International Journal of Behavioral Medicine (2021) 28:511–522
https://doi.org/10.1007/s12529-020-09940-2

FULL LENGTH MANUSCRIPT

A Cross-sectional Study of Attention Bias for Facial Expression Stimulation in Patients with Stroke at the Convalescence Stage

Hirokazu Takizawa[1] · Toshiyuki Ishioka[1] · Kohei Koizumi[1] · Jun Tayama[2] · Makoto Suzuki[3] · Naoki Nakaya[1] · Toyohiro Hamaguchi[1]

Accepted: 21 October 2020 / Published online: 1 December 2020

Abstract

Background Post-stroke depression increases the likelihood of adverse physical symptoms. Attentional bias (AB) for negative stimuli is important in depression onset, maintenance, and remission. Stroke is more likely in older adults, who can have reduced cognitive function. Individuals with mild cognitive impairment (MCI) can have delayed reaction times (RTs). We hypothesized that RT to select neutral facial expression is affected by depressive symptoms and cognitive function in patients with stroke.

Methods This study analyzed 61 patients with stroke. Beck Depression Inventory-Second Edition (BDI-II) and Profile of Mood States (short version) scores were determined. Task stimuli comprised eight pairs of facial expressions containing affective (angry) and neutral faces. AB was measured as the RT to select the neutral face in two simultaneously presented images using attention bias modification (ABM) software. Patients were grouped according to depressive symptoms using BDI-II scores. Between-subject factors of depressive symptoms and cognitive function were determined by ANCOVA.

Results No significant interaction was found between depressive symptoms and cognitive function on RT. There was a main effect of cognitive function, but not depressive symptoms. In patients with hemiparesis and depressive symptoms, RT was significantly shorter in patients without MCI compared with patients with MCI.

Conclusions People with stroke and elevated depression symptoms with hemiparesis but without MCI quickly selected neutral facial expressions from neutral and aversive expressions, and thus do not need ABM to escape aversive stimuli. ABM in response to aversive stimuli may be useful in evaluating negative emotions in individuals with post-stroke depression without MCI.

Keywords Attention bias · Mild cognitive impairment · Post-stroke depression · Response time

Introduction

About 30% of individuals with hemiparesis have depressive symptoms [1, 2] referred to as post-stroke depression (PSD). PSD is a symptomatic depression that occurs after the onset of stroke; most individuals with hemiparesis are older than 65 years [3]. The symptoms of PSD are reduced vitality, feelings of guilt, depression, irritability, and nervousness [4]. In younger people, depressive symptoms are characterized by a low, negative mood, and feeling useless [5], whereas depression in older adults is characterized by cognitive impairment [6]. Cognitive impairment is often recognized after stroke, and patients with PSD are known to have lower cognitive function than patients without depression [7]. In patients with hemiparesis, depression and cognitive impairment adversely affect activities of daily living (ADL) [8, 9] and quality of life [10]. It is still unclear whether depressive symptoms or cognitive function affect the ADL in people with stroke.

Various factors have been suggested to contribute to depression. Among them, cognitive bias, particularly processing bias (e.g., attentional bias [AB], memory bias) for negative stimuli, plays an important role in depression onset,

✉ Toyohiro Hamaguchi
hamaguchi-toyohiro@spu.ac.jp

1 Department of Rehabilitation, Graduate School of Health Sciences, Saitama Prefectural University, Saitama, Japan

2 Faculty of Human Sciences, Waseda University, Saitama, Japan

3 Faculty of Health Sciences, Tokyo Kasei University, Saitama, Japan

maintenance, and remission [11, 12]. Negative AB is critical in the formation of negative cognitive bias [13–16], which increases vulnerability to depression [17]. Moreover, negative AB is reduced when depression severity improves; that is, improvements in depression severity lead to modifications in AB [18–21]. Therefore, depressive symptoms can be reduced by attentional bias modification (ABM) training [19–21]. Furthermore, cognitive behavioral therapy for patients with depressive symptoms has been shown to improve reaction time (RT) to neutral and threat stimuli [22], which suggests that depressive symptoms are related to AB. To date, there have been no reports on AB in individuals with hemiparesis and depressive symptoms, and the characteristics of AB in individuals with stroke are unknown. If the characteristics of AB in individuals with stroke are clarified, it is expected that depressive symptoms will be improved by ABM.

Stroke is more common in older adults. Previous studies of AB in older adults have shown that they are more focused on neutral stimuli than negative stimuli compared with younger people [23, 24]. The avoidance of negative stimuli in older adults can be explained by two strategies. First, it could represent the positivity effect, in which information processing selectively captures neutral or positive information over negative information [25]. Older adults have been shown to avoid negative stimuli when they are in a negative mood and instead focus on neutral or positive stimuli [26]. Moreover, studies of older adults have shown that they avoid negative information and select positive information [23]. Second, it may represent harm avoidance, which is a personality trait characterized by excessive worrying and pessimism [27, 28]. Harm avoidance has been reported to be positively correlated with PSD symptoms [29]. People with harm avoidance temperaments have an increased risk of developing stroke [30], and people with hemiparesis may potentially exhibit harm avoidance. It has been reported that people with higher harm avoidance tend to have shorter simple RTs than those with lower harm avoidance [31]. In addition, people with higher harm avoidance who received cortisol had faster RTs to avoid than to approach anger stimuli [32]. This suggests that people with harm avoidance personalities should have shorter RTs to avoiding aversive stimuli. Although the age-related positivity effect has been noted in many studies (see [23] for a meta-analysis), the strength of this effect, and indeed whether it is noted at all, is moderated by several factors, including the type of stimuli presented and the degree of cognitive control. It has been reported that increasing the difficulty of tasks in older adults reduces the gaze time for positive stimuli compared with simple tasks [33].

AB is measured as the time it takes to make a selection based on certain conditions, after applying an expression stimulus [12, 15, 17]. The RT is an indicator of AB and includes the attention-to-cognition-behavior time from processing a stimulus to acting [34]. The process of an input stimulus reaching the retina and subsequently activating the visual cortex takes approximately 30 ms [35]. Similarly, the latency from the visual stimulus to the medial prefrontal cortex is 115–180 ms [36]. Determining whether a facial expression is neutral or negative takes 300 ms to process in the frontal cortex [37]. Approximately 25 ms is needed for information to be transmitted from the motor cortex to the muscle through the nervous system [38], and the simple RT after visual stimulation without cognitive processing has been reported to be 200 ms [36].

There are various methods for measuring AB, including picture and word stimuli [39]. Two types of attention tasks use emotional stimuli. One focuses on measuring attention toward emotional stimuli, and the other measures attention away from emotional stimuli, referred to as engagement and disengagement, respectively. Engagement is usually assessed by measuring the RT of redirecting the attention from neutral to emotional stimuli. Disengagement is assessed by measuring the RT of redirecting the attention from emotional to neutral stimuli [15, 40]. AB can be examined via a task in which participants must instantaneously select one of two images presented simultaneously, where one image triggers an emotion and the other is neutral [16]. In cases where the emotional image presents an aversive stimulus, it has been established that the RT for the negative stimulus is reduced [14, 41]. People with depressive symptoms have been shown to have decreased maintenance of attention to positive stimuli and increased maintenance of attention to negative stimuli [14, 42]. People with anxiety symptoms have increased alertness to threatening stimuli, making it difficult to release their attention [41, 43]. Based on these findings, ABM includes exercises to disengage attention from threatening stimuli [44–46] and exercises to desensitize by exposure to these stimuli [47], which attenuate anxiety and depression, respectively.

AB is often measured with the dot probe task. This task is used to select the position and shape of dots displayed after two image stimuli are presented. If image recognition is difficult to achieve, AB cannot be evaluated. It has been reported that most individuals with stroke are older adults and that their facial expression recognition is lower than in younger individuals [48]. In addition, it is reported that older adults with depressive symptoms are less accurate in facial expression recognition tasks than those without depressive symptoms [49]. In another study, it was reported that individuals with hemiparesis have less accurate facial expression recognition than those without stroke [50, 51]. From the above, AB is difficult to detect with the dot probe task if facial expression recognition is reduced in patients with post-stroke depressive symptoms.

On the contrary, older adults are known to have longer cognitive processing and motor response times and, therefore, an increased RT compared with younger people [52, 53]. RTs in patients with mild cognitive impairment (MCI) have been shown to be longer than those in age-matched controls [54]. Therefore, individuals with impaired cognitive function of organic cause or suspected dementia by low Mini-Mental State Examination (MMSE) scores are usually excluded from ABM studies [24, 42]. In other words, cognitive decline inevitably influences RT measurements in individuals with hemiparesis. If AB differs between individuals with hemiparesis with and without depressive symptoms, ABM could be applied as a support method to relieve mood disturbances such as depression and anxiety. However, if cognitive functions affect the RT, it is necessary to verify whether depressive symptoms or cognitive functions affect AB.

Therefore, in this study, we measured the AB of individuals with hemiparesis by performing a facial expression selection task to select a neutral facial expression image from an affective facial expression image and a neutral facial expression image. AB in individuals with hemiparesis may be associated with both depressive symptoms and cognitive function. Older adults with depressive symptoms have been shown to have a shorter RT to neutral than aversive stimuli [26]. If the AB for patients with hemiparesis is towards a negative stimulus, the attention has to be avoided from the negative stimulus. Conversely, if the AB for patients with hemiparesis is away from the negative stimulus, training to expose attention to the negative stimulus is required. Moreover, RT in older adults with reduced cognitive function has been shown to be slower than in those with higher cognitive function [54]. In order to confirm the necessity of ABM training by cognitive function, the differences in AB with and without MCI have to be addressed. However, it is unclear whether depressive symptoms and/or cognitive function in individuals with hemiparesis affect RT. Therefore, the aim of the present study was to characterize AB in individuals with hemiparesis. The hypothesis was that (1) RT in patients with stroke with depressive mood is faster than in those without depressive mood, (2) RT in patients with stroke with MCI is slower than in those without MCI. The knowledge of the characteristics of AB in individuals with hemiparesis can help in the development of ABM's intervention strategies in individuals with hemiparesis.

Methods

Study Design

This study used a cross-sectional design to compare differences in RT, which is an indicator of AB, depending on the presence or absence of PSD. Data sampling was performed by one researcher and was discontinuous during the study period.

Participants

Participants of this study were patients with hemiparesis admitted to the Rehabilitation Hospital in Japan between April 2016 and July 2018. The patients were admitted after stroke onset to the research institution for their training in the convalescent rehabilitation ward. The research procedures were explained to the enrolled patients who met the inclusion criteria and their consent to participate in the study was obtained. This study was approved by the University Ethics Committee (27510) and the Hospital Ethics Committee (H27-10).

The inclusion criteria of the study were as follows: (1) patients over 20 years of age, and thus able to make decisions for themselves as adults according to Japanese law; (2) diagnosis of stroke (cerebral infarction, cerebral hemorrhage, or subarachnoid hemorrhage) [4, 10]; (3) absence of severe aphasia influencing communication [4, 9]; and (4) MMSE score of 24 or higher [9, 26, 30, 31]. Patients were classified into the depressive group if they had a Beck Depression Inventory-Second Edition (BDI-II) score > 16 [55, 56]; patients with a score of 15 or lower were classified into the control group.

Exclusion criteria were (1) history of depression before stroke onset or family history of depression [4, 9, 10]; (2) difficulties to discriminate between the two expressions neutral and disgusted in facial images; and (3) a correct response rate below 70% in the first 10 trials of the dot probe task, according to criteria established in a previous study [57].

Experimental Procedure

AB measurements and psychological scales were administered for up to 40 min per person. Testing was performed in a private room in the hospital's rehabilitation ward. First, the patients' psychological states were evaluated using the BDI-II and the shortened version of the Profile of Mood States (POMS) through structured interviews. Next, the RTs were measured using the ABM training software (Fig. 1). At the start of each trial, a fixation cross appeared for 500 ms. Subsequently, participants were presented with two stimuli arranged vertically, one neutral and one angry, for 500 ms. The participants were instructed to indicate as quickly as possible the location of the neutral face (above vs. below on the screen) by pressing a button.

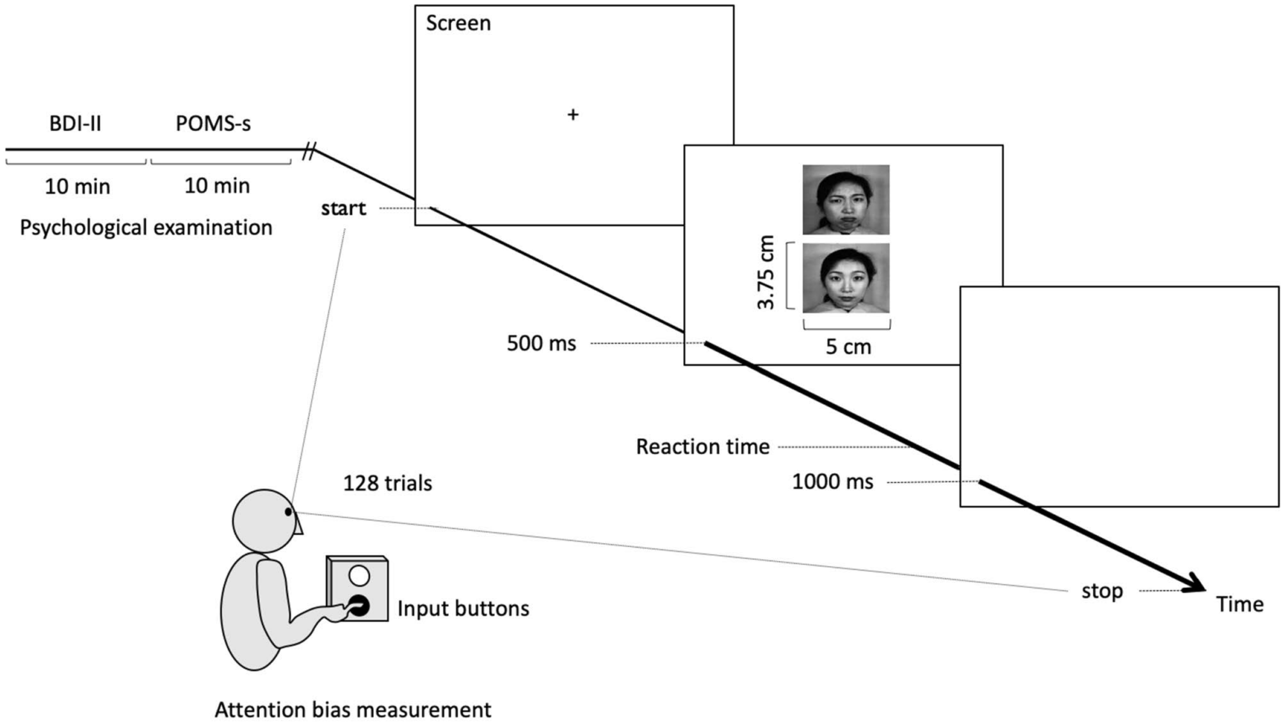

Fig. 1 Protocol of this study. First, the Beck Depression Inventory-Second Edition (BDI-II) and Profile of Mood States short version (POMS) were administered. Then, the AB was measured as the reaction time between the presentation of the two images via the ABM training software and the participant's image selection by pressing a button. The stimuli for the task comprised random image pairs of facial expressions that contained one affective (angry) and one neutral photograph with 128 repetitions

AB Measurements

AB was measured using the ABM training software (Ideoquest, Tokyo, 2012) installed on a laptop computer. A 15-inch liquid crystal display screen was used to present the stimuli. The participants used a button-based input device to choose instantaneously between two images displayed on the screen. The participants pressed the button with their non-paralyzed side hand. Hand dominance was not considered. The distance between the participant's face and the display screen was approximately 45 cm. RT, which was used as an index of AB, was measured as the time between the presentation of the two images via the ABM training software and the participant's button response to indicate their choice, using the computer's internal clock. Stimuli for the task consisted of pairs of facial expressions that contained one affective (angry) and one neutral photograph. The computer recorded the RTs for each response (Fig. 1) [58]. RT was measured as the time from image presentation to button selection. Outlier exclusion criteria were set based on previous studies targeting the same age band as in this study; RTs < 300 ms or > 3000 ms were excluded from the statistical analysis because the attentional response was too early or too late, respectively [22].

Confounding factors that can affect RT include fatigue and age due to MCI and the dominant hand used for measurement. *t* tests were used to analyze age-related differences in RT among patients with or without MCI. To confirm that fatigue in patients with MCI did not affect RT, all recorded RTs were compared using the Kruskal–Wallis test.

For the facial expressions used as the stimuli in this study, aversive (anger) and neutral photographs obtained from the Japanese Female Facial Expression Database were displayed at a size of 5.0 × 3.5 cm in length and width, respectively. The image set comprised eight images of facial expressions showing aversion and eight images showing neutrality; one pair comprising one neutral and one aversive expression was randomly displayed 128 times (Fig. 2). The number of trials was determined with reference to a previous study [58]. The use of facial expression images as facial expression stimuli has been confirmed by Gabor coding [59].

Psychological Examination

The BDI-II Japanese version [60] was used to assess depressive symptoms in patients with stroke [61]. The POMS (short version) was used to evaluate mood states other than depressive symptoms [62, 63]. The BDI-II is a self-administered questionnaire comprising 21 items. It asks how

Fig. 2 Facial expressions used as stimuli. The photographs displaying anger or neutrality (8 images each) were obtained from the Japanese Female Facial Expression Database. The photos were presented as randomly assigned vertical pairs of angry and neutral faces. A total of eight pairs were used for the 128 trials

the respondent felt during the past two weeks, rating each item from 0 to 3. The higher the score, the more severe the depressive symptoms. The BDI-II identifies the presence of depressive symptoms with a score of 16 or more [55, 56]. This cut-off point was set with reference to depressive symptoms due to physical disability.

The short version of the POMS is a self-administered questionnaire consisting of 30 items that measure six mood states: tension-anxiety, depression-dejection, anger-hostility, vigor, fatigue, and confusion.

Measurement of Cognitive Function

The MMSE was used to measure cognitive function in patients with hemiparesis. The MMSE is widely used as a screening test for cognitive function. It consists of 11 items, and a score of 23 or less is considered indicative of dementia [64]. The MMSE Japanese version has been verified for reliability and validity [65]. According to previous studies, the presence or absence of MCI was classified using an MMSE threshold score of 27 [66, 67]. This cut-off point's sensitivity and specificity are 88% and 70%, respectively. In this study, patients with MMSE scores of 24–27 were considered to have MCI.

Patient Characteristics

Information on patient characteristics, such as age, disease name, injured hemisphere, brain lesions, medical condition, days from onset of stroke to examination, and motor paralysis, was obtained from medical records. Brain lesions were checked by a neurologist. The Brunnstrom recovery stage (BRS), which indicates the severity of motor paralysis, is expressed in 6 stages (1 is the most severe and 6 is extremely mild) [68]. The Functional Independence Measure (FIM) was used to determine ADL abilities [69, 70]. FIM consists of 13 motor items such as self-care and mobility and five cognitive items such as communication and social recognition, making a total of 18 items. Each item of the FIM is evaluated on a scale of 1 to 7, with 1 point being completely dependent on assistance in ADL and 7 points being completely independent. Thus, the total FIM score ranges from 18 to 126, and the higher the score, the higher the degree of independence in ADL.

Statistical Analysis

Patients with hemiparesis were grouped according to depressive symptoms using the BDI-II [55, 56]. ANCOVA was used to evaluate if depressive symptoms (depressive vs. non-depressive) and cognitive function (MCI vs. non-MCI) affected RT in patients with hemiparesis. Multiple comparison analysis was performed by Bonferroni correction. Factors that may affect RT are age [71], paralyzed side, and severity of motor paralysis. Considering these factors is necessary when measuring RT. In this study, the influence of the severity of motor paralysis is considered small because the test was performed on the non-paralyzed side. In this study, the measuring hand of the test differs depending on the paralyzed side. Because these factors could indirectly influence RT, they were administered as covariates. To test the consistency of the ANCOVA analysis, a sensitivity analysis was performed using adjusted MCI cut-offs and to confirm that the results did not differ due to a different cut-off point. The cut-off points for the sensitivity analysis were MMSE scores of 25, 26, and 28. One-way ANOVA was employed to compare the characteristics of the patient groups with and without depression. Kruskal-Wallis was used to assess the fatigue effect on RT in 128 trials because the data of 128 trials were not normally distributed. *t* test was used to compare the RT in patients with MCI and without MCI and to determine whether paralysis on the dominant side affected the RT delay and the loss of accuracy. In addition, linear regression analysis was performed, with RT as the dependent variable and MMSE and BDI-II scores as the independent variables. In this regression analysis, subjects' age, paralyzed side, and severity were used as covariates. All statistical analyses were performed using SPSS ver. 25 (IBM, Tokyo), and the significance level was set at 5%.

Sample Size

To the best of our knowledge, there is no prior study of attention bias in patients with hemiparesis to date. The number of participants required for the analysis was calculated using G* power [72], with a partial η^2 of 0.8, effect size of 2, alpha error of 0.05, and a power of 0.8 by ANCOVA. The required sample size was four groups of eight each, for a total of 32 participants.

Results

Patient Statistics

A total of 620 patients with stroke were admitted during the study period; 78 patients (mean age = 64 years, SD = 12 years) who met the study inclusion criteria were surveyed. Seventeen patients were excluded from statistical analyses because their first 10 responses contained less than 70% correct answers [57]. Thus, 61 patients (mean age = 62 years, SD = 12 years) were statistically analyzed (Fig. 3). Their characteristics are shown in Table 1 and Supplement 1.

Comparison of RT by Depressive Symptoms and Cognitive Function in Patients with Stroke

ANCOVA, with age as covariate, revealed a main effect of cognitive function on RT ((F [3, 57] = 7.488, $p = 0.008$, $\eta^2 = 0.118$; Fig. 4). No significant interaction was found between depressive symptoms and cognitive function on RT (F [3, 57] = 0.492, $p = 0.486$, $\eta^2 = 0.009$). There was no main effect of depressive symptoms on RT (F [3, 57] = 2.719, $p = 0.105$, $\eta^2 = 0.046$). In patients with

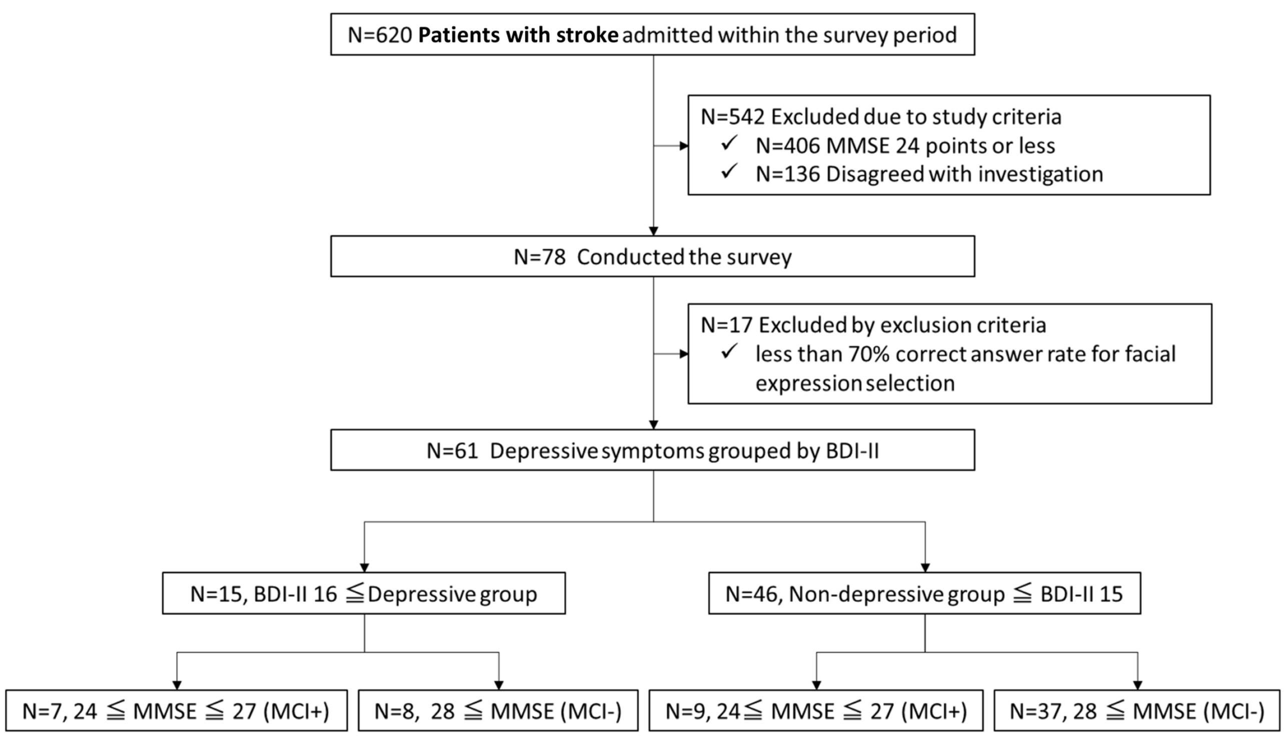

Fig. 3 Selection process of the study population. A total of 620 patients with hemiparesis were admitted during the study period, and 78 patients met the inclusion criteria. Of these, 17 patients were excluded from statistical analysis because their first 10 answers were less than 70% correct. Finally, 61 patients in four subgroups were statistically analyzed. MCI, mild cognitive impairment; MMSE, Mini-Mental State Examination; BDI-II, Beck Depression Inventory-Second Edition; MCI, mild cognitive impairment

Table 1 Comparisons of variables within four subgroups

Variable	Depressive group		Non-depressive group	
	MCI (n = 7)	Non-MCI (n = 8)	MCI (n = 9)	Non-MCI (n = 37)
Age	69 (12)	55 (6)	63 (10)	62 (12)
Days from onset	67 (30)	96 (44)	109 (48)	90 (36)
BRS (hand score)	4.9 (1.8)	4.7 (1.4)	4.6 (1.6)	4.9 (1.2)
FIM motor score	74.4 (8.1)	77.9 (8.5)	78.2 (10.1)	78.5 (7.2)
Cognitive score	26.7 (4.4)	30.9 (3.7)	28.9 (4.5)	30.1 (3.2)
Total score	101.1 (7.5)	108.8 (11.4)	107.1 (12.5)	108.6 (9.5)
BDI-II	22.1 (3.6)	20.5 (4.5)	4.9 (5.3)	6.5 (4.3)
POMS-short T-A	4.9 (3.4)	8.0 (3.3)	2.1(2.0)	3.1 (3.3)
D	5.4 (2.6)	4.0 (3.2)	0.9 (0.9)	1.7 (2.0)
A-H	2.9 (2.8)	2.0 (2.2)	1.4 (2.2)	1.1 (1.5)
V	4.4 (3.7)	3.1(2.1)	7.7 (4.2)	7.5 (4.3)
F	5.3 (4.8)	3.9 (2.6)	1.4 (1.7)	2.2 (2.5)
C	6.0 (2.1)	7.8 (3.2)	3.9 (1.8)	4.0 (2.2)
TMD	20.0 (8.8)	22.5 (13.7)	2.1 (7.0)	4.5 (11.0)
MMSE	25.1 (1.0)	29.1 (0.8)	26.3 (0.7)	29.2 (0.8)
Gender: male/female	3/4	3/5	7/2	25/12
Diagnosis: CI/CH/SAH	5/2/0	3/4/1	2/7/0	27/10/0
Brain lesions				
Lesional side R/L	5/2	3/5	3/6	19/18
Cortical	1/1	1/0	0/0	2/1
Frontal	0/1	0/0	0/0	1/1
Parietal	0/0	1/0	0/0	1/0
Occipital	0/0	0/0	0/0	0/0
Temporal	1/0	0/0	0/0	0/0
Sub-cortical	3/1	2/4	3/6	14/12
Thalamus	1/0	0/2	3/0	1/1
Internal capsule	0/0	0/0	0/0	2/1
Putamen	1/0	0/2	2/1	5/4
Caudate	0/0	0/0	0/0	0/0
Hippocampus	0/1	0/0	0/0	0/0
Cerebellum	0/0	0/1	0/0	1/0
Brainstem	1/0	1/0	0/0	3/6
Medical condition				
Diabetes	2	1	1	11
High blood pressure	4	4	7	26
Hyperlipidemia	1	1	0	4
Heart failure	1	0	0	2
MI/AF	0/1	0/0	0/0	0/2
Accuracy %	87 (9)	81 (8)	84 (8)	86 (11)

These scores involve mean and standard deviations. There are overlapping areas of brain damage. Accuracy refers to AB measurement correct response rate. [a]*BRS* Brunnstrom recovery stage, [b]*FIM* functional independence measure, [c]*BDI-II* Beck Depression Inventory-Second Edition, [d]*POMS* Profile of Mood States, [e]*T-A* tension-anxiety, [f]*D* depression, [g]*A-H* anger-hostility, [h]*V* vigor, [i]*F* fatigue, [j]*C* confusion, [k]*TMD* total mood disturbance, [l]*MMSE* Mini-Mental State Examination, [m]*CI* cerebral infarction, [n]*CH* cerebral hemorrhage, [o]*SAH* subarachnoid hemorrhage, [p]*R* right, *L* left, [q]*MI* myocardial infarction, [r]*AF* atrial fibrillation

hemiparesis and depressive symptoms, Bonferroni multiple comparison analysis showed that RT was significantly shorter in patients without MCI (626 ± 59 ms) compared with patients with MCI (855 ± 63 ms) (p = 0.01, d = 1.942). There was no difference in RT among patients either with MCI (884 ± 55 ms) or without MCI (772 ± 27 ms) in patients without depressive symptoms (p = 0.07, d = 0.656).

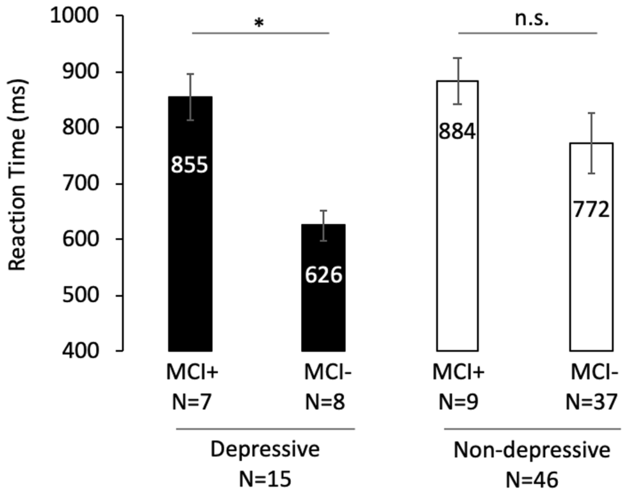

Fig. 4 Comparisons of RTs to select the neutral face in two simultaneously presented images. There was no interaction between depressive symptoms and cognitive function. Further, there was a main effect in cognitive function (MCI+ vs. MCI−) and no main effect in depressive symptoms (depressive vs. non-depressive). Patients without depressive symptoms did not show MCI-related RT differences (right), whereas those with depressive symptoms exhibited statistically significant differences (left). Bars and error bars present the mean and standard error, respectively. $^{*}p < 0.05$. MCI, mild cognitive impairment; MCI+, MMSE score is 24–27, MCI−, MMSE score is 28–30; MMSE, Mini-Mental State Examination; RT, reaction time; n.s., not significant

Sensitivity analysis showed no interaction or main effect in depression, but showed main effect in MCI of affected side (interaction: F [3, 57] = 0.1.350, $p = 0.250$, $\eta^2 = 0.038$; main effect [depression]: F [3, 57] = 2.765, $p = 0.102$, $\eta^2 = 0.047$; main effect [MCI]: F [3, 57] = 8.477, $p = 0.005$, $\eta^2 = 0.131$); and severity of motor paralysis (interaction: F [3, 57] = 2.692, $p = 0.106$, $\eta^2 = 0.046$; main effect [depression]: F [3, 57] = 2.692, $p = 0.106$, $\eta^2 = 0.046$; main effect [MCI]: F [3, 57] = 10.268, $p = 0.002$, $\eta^2 = 0.155$). There was no difference in RT comparisons with a cut-off score of MCI set at MMSE ≤ 25 (F [2, 57] = 0.037, $p = 0.848$, $\eta^2 = 0.001$); MMSE ≤ 26 (F [2, 57] = 0.004, $p = 0.949$, $\eta^2 < 0.001$); and MMSE ≤ 28 (F [3, 57] = 2.227, $p = 0.137$, $\eta^2 = 0.039$) (Supplement 2).

In the linear regression analysis, the MMSE score showed a significant regression model fit with RT (standard estimate = − 0.263, 95% CI − 0.514, − 0.0116; $p = 0.041$). No association was found between the BDI-II scores and RT (standard estimate = − 0.157, 95% CI − 0.471, 0.157; $p = 0.314$).

Kruskal–Wallis analysis showed that fatigue in patients with MCI did not affect RT ($p = 0.994$). t test comparing RT in patients with MCI and without MCI showed a significant difference between the two groups ($T = 2.000$, $p = 0.014$, $d = 0.799$). In addition, examination was performed to determine if paralysis on the dominant side affected the RT delay and loss of accuracy. There were no differences in RT ($T = 1.407$, $p = 0.165$, $d = 0.361$) and accuracy ($T = 0.400$, $p = 0.691$, $d = 0.102$) when paralysis was on the dominant side.

Comparison Among the Four Study Groups by Depression and Cognitive Function

To examine the association of factors affecting RT, age, days from onset to examination, motor paralysis, ADL, mood states, and cognitive function were compared among the four groups of patients with or without depressive symptoms and cognitive impairment using one-way ANOVA. No main effects were found for age, days since onset of stroke, motor paralysis, ADL, and mood symptoms of anger hostility among the four groups ($p > 0.05$). By contrast, main effects were detected in the BDI-II scores; and the POMS subscales of tension anxiety, depression dejection, vigor, fatigue, confusion, and total mood disturbance; as well as the MMSE ($p < 0.05$, Table 1).

Discussion

This study examined whether RT is affected by depressive symptoms and cognitive function in patients with hemiparesis. MCI affected RT in patients with hemiparesis, whereas depressive symptoms did not. Patients without MCI had shorter RTs compared with those with MCI among patients with hemiparesis and depressive symptoms. In stroke patients without depressive symptoms, RTs did not differ between those with MCI and those without. This suggests that the differential RT observed in individuals with hemiparesis was dependent on cognitive function and depressive symptoms when selecting a neutral facial expression from angry and neutral faces. From the results of the regression analysis, it was found that RT can predict MCI, but it is difficult to predict depressive symptoms. RT was shown to be a factor affecting MCI. These results partially support the hypothesis that depressive symptoms and MCI affect RT in individuals with hemiparesis.

According to our knowledge, this is the first study to compare AB according to the presence of post-stroke depressive symptoms and the degree of cognitive function impairment. The data of this study can serve as a benchmark for AB in individuals with hemiparesis because only participants who were able to correctly select neutral facial expressions from neutral and angry expressions were analyzed. Of the 61 patients analyzed, 15 had depression according to the test scores, and 46 were not depressed. The rate of depression after stroke in the present study (patients with depression: patients without depression, 1:3) was the same as that observed in previous studies [1, 2]. Therefore, the prevalence of individuals with hemiparesis and depression in our data was similar to that reported in previous studies.

The results of this study suggest that AB occurs among patients with stroke but without MCI independent of the presence or absence of depressive symptoms. In the selection task of neutral stimuli from angry and neutral expressions, younger people without depressive symptoms have been shown to have shorter RTs than those with depressive symptoms [14, 21]. According to a study that performed similar tasks in older adults, RTs were lower in people with depressive symptoms than in those without depressive symptoms [22]. One study of older adults has reported no difference in RT to detect neutral and aversive stimuli [24]. Younger people with depression have a longer RT for neutral stimuli. Conversely, older adults with depression have either a shorter RT for neutral stimuli or no difference compared with those without depression. This phenomenon shows that cognitive function influences RT in older adults, and thus suggests that depressive symptoms may not affect RT in individuals with hemiparesis and cognitive impairment.

Previous studies have reported a relation between MCI and slow RT in older adults [73]. Cognitive impairment in older adults has been reported to result in delays in motor response and information processing [54]. Individuals with MCI have been reported to have slow motor responses to stimuli [74]. Similarly, the results of this study suggest that RT was affected by cognitive function in individuals with hemiparesis. Therefore, cognitive function may influence RT in individuals with hemiparesis as well as in older adults.

In this study, patients without MCI had a shorter RT compared with those with MCI among individuals with hemiparesis and depressive symptoms. This finding is similar to previous studies that have reported shorter RT for neutral stimuli selected from a choice of angry and neutral stimuli in older adults [24, 75]. Older adults have been shown to pay more attention to non-negative stimuli when in a negative mood [27]. These results suggest that the positivity effect selectively captures positive and neutral information over negative information. In addition, people with depressive symptoms have been reported to exhibit harm avoidance personality traits [28, 29]. People with Internet addiction are reported to have high harm avoidance and short RT [32], and people with bipolar disorder have been reported to have higher harm avoidance and slower RT than healthy participants [76]. Patients exhibiting high levels of harm avoidance have been shown to have reduced RTs to avoiding irritation when treated with cortisol [32]. Harm avoidance and the positivity effect may reduce RT by promoting the avoidance of aversive stimuli in individuals with stroke and depressive symptoms.

This study used a face selection task to measure RT rather than a dot probe task. The dot probe task involves selecting the position or shape of dots displayed after image stimulation, and it may not be able to evaluate AB accurately if participants have difficulty recognizing facial expressions. Most individuals with stroke are older adults. Older adults are known to have lower facial expression recognition than younger adults [48], and those with depression have more difficulty recognizing facial expressions than older adults without depression [49]. Further, individuals with hemiparesis do not recognize facial expressions as well as healthy individuals [50, 51]. Thus, individuals with hemiparesis and depressive symptoms may have reduced facial expression recognition, which may make it difficult to detect AB using the dot probe task.

There are two methods of intervention for PSD: exposure to aversive stimuli [47] and quick avoidance of stimuli [44, 45]. In ABM, the exposure to aversive stimuli aims at desensitization by actively paying attention to stimuli that cause unpleasant emotions [77]. Conversely, ABM for diverting attention from an aversive stimulus is used when a patient with depression or anxiety is attentive to a subject that provokes an aversion. A suitable interventional method for attenuating depressive symptoms in patients with PSD but without MCI may be desensitization by exposure to aversive stimuli, or methods other than ABM may be appropriate in clinical practice.

This study has the following limitations: first, the patients with hemiparesis in this study were patients at the convalescence stage approximately 90 days after the disease onset. It is unclear whether similar results would be obtained in individuals with hemiparesis in the chronic phase or directly after disease onset in the acute phase. AB might vary due to psychological changes in the process of stroke recovery; therefore, it is necessary to investigate AB for cognitive and psychological interventions in the recovery process, i.e., in the chronic and the acute phase of the stroke. Second, this study was conducted at a single institution, and it is necessary to investigate whether the results can be reproduced elsewhere. Further, an additional study is needed to determine whether the same results can be obtained using the dot probe task. Third, the sample size of this study was smaller than originally planned. No significant difference was detected for depressive symptoms, and the possibility of a type 2 error cannot be ruled out. In addition, type 1 errors may have occurred in the post hoc analysis. To verify the results of this study, a future multicenter approach with a larger sample size is required. Fourth, the study did not test for unilateral spatial neglect in patients with stroke. Facial expression recognition and response time accuracy can both be affected in patients with unilateral spatial neglect. Since the patients in this study did not have severe cognitive impairment, unilateral spatial neglect could have been evaluated in advance before measuring the attention bias of individuals with hemiparesis. Fifth, as a method of AB measurement in this study, the time for facial expression selection was measured, but not the simple reaction time. However, previous studies have reported that the simple reaction time of older adults is 266–308 ms and that for patients with MCI is 309–359 ms [78]. The response time of stimuli with emotional value in older adults is 717–873 ms [22, 79]. Therefore, it is considered that similar performance can be measured because the reaction time of 626–884 ms in this study was similar to the reaction time with the emotional value of older adults. Additionally, the dominant hand was not being checked. Instead, we compared the RT differences between the right and left hands and confirmed that there were no differences. Furthermore, in a previous study, participants measured the RT using auditory stimulation to move the thumb with their left and right hands. There was no difference in the RT of thumb movements using auditory stimulation in the elderly [80]. Although the present study incorporated a visual stimulus, no differences are expected between the dominant and the non-dominant hand.

Conclusions

The results of this study show that patients with depressive symptoms and hemiparesis but without MCI can quickly select a neutral facial expression when presented with a neutral and an angry expression. Thus, patients with stroke and depression but without MCI do not need ABM to avoid aversive stimuli. Interventions that expose these patients to aversive stimuli may be appropriate, or cognitive behavioral intervention may be indicated instead of ABM.

Supplementary Information The online version contains supplementary material available at (https://doi.org/10.1007/s12529-020-09940-2).

Acknowledgments We would like to thank the rehabilitation staff at the Toda Chuo Rehabilitation Hospital for their help to accomplish this study.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study. Additional informed consent was obtained from all individual participants for whom identifying information is included in this article.

References

1. Mitchell AJ, Sheth B, Gill J, et al. Prevalence and predictors of post-stroke mood disorders: a meta-analysis and meta-regression of depression, anxiety and adjustment disorder. Gen Hosp Psychiatry. 2017;47:48–60.
2. Hackett ML, Yapa C, Parag V, Anderson CS. Frequency of depression after stroke: a systematic review of observational studies. Stroke. 2005;36:1330–40.
3. Krishnamurthi RV, Feigin VL, Forouzanfar MH, et al. Global and regional burden of first-ever ischaemic and haemorrhagic stroke during 1990–2010: findings from the Global Burden of Disease Study. Lancet Glob Health. 2010;2013:e259-281.
4. Li J, Oakley LD, Brown RL, Li Y, Ye M, Luo Y. Early symptom measurement of post-stroke depression (PSD). J Affect Disord. 2016;197:215–22.
5. Wuthrich VM, Johnco CJ, Wetherell JL. Differences in anxiety and depression symptoms: comparison between older and younger clinical samples. Int Psychogeriatr. 2015;27:1523–32.
6. Wei J, Ying M, Xie L, et al. Late-life depression and cognitive function among older adults in the U.S.: The National Health and Nutrition Examination Survey 2011–2014. J Psychiatr Res. 2019;111:30–5.
7. Akinyemi RO, Allan L, Owolabi MO, et al. Profile and determinants of vascular cognitive impairment in African stroke survivors: the CogFAST Nigeria Study. J Neurol Sci. 2014;346:241–9.
8. Ezema CI, Akusoba PC, Nweke MC, Uchewoke CU, Agono J, Usoro G. Influence of post-stroke depression on functional independence in activities of daily living. Ethiop J Health Sci. 2019;29:841–6.
9. Fujita T, Sato A, Tsuchiya K, et al. Relationship between grooming performance and motor and cognitive functions in stroke patients with receiver operating characteristic analysis. J Stroke Cerebrovasc Dis. 2017;26:2828–33.
10. Haghgoo HA, Pazuki ES, Hosseini AS, Rassafiani M. Depression, activities of daily living and quality of life in patients with stroke. J Neurol Sci. 2013;328:87–91.
11. Mathews A, MacLeod C. Cognitive vulnerability to emotional disorders. Annu Rev Clin Psychol. 2005;1:167–95.
12. Taylor JL, John CH. Attentional and memory bias in persecutory delusions and depression. Psychopathology. 2004;37:233–41.
13. Cavanagh J, Geisler MW. Mood effects on the ERP processing of emotional intensity in faces: a P3 investigation with depressed students. Int J Psychophysiol. 2006;60:27–33.
14. Joormann J, Gotlib IH. Selective attention to emotional faces following recovery from depression. J Abnorm Psychol. 2007;116:80–5.
15. Koster EH, Crombez G, Verschuere B, Van Damme S, Wiersema JR. Components of attentional bias to threat in high trait anxiety: facilitated engagement, impaired disengagement, and attentional avoidance. Behav Res Ther. 2006;44:1757–71.
16. Surguladze S, Brammer MJ, Keedwell P, et al. A differential pattern of neural response toward sad versus happy facial expressions in major depressive disorder. Biol Psychiatry. 2005;57:201–9.
17. MacLeod C, Rutherford E, Campbell L, Ebsworthy G, Holker L. Selective attention and emotional vulnerability: assessing the causal basis of their association through the experimental manipulation of attentional bias. J Abnorm Psychol. 2002;111:107–23.
18. Leyman L, De Raedt R, Vanderhasselt MA, Baeken C. Effects of repetitive transcranial magnetic stimulation of the dorsolateral prefrontal cortex on the attentional processing of emotional information in major depression: a pilot study. Psychiatry Res. 2011;185:102–7.

19. Dai Q, Hu L, Feng Z. Attentional bias modification reduces clinical depression and enhances attention toward happiness. J Psychiatr Res. 2019;109:145–55.
20. Lazarov A, Bar-Haim Y. Attention bias modification treatment reduces depression symptoms in youth. J Am Acad Child Adolesc Psychiatry. 2016;55:161–2.
21. Yang W, Zhang JX, Ding Z, Xiao L. Attention bias modification treatment for adolescents with major depression: a randomized controlled trial. J Am Acad Child Adolesc Psychiatry. 2016;55(208–218):e2.
22. Mohlman J, Price RB, Vietri J. Attentional bias in older adults: effects of generalized anxiety disorder and cognitive behavior therapy. J Anxiety Disord. 2013;27:585–91.
23. Reed AE, Chan L, Mikels JA. Meta-analysis of the age-related positivity effect: age differences in preferences for positive over negative information. Psychol Aging. 2014;29:1–15.
24. Namaky N, Beltzer ML, Werntz AJ, Lambert AE, Isaacowitz DM, Teachman BA. Moderators of age effects on attention bias toward threat and its association with anxiety. J Affect Disord. 2017;216:46–57.
25. Carstensen LL, DeLiema M. The positivity effect: a negativity bias in youth fades with age. Curr Opin Behav Sci. 2018;19:7–12.
26. Isaacowitz DM, Toner K, Goren D, Wilson HR. Looking while unhappy: mood-congruent gaze in young adults, positive gaze in older adults. Psychol Sci. 2008;19:848–53.
27. Prochwicz K, Gawęda Ł. Depression and anxiety mediate the relationship between temperament and character and psychotic-like experiences in healthy subjects. Psychiatry Res. 2016;246:195–202.
28. Balestri M, Porcelli S, Souery D, et al. Temperament and character influence on depression treatment outcome. J Affect Disord. 2019;252:464–74.
29. Afanasiev S, Aharon-Peretz J, Granot M. Personality type as a predictor for depressive symptoms and reduction in quality of life among stroke survivals. Am J Geriatr Psychiatry. 2013;21:832–9.
30. Wilson RS, Boyle PA, Levine SR, et al. Harm avoidance and cerebral infarction. Neuropsychology. 2014;28:305–11.
31. Choi JS, Park SM, Roh MS, et al. Dysfunctional inhibitory control and impulsivity in internet addiction. Psychiatry Res. 2014;215:424–8.
32. van Peer JM, Roelofs K, Rotteveel M, van Dijk JG, Spinhoven P, Ridderinkhof KR. The effects of cortisol administration on approach-avoidance behavior: an event-related potential study. Biol Psychol. 2007;76:135–46.
33. Knight M, Seymour TL, Gaunt JT, Baker C, Nesmith K, Mather M. Aging and goal-directed emotional attention: distraction reverses emotional biases. Emotion. 2007;7:705–14.
34. Gupta RS, Kujawa A, Vago DR. The neural chronometry of threat-related attentional bias: event-related potential (ERP) evidence for early and late stages of selective attentional processing. Int J Psychophysiol. 2019;146:20–42.
35. Inui K, Kakigi R. Temporal analysis of the flow from V1 to the extrastriate cortex in humans. J Neurophysiol. 2006;96:775–84.
36. Di Russo F, Berchicci M, Bianco V, et al. Normative event-related potentials from sensory and cognitive tasks reveal occipital and frontal activities prior and following visual events. Neuroimage. 2019;196:173–87.
37. Patel SH, Azzam PN. Characterization of N200 and P300: selected studies of the event-related potential. Int J Med Sci. 2005;2:147–54.
38. Ziemann U, Tergau F, Wassermann EM, Wischer S, Hildebrandt J, Paulus W. Demonstration of facilitatory I wave interaction in the human motor cortex by paired transcranial magnetic stimulation. J Physiol. 1998;511:181–90.
39. Beard C, Sawyer AT, Hofmann SG. Efficacy of attention bias modification using threat and appetitive stimuli: a meta-analytic review. Behav Ther. 2012;43:724–40.
40. Demeyer I, Sanchez A, De Raedt R. Older adults' attentional deployment: differential gaze patterns for different negative mood states. J Behav Ther Exp Psychiatry. 2017;55:49–56.
41. Bar-Haim Y, Lamy D, Pergamin L, Bakermans-Kranenburg MJ, van IJzendoorn MH. Threat-related attentional bias in anxious and nonanxious individuals: a meta-analytic study. Psychol Bull. 2007;133:1–24.
42. Broomfield NM, Davies R, MacMahon K, Ali F, Cross SM. Further evidence of attention bias for negative information in late life depression. Int J Geriatr Psychiatry. 2007;22:175–80.
43. Armstrong T, Olatunji BO. Eye tracking of attention in the affective disorders: a meta-analytic review and synthesis. Clin Psychol Rev. 2012;32:704–23.
44. Kuckertz JM, Najmi S, Baer K. Amir N. Refining the analysis of mechanism-outcome relationships for anxiety treatment: A preliminary investigation using mixed models. Behav Modif; 2019. p. 1454455198421055.
45. See J, MacLeod C, Bridle R. The reduction of anxiety vulnerability through the modification of attentional bias: a real-world study using a home-based cognitive bias modification procedure. J Abnorm Psychol. 2009;118:65–75.
46. Luo X, Ikani N, Barth A, Rengers L, Becker E, Rinck M. Attention bias modification in specific fears: spiders versus snakes. J Behav Ther Exp Psychiatry. 2015;49(Pt A):30–6.
47. Sharpe L, Johnson A, Dear BF. Attention bias modification and its impact on experimental pain outcomes: comparison of training with words versus faces in pain. Eur J Pain. 2015;19:1248–57.
48. Campbell A, Murray JE, Atkinson L, Ruffman T. Face age and eye gaze influence older adults' emotion recognition. J Gerontol B Psychol Sci Soc Sci. 2017;72:633–6.
49. Shiroma PR, Thuras P, Johns B, Lim KO. Facial recognition of happiness among older adults with active and remitted major depression. Psychiatry Res. 2016;243:287–91.
50. Braun M, Traue HC, Frisch S, Deighton RM, Kessler H. Emotion recognition in stroke patients with left and right hemispheric lesion: results with a new instrument-the FEEL Test. Brain Cogn. 2005;58:193–201.
51. Abbott JD, Wijeratne T, Hughes A, Perre D, Lindell AK. The perception of positive and negative facial expressions by unilateral stroke patients. Brain Cogn. 2014;86:42–54.
52. Hussein T, Yiou E, Larue J. Age-related differences in motor coordination during simultaneous leg flexion and finger extension: influence of temporal pressure. PLoS ONE. 2013;8:e83064.
53. Mary A, Bourguignon M, Wens V, et al. Aging reduces experience-induced sensorimotor plasticity. A magnetoencephalographic study Neuroimage. 2015;104:59–68.
54. Salek Y, Anderson ND, Sergio L. Mild cognitive impairment is associated with impaired visual-motor planning when visual stimuli and actions are incongruent. Eur Neurol. 2011;66:283–93.
55. Warmenhoven F, van Rijswijk E, Engels Y, et al. The Beck Depression Inventory (BDI-II) and a single screening question as screening tools for depressive disorder in Dutch advanced cancer patients. Support Care Cancer. 2012;20:319–24.
56. Huffman JC, Doughty CT, Januzzi JL, Pirl WF, Smith FA, Fricchione GL. Screening for major depression in post-myocardial infarction patients: operating characteristics of the Beck Depression Inventory-II. Int J Psychiatry Med. 2010;40:187–97.
57. Evans TC, Britton JC. Improving the psychometric properties of dot-probe attention measures using response-based computation. J Behav Ther Exp Psychiatry. 2018;60:95–103.
58. Koizumi K, Tayama J, Ishioka T, et al. Anxiety, fatigue, and attentional bias toward threat in patients with hematopoietic tumors. PLoS ONE. 2018;13:e0192056.

59. Dailey MN, Joyce C, Lyons MJ, et al. Evidence and a computational explanation of cultural differences in facial expression recognition. Emotion. 2010;10:874–93.
60. Kojima M, Furukawa TA, Takahashi H, Kawai M, Nagaya T, Tokudome S. Cross-cultural validation of the Beck Depression Inventory-II in Japan. Psychiatry Res. 2002;110:291–9.
61. Lerdal A, Kottorp A, Gay CL, Grov EK, Lee KA. Rasch analysis of the Beck Depression Inventory-II in stroke survivors: a cross-sectional study. J Affect Disord. 2014;158:48–52.
62. Yokoyama K, Araki S, Kawakami N. Takeshita T [Production of the Japanese edition of profile of mood states (POMS): assessment of reliability and validity]. Nihon Koshu Eisei Zasshi. 1990;37:913–8.
63. Ohnishi A, Mori K, Kohriyama K, Miyata M, Murai Y. Ikeda M [Japanese translation of profile of mood states (POMS)–interpretation of the fifty-six items of mood factors and their application in a manufacturing automotive parts factory]. J UOEH. 1993;15:147–54.
64. Bour A, Rasquin S, Boreas A, Limburg M, Verhey F. How predictive is the MMSE for cognitive performance after stroke? J Neurol. 2010;257:630–7.
65. Shigemori K, Ohgi S, Okuyama E, Shimura T, Schneider E. The factorial structure of the Mini-Mental State Examination (MMSE) in Japanese dementia patients. BMC Geriatr. 2010;10:36.
66. Roalf DR, Moore TM, Mechanic-Hamilton D, et al. Bridging cognitive screening tests in neurologic disorders: a crosswalk between the short Montreal Cognitive Assessment and Mini-Mental State Examination. Alzheimers Dement. 2017;13:947–52.
67. Tsai JC, Chen CW, Chu H, et al. Comparing the sensitivity, specificity, and predictive values of the Montreal cognitive assessment and mini-mental state examination when screening people for mild cognitive impairment and dementia in Chinese population. Arch Psychiatr Nurs. 2016;30:486–91.
68. Brunnstrom S. Motor testing procedures in hemiplegia: based on sequential recovery stages. Phys Ther. 1966;46:357–75.
69. Kokura Y, Maeda K, Wakabayashi H, Nishioka S, Higashi S. High nutritional-related risk on admission predicts less improvement of functional independence measure in geriatric stroke patients: a retrospective cohort study. J Stroke Cerebrovasc Dis. 2016;25:1335–41.
70. Umehara T, Tanaka R, Tsunematsu M, et al. Can the amount of interventions during the convalescent phase predict the achievement of independence in activities of daily living in patients with stroke? A retrospective cohort study. J Stroke Cerebrovasc Dis. 2018;27:2436–44.
71. Hanley CJ, Burianová H, Tommerdahl M. Towards establishing age-related cortical plasticity on the basis of somatosensation. Neuroscience. 2019;404:407–12.
72. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods. 2007;39:175–91.
73. Phillips M, Rogers P, Haworth J, Bayer A, Tales A. Intra-individual reaction time variability in mild cognitive impairment and Alzheimer's disease: gender, processing load and speed factors. PLoS ONE. 2013;8:e65712.
74. Missonnier P, Deiber MP, Gold G, et al. Working memory load-related electroencephalographic parameters can differentiate progressive from stable mild cognitive impairment. Neuroscience. 2007;150:346–56.
75. Demeyer I, De Raedt R. Attentional bias for emotional information in older adults: the role of emotion and future time perspective. PLoS ONE. 2013;8:e65429.
76. Vierck E, Joyce PR. Influence of personality and neuropsychological ability on social functioning and self-management in bipolar disorder. Psychiatry Res. 2015;229:715–23.
77. Van Bockstaele B, Notebaert L, MacLeod C, et al. The effects of attentional bias modification on emotion regulation. J Behav Ther Exp Psychiatry. 2019;62:38–48.
78. Bagurdes LA, Mesulam MM, Gitelman DR, Weintraub S, Small DM. Modulation of the spatial attention network by incentives in healthy aging and mild cognitive impairment. Neuropsychologia. 2008;46:2943–8.
79. Cabrera I, Brugos D, Montorio I. Attentional biases in older adults with generalized anxiety disorder. J Anxiety Disord. 2020;71:102207.
80. Levin O, Cuypers K, Netz Y, et al. Age-related differences in human corticospinal excitability during simple reaction time. Neurosci Lett. 2011;487:53–7.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.