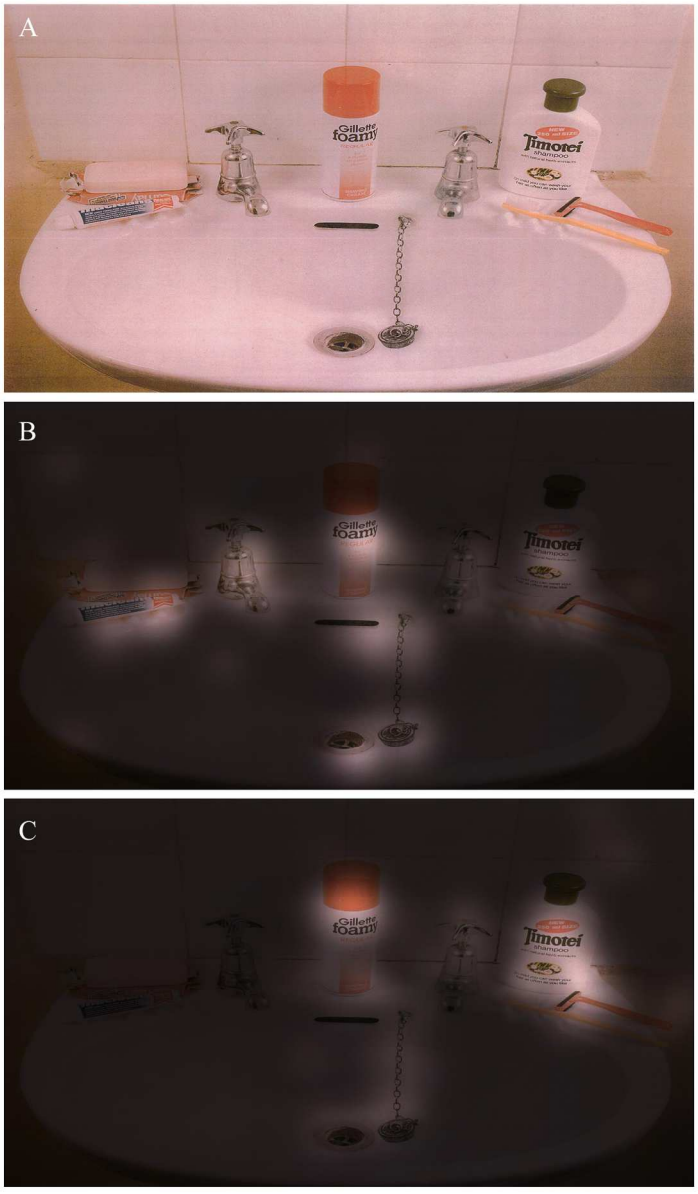

(A) Image of the Behavioral Inattention Test, depicting a washbasin. (B) The healthy subject revealed fixations in all image areas with high detail. (C) The patient presented an absence of fixations (clear spots) in the left side of the image, which evidenced complete inattention to the left hemispace.
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Through the eyes of neglect patients. A preliminary eye-tracking study of unilateral spatial neglect

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To the editor

Incidence of Unilateral Spatial Neglect (USN) has been described in up to 30-70% after an injury to the right hemisphere. USN is one of the strongest predictors of poor functional recovery, which can lead to more prolonged hospitalization (1) and disrupt rehabilitation and recovery of functional disabilities after stroke (2), thus limiting independence (1). However, USN is not usually assessed in routine examinations after stroke (1). This fact could be motivated by the clinical heterogeneity of this syndrome and by the lack of standardized assessment tools. USN is assessed through functional or behavioral tests, or by observation (1). Functional tests focus on functional impairments but do not provide information about the deficits, which makes them suitable for assessment but not for establishing customized intervention protocols. Behavioral tests are usually paper-and-pencil tasks that can be compensated, thus hiding the clinical condition of individuals with USN. Some of the behavioral tests, as the Behavioral Inattention Test (BIT) (3), evaluate the performance on daily activities such as phone dialing, coin sorting, or map navigation, in addition to performance on conventional cancellation tasks. However, the long duration of these tests can make them tiresome for many patients, especially for those with prominent attentional problems, and time-consuming for the clinical staff. The need for a therapist during the course of the test and its psycholinguistics requirements could also prevent the widespread use of these tests.

USN has been reported to alter visual search (4), which has been posed a cortically mediated behavior that involves attentional processing (5). Individuals with USN tend to compensate visual search capability and achieve balance on the neglected side with cervical rotations (6, 7). Spatial and temporal patterns of visual search during cancellation, visuomotor, and visual search tasks have been proposed to improve

examination (8). However, neutral stimuli may not be valid for assessing USN, since emotional valence has been shown to affect the spatial imbalance of both performance speed and stability in USN (9).

We present a novel technique based on eye-tracking technology to quantify visual search on a behavioral task that could overcome some of the limitations of the current clinical examination tools for USN.

Case report

A 65-year-old woman with a right internal carotid artery occlusion that led to an ischemic focal lesion in the basal ganglia with hemorrhagic transformation of the non-dominant cerebral hemisphere was admitted to our facility. The woman stayed one month in an acute in-patient care hospital, where she received physical therapy, and was referred to a long-stay hospital, where she underwent a holistic neurorehabilitation program during five months. After that, six months after the onset, she was admitted in our long-term neurorehabilitation outpatient program. Neurological examination at admission revealed severe left hemiparesis and pronounced USN (National Institutes of Health Stroke Scale=12). The subject presented psychopathological disorders involving apathy and emotional lability that affected her daily living (Neuropsychiatric Inventory=9) and self-awareness deficits of her impairments, limitations, and future planning (Self-Awareness Deficit Interview: 2+3+3). With regards to the neuropsychological domain, she was oriented to time and place, obtained a Mini-Mental State Examination score of 25/30, and showed attentional (Conners' Continuous Performance Test II – Hit Reaction Time=1064.7 ms, Corsi Block-Tapping Test total score=4), memory (California Verbal Learning Test - Total Learning=30; Immediate Free Recall=5; Delayed Free Recall=5), and a discrepancy between the performance on paper-and-pencil test to assess USN (BIT – Conventional subtest=133/146; BIT –

Behavioral subtest=68/81) and the functional difficulties that this syndrome caused in her everyday functioning (Catherine Bergego Scale=23). The patient was enrolled in an experimental eye-tracking study where she and a healthy matched woman were required to look for 60 seconds an image of the BIT depicting a washbasin (Behavioral subtest. Picture two, version B) and name the items present in it (Figure 1.A). Gaze parameters of both subjects were recorded using a low-cost eye-tracking device (The Eye Tribe Aps©, Copenhagen, Denmark) and heat maps were estimated as superimposed distributions of eye fixations using OGAMA 4.5 (10). In contrast to the healthy subject, who revealed distributed fixations in all the image (Figure1.B), the patient presented an absence of fixations in the left side of the image (Figure1.C), thus confirming the diagnosis and illustrating the behavioral complications that affected her everyday functioning.

Discussion

Even though USN is a frequent and disabling consequence after stroke and standardized tools are available for therapists to identify this syndrome, their use in the clinical practice is dramatically low. We have presented a novel method to examine USN using an image of the BIT and eye-tracking technology to determine the gaze patterns of a post-stroke subject with USN. Benefits of this protocol could be threefold: first, it provides qualitative (visual) but also quantitative (fixation times, gaze patterns, etc.) information; second, it is easy to administer and not time-consuming; and third, no specific cognitive or psycholinguistic condition is required to patients. Additionally, the system allows repeated assessments which is important to adjust interventions during the rehabilitation process. Recent advances have given rise to low-cost eye-tracking devices that are available for $100 and free software for data processing, which could promote the clinical integration on this technology. Even though this protocol focuses

on the visual input and the peripersonal space, it could be a potential tool to provide relevant information about the deficits and their functional consequences.

In our particular case, conventional measures of USN, as the BIT, were not sufficient to reflect the severity of the impairment, which was evidenced by the gaze parameters. Objective information as, but not limited to, superimposed distributions of eye fixations provided by eye-tracking technology could be useful as complementary data for assessing USN.

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Figures

Figure 1. Heat maps on the Behavioral Inattention Test image

(A) Image of the Behavioral Inattention Test, depicting a washbasin. (B) The healthy subject revealed fixations in all image areas with high detail. (C) The patient presented an absence of fixations (clear spots) in the left side of the image, which evidenced complete inattention to the left hemispace.