Title: Pareidolias in REM sleep behavior disorder: a possible predictive marker of Lewy body diseases?

Subtitle: Pareidolias in REM sleep behavior disorder

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Abstract:

Study objectives: To investigate conditions and clinical significance of pareidolias in patients with idiopathic REM sleep behavior disorder (iRBD).

Methods: This cross-sectional study examined 202 patients with idiopathic rapid eye movement sleep behavior disorder (66.8±8.0 yr, 58 female) and 46 healthy control subjects (64.7±5.8 yr, 14 female). They underwent the Pareidolia test, a newly developed instrument for evoking pareidolias, video-polysomnography, olfactory tests, and Addenbrooke's cognitive examination – revised.

Results: Results show that 53.5% of iRBD patients exhibited one or more pareidolic responses: the rate was higher than control subjects showed (21.7%). The pictures evoking pareidolic responses were more numerous for iRBD patients than for control subjects (1.2±1.8 vs. 0.4±0.8, $P < .001$). Sub-group analyses revealed that iRBD patients with pareidolic responses had higher amounts of REM sleep without atonia (RWA), with lower sleep efficiency, lower cognitive function, and older age than subjects without pareidolic responses. Results of multivariate analyses show the number of pareidolic responses as a factor associated with decreased cognitive function in iRBD patients with better predictive accuracy. Morbidity length and severity of rapid eye

movement sleep behavior disorder, olfactory function, and the amount of RWA were not factors associated with better predictive accuracy.

Conclusions: Half or more of the iRBD patients showed pareidolic responses. The responses were proven to be associated more intimately with their cognitive decline than clinical or physiological variables related with RBD. Pareidolias in iRBD are useful as a predictive marker of future development of Lewy body diseases.

Keywords:

Pareidolias, rapid eye movement sleep behavior disorder, dementia with Lewy bodies, visual hallucination, visual illusion

Statement of Significance:

Pareidolia, a complex visual illusion by which a person perceives ambiguous forms as meaningful objects and a potential surrogate indicator of visual hallucinations, is experienced more frequently by patients with REM sleep behavior disorder than by

control subjects. Patients with pareidolia had a greater amount of REM sleep without atonia, lower sleep efficiency, and lower cognitive function than those without. Pareidolia rather than REM sleep behavior disorder-related variables was associated with their cognitive decline, which suggests that patients with pareidolia constitute a subgroup close to clinical Lewy body diseases.

Introduction

Rapid eye movement sleep behavior disorder (RBD) has been recognized increasingly as a prodromal phase of alpha-synucleinopathies.[1] Under these circumstances, reports of the last decade have described possible early markers of the development of alpha-synucleinopathies from idiopathic RBD (iRBD): olfactory dysfunction,[2] electroencephalographic slowing findings,[3] disturbed color vision,[4] and the amount of rapid eye movement sleep without atonia.[5]

Pareidolias are complex visual illusions of meaningful objects such as faces of persons or animals deriving from ambiguous forms embedded in visual scenes. They phenomenologically resemble visual hallucinations, which are cardinal symptoms of dementia with Lewy bodies (DLB) or Parkinson's disease.[6] A recent study has established a useful tool, the Pareidolia test, to evoke and measure pareidolias as a surrogate indicator of visual hallucinations in patients with DLB.[7] The study group found that pareidolic responses were observed more frequently in patients with DLB than in patients with Alzheimer's disease or healthy control subjects, and that the responses were detected even in patients without visual hallucinations.[7, 8] Thereafter, they reported detection of the responses in patients with Parkinson disease without dementia.[9]

Given these recent observations, we hypothesized that pareidolias would be observed in patients with iRBD. This study was conducted to investigate the frequency of pareidolias and the clinical significance of the phenomenon for iRBD.

METHODS

Participants

This study enrolled 202 consecutive patients with iRBD who visited the outpatient clinic of the Japan Somnology Center, Neuropsychiatric Research Institute (Yoyogi Sleep Disorder Center) during December 2012 – March 2015. Inclusion criteria were the following: (1) diagnosed as iRBD according to the second edition of International Classification of Sleep Disorders [10] based on a clinical interview at the first visit and findings of nocturnal polysomnography; (2) no history of other sleep disorder or alpha-synucleinopathy based on clinical charts, interviews, and imaging findings if available; (3) free of medication including antiepileptic drugs, antidepressants, anticholinergic drugs, cholinesterase inhibitors, hypnotics, psychostimulant drugs, or dopaminergic drugs. Additionally, 46 age-matched and sex-matched healthy control subjects were recruited through an announcement to patients' family members or members of a private recruiting company's research panel.

All participants underwent nocturnal polysomnography and a structured clinical interview by board-certified sleep specialists and neurologists. They also answered the Epworth Sleepiness Scale[11] and validated questionnaires for the evaluation of RBD symptoms: Japanese versions of RBD screening questionnaire[12] and RBD questionnaire.[13] Addenbrooke's cognitive examination – revised,[14] behavioral assessment using the Neuropsychiatric Inventory,[15] the Sniffin' Sticks test[16] and the Pareidolia test[7] were administered before nocturnal polysomnography.

Written informed consent was obtained from all participants. The Ethical Committee of the Neuropsychiatric Research Institute reviewed and approved the study protocol, which is in accordance with the Declaration of Helsinki.

Nocturnal polysomnography and scoring

Diagnostic nocturnal video-polysomnography was performed using a standard system (Alice 5; Respironics Inc., Murrysville, PA, USA) including six channels of scalp electroencephalographic data (F3/A2, F4/A1, C3/A2, C4/A1, O1/A2, O2/A1), two of electrooculography, submental electromyography, electrocardiography, nasal/oral airflow data, a percutaneous oximetry sensor for recording oxygen saturation data, a microphone for detecting snoring sounds, chest/abdominal respiratory effort data, and

bilateral anterior tibialis electromyography. Sleep stages and electroencephalographic arousal, periodic limb movements during sleep, respiratory events, and RWA were scored carefully by board-certified sleep technologists according to criteria set by the American Academy of Sleep Medicine.[17]

Behavioral assessment

Three domains of the Neuropsychiatric Inventory were administered to participants: delusion, hallucination, and fluctuations in cognition. Some modification of the original Neuropsychiatric Inventory relevant to the three domains was made as follows: (1) the "delusion" domain was separated into persecutory delusion and delusional misidentification categories; and (2) an additional domain for fluctuation in cognition was employed.[18] For each behavior, the frequency (range 1–4), severity (range 1–3), and total score (frequency score multiplied by the severity score) were recorded.

Pareidolia test

We administered a 10 scene picture version of the pareidolia test using procedures described in an earlier report.[7, 19] The pictures show animals, plants, or artifacts. Subjects were instructed to view these pictures sequentially and then to point

to and describe the objects seen in each picture in as much detail as possible within one minute each. The examiner wrote down subjects' answers, and scored the number of pareidolic responses in which subjects falsely identified objects that were not included in the pictures. Examples of pareidolic responses are portrayed in Figure 1. The number of pictures with pareidolic responses was adopted as the outcome measure.

Statistical analysis

To test the normality and equality of variances of the continuous variables, the Shapiro–Wilk test and Levene test were applied. After checking the normality and equality of variances with a *P* value greater than .05, demographic and clinical profiles were compared between the patients with iRBD and the control subjects using Student's *t*-test. Clinical and polysomnographic variables of iRBD patients with and without pareidolic responses were compared using Mann–Whitney U-tests. The numbers of pictures eliciting pareidolic responses for iRBD patients and control subjects were compared using Mann–Whitney U-tests. Chi-square tests were used to compare the categorical variables of iRBD patients and the control subjects. To explore factors that can explain cognitive function in iRBD patients, multiple regression analysis was conducted using bidirectional stepwise methods. Before multiple regression analysis,

correlation analyses were conducted to select appropriate explanatory variables excluding multicollinearity. Demographic and nocturnal polysomnographic variables, RBD-related clinical variables and the number of pareidolic responses in the pareidolia test were adopted for each model 1–3 stepwise. All statistical analyses were conducted using software (SPSS 22.0; SPSS Inc.). Significance was inferred for $P < .05$.

RESULTS

Physical and clinical profiles of study subjects

Table 1 presents the results. Compared to control subjects, the iRBD patients showed lower threshold–discrimination–identification score on the Sniffin' Sticks Test and higher scores of the RBD screening questionnaire and higher scores on the RBD questionnaire (t=10.944, -23.766, and -23.435). Compared to control subjects, the iRBD patients also showed disrupted nocturnal sleep manifested as lower sleep efficiency and higher arousal index (t=2.562 and -5.874), a shorter sleep period time and shorter total sleep time (t=-2.916 and 3.266), a higher periodic limb movement during the sleep index and apnea hypopnea index (t=-6.192 and -3.612), and a greater percentage of phasic and tonic electromyographic activity (t=-11.394 and -10.864). No difference between the iRBD patients and control subjects was observed in terms of subjective daytime sleepiness. In neither group did any person have any complaint of delusion,

hallucination, or fluctuation in cognition. However, compared to control subjects, the iRBD patients showed a lower total score on the Addenbrooke's cognitive examination – revised (t=-2.668).

Distribution of subjects with pareidolic responses

Figure 2 depicts the distribution of subjects with pareidolic responses in the iRBD patients and control subjects. Of 202 iRBD patients, 108 patients (53.5%) showed one or more pareidolic responses: the rate was higher than that of the control subjects (10 subjects, 21.7%) (χ2=15.121, P< .001). The maximum number of pictures with pareidolic responses was nine among the iRBD patients, but the number was only three among the control subjects.

Pareidolic responses and cognitive measures of iRBD patients and control subjects

Figure 3A presents the numbers of pictures with pareidolic responses for the iRBD patients and control subjects. Compared to the control subjects, iRBD patients reported significantly more numerous pictures with pareidolic responses (1.2±1.8 vs. 0.4±0.8, Z=-3.793, P< .001). Figure 3B presents scores of Addenbrooke's cognitive examination – revised. The iRBD patients showed a significantly lower score than

control subjects did (93.0±7.0 vs. 95.2±4.3, t=-2.668, P= .009).

Clinical and polysomnographic data from iRBD patients with and without pareidolic responses

Results are presented in Table 2. Compared to patients without pareidolic responses, iRBD patients with pareidolic responses were found to have older age (Z=-3.962, P< .001), higher percentage of waking after sleep onset (Z=-2.987, P= .003), and lower sleep efficiency (Z=-2.780, P= .005). They also showed higher amounts of RWA (tonic: Z=-1.973, P= .049; phasic: Z=-2.595, P= .009). For neuropsychological measures, compared to the iRBD patients without pareidolic responses, those with pareidolic responses had a lower total score of the Addenbrooke's cognitive examination (Z=-4.507, P< .001), and also showed lower scores of verbal fluency (Z=-5.030, P< .001), language (Z=-3.636, P< .001), and visuospatial perception (Z=-3.570, P< .001).

Factors explaining cognitive function in iRBD patients

Table 3 presents multiple regression analysis results. In model 1, for which demographic and nocturnal polysomnographic variables were used as explanatory variables, age, education level, and sleep efficiency were explainable by the total score of Addenbrooke's cognitive examination (R= .522, R^2= .273). In model 2, for which RBD-related clinical variables were added to the explanatory variables, age, education level and sleep efficiency were explainable by the total score. However, none of the RBD-related clinical variables were associated (R= .545, R^2= .297). In contrast, in model 3, the number of pareidolic responses in the Pareidolia test was extracted as a factor associated with the score of the Addenbrooke's cognitive examination – revised with higher goodness of fit than that of model 2 (R= .613, R^2= .376).

DISCUSSION

This report is the first to describe pareidolias in iRBD patients. The results supported our hypothesis: iRBD patients experience pareidolias more frequently than healthy control subjects do (53.5% vs. 21.7%). Patients who gave pareidolic responses had a greater level of motor dysregulation during REM sleep, lower cognitive function,

and deteriorated sleep stability. Furthermore, the pareidolias were proven to be associated with impaired cognitive function in these patients, although other RBD-related clinical variables were not. These findings suggest that iRBD with pareidolias represents advanced stages of the disorder and suggest that it can be predictive of near-future conversion to clinical Lewy body disease.

Recent studies have revealed that patients with DLB give pareidolic responses more frequently than patients with Alzheimer's disease or healthy control subjects.[7, 8] The number of pareidolic responses was found to be correlated with the severity of visual hallucinations in DLB. Phenomenological similarities exist between the two conditions. These observations suggest that visual hallucinations and pareidolias have common underlying mechanisms. In addition to visuoperceptual deficits, attentional deficits might be crucially important for visual hallucinations in Lewy body diseases.[7, 20, 21] Results of previous studies of cholinergic and anticholinergic agents suggest that cholinergic dysfunction is involved in attentional deficits and visual hallucinations in DLB.[18, 22, 23] Similarly, pareidolias were reportedly improved by donepezil, a cholinesterase inhibitor, in DLB.[8] In agreement with these observations, recent imaging studies have revealed that Parkinson's disease patients with visual hallucinations show reduced volume of cholinergic neuronal structures such as the pedunculopontine

nucleus.[24, 25] In contrast to DLB patients, iRBD patients with pareidolias showed neither marked attentional deficits nor visuoperceptual dysfunction. However, mild cholinergic abnormalities can occur in them by upper brainstem lesions as RBD pathology. In iRBD patients, pareidolias are probably associated with cholinergic abnormalities. However, in an early stage of neurodegenerative disease course, they are not so severe that they are detected as neuropsychological dysfunction including attentional deficits.

In DLB patients, four or more pareidolic responses were observed in 100% of DLB patients, of whom 73.5% had visual hallucinations.[7, 8] Moreover, in PD without dementia patients, one or more pareidolic responses were observed in 57% of patients without visual hallucinations; two or more were observed in all those with visual hallucinations.[9] In accordance with results of their studies, the iRBD patients examined in the present study demonstrated a higher number of pareidolic responses than healthy control subjects did, although none had experienced visual hallucinations. The rate of pareidolic responses of the current iRBD patients was apparently lower in patients with Lewy body diseases, which suggests that iRBD herald Lewy body diseases. It is particularly interesting that the iRBD patients with pareidolic responses showed greater amounts of RWA, lower sleep efficiency, and a greater amount of wake after sleep onset than the iRBD patients without pareidolic responses. Reportedly, the amount of RWA

increases over time,[26] possibly indicating progressive impairment of the lower brainstem neural structures that are responsible for controlling the quantity of excessive muscle activity.[27] Moreover, RWA can herald either RBD or synuclein-mediated neurodegenerative disorders.[28–30] Additionally, sleep–wake cycle disruption is commonly observed in synuclein-mediated neurodegenerative disorders originating from degeneration of the upper brain stem areas that modulate sleep–wake stability.[31, 32] Furthermore, impaired brainstem regulation of the sleep–wake cycle manifested as sleep fragmentation or fluctuating vigilance is associated with the development of visual hallucinations.[33] Some have proposed that RBD might be an early non-dopaminergic manifestation of Parkinson's disease identified in Stage 2 of the Braak staging system for synuclein-mediated neurodegeneration.[34, 35] Given the current findings of a greater level of motor dysregulation during REM sleep and sleep–wake disruption, it can be inferred that iRBD patients with pareidolias represent a subgroup of more advanced pathological status in the ascending neuropathological course than iRBD patients without pareidolias do. A recent neuroimaging study elucidated cholinergic denervation in neocortical, limbic, and thalamic areas in Parkinson disease patients with RBD.[36] This finding also raises the possibility that cholinergic dysfunction is partly associated with pareidolias in iRBD.

Results demonstrate that RBD patients with pareidolias showed lower cognitive function than RBD patients without pareidolias, which suggests that pareidolias in this disorder represent the subgroup closer to clinical Lewy body diseases. Results of comparison between the patients and control subjects revealed that the distribution of the score of cognitive function measure in the patients apparently overlapped with that in healthy control subjects, although the numbers of pareidolias differ greatly between the two groups (Figs. 3A, 3B). These results demonstrate that the presence of pareidolias might enable us to recognize the heterogeneous subgroup of the disorder more precisely than when using cognitive function measures, even before the clinical manifestation of Lewy body diseases. Several prospective reports have described predictive factors for the development of synuclein-mediated neurodegenerative disorders from RBD. Some examples are the amounts of RWA,[5, 28] olfactory dysfunction,[2] and color vision.[4] However, no report in the relevant literature has described a study that specifically examines factors that can identify future symptomatic phenotypes of these neurodegenerative disorders. Visual hallucination, a devastating non-motor symptom of synuclein-mediated neurodegenerative disorders, is known to occur in more than 80% of DLB, in contrast to no more than 30% of Parkinson disease.[37–39] In this study, only pareidolic responses, but not other RBD-related variables,

were associated with lower cognitive function in iRBD. In light of that fact, it can be speculated that pareidolias in this disorder can predict the future development of Lewy body diseases, especially for people who experience visual hallucinations earlier. Future prospective studies must be conducted to confirm this hypothesis, particularly addressing clinical manifestations of visual hallucinations.

Some limitations must be explained along with results of this study. First, a possible observer bias must be inferred because the examiners of the pareidolia test viewed subjects' clinical information. Second is a possible underdiagnosis of alpha-synucleinopathies at the time of study entry by iRBD patients because clinical hallmarks might not appear in the early stage of Lewy body diseases. Furthermore, unfortunately, not all the iRBD patients underwent neurological examinations to rule out the presence of Lewy body diseases.

Pareidolias are observed more frequently in iRBD patients than in healthy control subjects. Patients with pareidolias are characterized by their higher degrees of motor dysregulation during REM sleep and sleep disruption during nocturnal sleep. Furthermore, in these patients, pareidolias, rather than the other RBD-related clinical variables, are associated with cognitive decline. Pareidolias in iRBD can herald future clinical manifestation of Lewy body diseases.

AUTHOR CONTRIBUTIONS

All authors contributed to data collection, analysis, and manuscript preparation. Dr. T. Sasai-Sakuma, the corresponding author, who had full access to all data related to the study, takes responsibility for data integrity and accuracy of the data analysis. Dr. Sasai-Sakuma is responsible for coordination, planning, recruitment, clinical assessment, and data analysis of the study, in addition to manuscript preparation. Dr. Y. Nishio is responsible for planning, interpretation of results, and manuscript preparation. Dr. K. Yokoi is responsible for planning and interpretation of the results, and for manuscript preparation. Dr. E. Mori is responsible for manuscript planning. Dr. Y. Inoue is responsible for planning, interpretation of results, and manuscript preparation.

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LEGENDS

Figure 1. Examples of pareidolic response:

Patients with RBD often misidentified objects or patterns in these pictures as real faces or figures of people and animals (yellow arrow).

Figure 2. Distribution of subjects with pareidolic responses:

RBD, rapid eye movement sleep behavior disorder.

Figure 3. (A) Numbers of pictures with pareidolic responses, and (B) scores of Addenbrooke's cognitive examination – revised in patients with RBD and control subjects:

RBD, rapid eye movement sleep behavior disorder; ACE-R, Addenbrooke's cognitive examination – revised.

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Table 1. Physical and clinical profiles of study subjects

	Idiopathic RBD (*n*=202)	Healthy controls (*n*=46)	*P* values
Age, yr	66.8±8.0	64.7±5.8	.097
Sex (female/male)	58/144	14/32	.816
Education, yr	13.8±2.5	14.6±2.4	.231
Morbidity length of RBD, yr	6.8±7.1	-	-
UPDRS part III (motor part)	2.4±4.0	-	-
RBDSQ-J	8.3±2.6	1.7±1.4	<.001
RBDQ-JP	37.0±15.7	5.4±5.0	<.001
TDI score on Sniffin' Sticks Test	16.9±7.1	27.3±4.9	<.001
Epworth Sleepiness Scale	6.0±4.0	7.2±2.2	
Polysomnographic variables			
SPT, min	460.8±63.0	490.3±50.8	.004
TST, min	372.7±79.2	414.0±61.7	.001
Wake after sleep onset, %SPT	18.9±14.2	15.1±11.8	.097
N1, %SPT	18.4±14.2	10.9±6.2	<.001
N2, %SPT	43.8±14.3	53.8±10.3	<.001
N3, %SPT	2.8±5.3	3.1±4.5	.701
REM, %SPT	16.1±6.7	17.1±6.3	.400
Sleep efficiency, %	76.8±15.5	82.1±11.5	.034
Arousal index, h^{-1}	16.7±9.9	11.0±4.4	<.001
Apnea–hypopnea index, h^{-1}	7.7±10.9	3.8±4.8	<.001

PLMS index, h^{-1}	22.6±35.3	3.6±11.5	<.001
Tonic EMG activity, %REM	15.2±18.1	0.0±0.0	<.001
Phasic EMG activity, % REM	17.8±15.1	1.4±1.7	<.001
Addenbrooke's cognitive examination			
Total [100]	93.0±7.0	95.2±4.3	.009
Attention [18]	17.1±4.2	17.2±0.9	.920
Memory [26]	22.6±3.7	23.3±2.8	.125
Verbal fluency [14]	13.0±1.9	13.5±1.1	.024
Language [26]	25.1±1.2	25.5±1.1	.075
Visuospatial perception [16]	15.5±1.4	15.7±0.7	.102
Neuropsychiatric inventory			
Persecutory delusions	0.0±0.0	0.0±0.0	-
Misidentification delusions	0.0±0.0	0.0±0.0	-
Hallucinations	0.0±0.0	0.0±0.0	-
Fluctuations in cognition	0.0±0.0	0.0±0.0	-

Values are expressed mean±standard deviation. The maximum scores for each dimension in Addenbrooke's cognitive examination are indicated in square brackets. RBD, rapid eye movement sleep behavior disorder; UPDRS, Unified Parkinson's Disease Rating Scale; RBDSQ-J, Japanese version of RBD screening questionnaire; RBDQ-JP, Japanese version of the RBD questionnaire; TDI, threshold–discrimination–identification; SPT, sleep period time; TST, total sleep time; PLMS, periodic limb movements during sleep; EMG, electromyogram; REM, rapid eye movement

Table 2. Clinical and polysomnographic variables between iRBD patients with and without pareidolic responses

	idiopathic RBD without pareidolic responses* (*n*=94)	idiopathic RBD with pareidolic responses* (*n*=108)	*P* values
Age, yr	65.0 (10.0)	68.0 (9.0)	<.001
Education, yr	16.0 (4.0)	12.0 (4.0)	.231
Morbidity length of RBD, yr	5.0 (6.0)	4.0 (7.0)	.400
RBDSQ-J	9.0 (3.0)	9.0 (3.0)	.482
RBDQ-JP	35.0 (17.0)	35.0 (22.0)	.368
TDI score on Sniffin' Sticks Test	17.0 (10.0)	15.0 (9.0)	.153
Epworth Sleepiness Scale	5.0 (4.5)	5.0 (5.0)	.724
Polysomnographic variables			
SPT, min	456.0 (72.8)	462.8 (84.8)	.332
TST, min	390.5 (68.5)	376.5 (127.0)	.068
Wake after sleep onset, %SPT	13.0 (12.0)	18.4 (19.5)	.003
N1, %SPT	16.7 (14.9)	13.5 (14.8)	.155
N2, %SPT	46.4 (18.5)	43.5 (19.6)	.151
N3, %SPT	0.2 (3.1)	0.3 (3.7)	.501
REM, %SPT	16.9 (9.1)	14.5 (10.3)	.068
Sleep efficiency, %	83.2 (16.0)	77.8 (21.9)	.005

Arousal index, h^{-1}	15.8 (11.7)	13.0 (14.5)	.266
Apnea–hypopnea index, h^{-1}	3.7 (6.7)	3.1 (9.0)	.498
PLMS index, h^{-1}	7.3 (41.4)	5.0 (33.2)	.598
Tonic EMG activity, %REM sleep	5.2 (14.1)	12.9 (24.1)	.049
Phasic EMG activity, % REM sleep	11.0 (16.5)	18.3 (20.5)	.009
Addenbrooke's cognitive examination			
Total [100]	96.0 (5.0)	93.0 (9.8)	<.001
Attention [18]	17.0 (1.3)	17.0 (2.0)	.178
Memory [26]	25.0 (3.0)	23.0 (5.8)	.005
Verbal fluency [14]	14.0 (3.0)	13.0 (2.0)	<.001
Language [26]	26.0 (1.0)	25.0 (2.0)	<.001
Visuospatial perception [16]	16.0 (2.0)	16.0 (1.0)	<.001
Neuropsychiatric inventory			
Persecutory delusions	0.0 (0)	0.0 (0)	
Misidentification delusions	0.0 (0)	0.0 (0)	
Hallucinations	0.0 (0)	0.0 (0)	
Fluctuations in cognition	0.0 (0)	0.0 (0)	

Values are expressed as median (inter-quartile range). Maximum scores for each dimension in Addenbrooke's cognitive examination are shown in square brackets. *Number of scenery pictures with pareidolic responses >=1.

RBD, rapid eye movement sleep behavior disorder; RBDSQ-J, Japanese version of the RBD screening questionnaire; RBDQ-JP, Japanese version of the RBD questionnaire; TDI, threshold–discrimination–identification; SPT, sleep period time; TST, total sleep time; PLMS, periodic limb movements during sleep; EMG, electromyogram; REM, rapid eye movement

Table 3. Factors explaining cognitive function in iRBD patients

	Total scores on Addenbrooke's cognitive examination		
	Model 1	Model 2	Model 3
Demographic and n-PSG variables			
Age, yr	-.245***	-.241**	-.195**
Education, yr	.350***	.385***	.285***
Epworth Sleepiness Scale	-.115	-.001	.032
Sleep efficiency, %	.176**	.149*	.115
Arousal index, n/h	.036	.015	-.024
Stage N3	.057	1.022	.053
RBD-related clinical variables			
Morbidity length of RBD		-.072	-.116
TDI score on Sniffin' Sticks Test		.070	.058
RBDQ-JP		-.037	.009
Tonic, %REM sleep		.027	.026
Phasic, %REM sleep		.054	.030
Number of pareidolic responses in the Pareidolia test			-.344***
B	87.730	87.333	94.881
R	.522	.545	.613
R^2	.273	.297	.376

Values are expressed as standardized beta on multiple regression analysis. *P< .05, **P< .01, ***P< .001.

n-PSG, nocturnal polysomnography; N3, NREM3; RBD, rapid eye movement sleep behavior disorder; TDI, threshold–discrimination–identification; RBDQ-JP, Japanese version of the RBD questionnaire; REM, rapid eye movement

Figure 1.

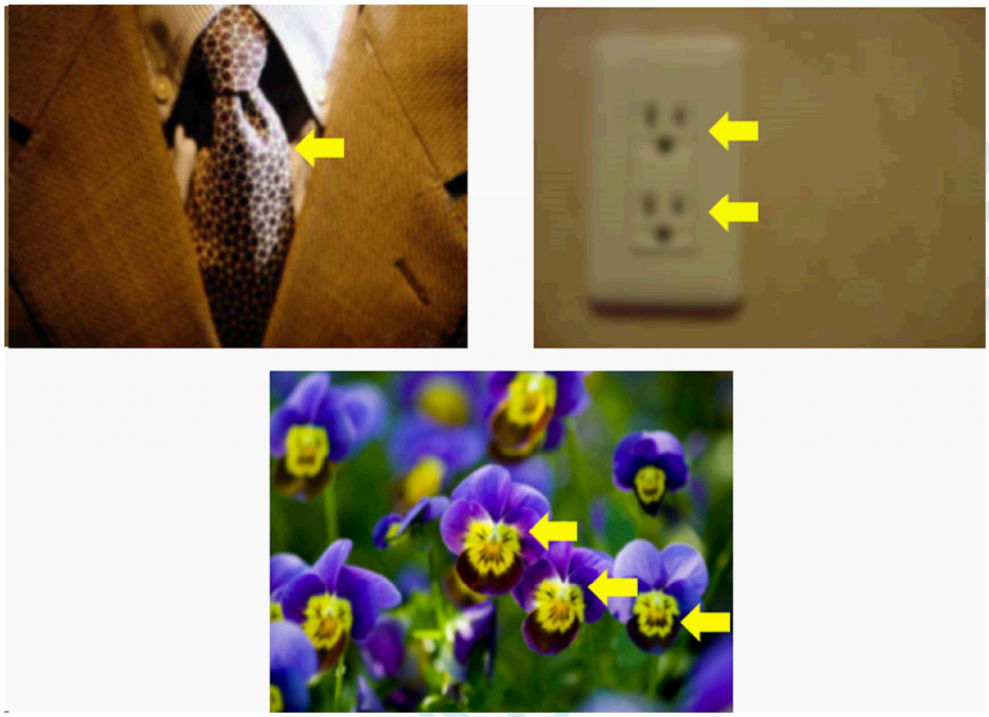

Figure 2.

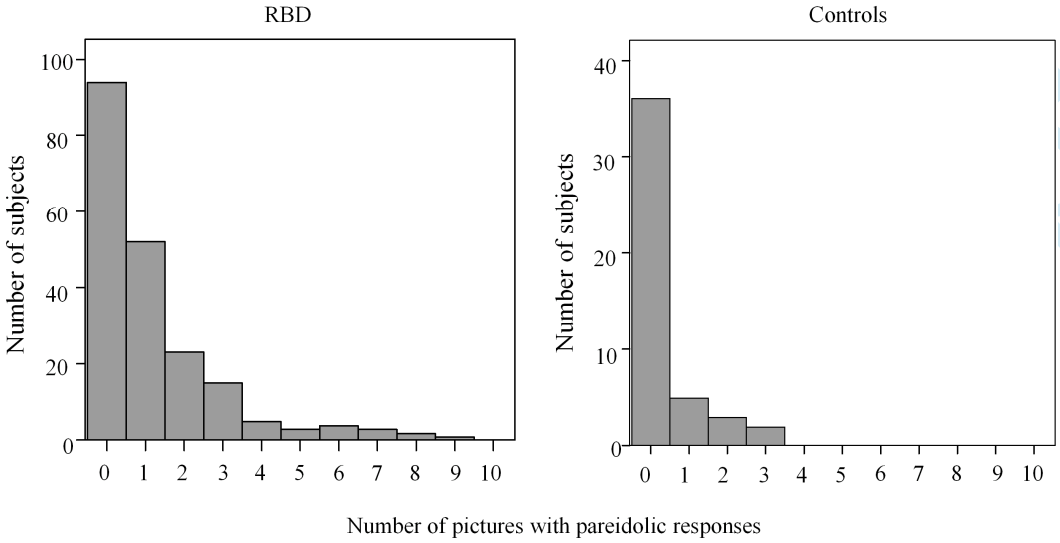

Figure 3.