Review Article

Visuo-cognitive skill deficits in Alzheimer's disease and Lewy body disease: A comparative analysis

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Abstract

Dementia is a chronic neurodegenerative disorder characterized by progressive cognitive loss. Alzheimer's disease (AD) and the Lewy body disease are the two most common causes of age-related degenerative dementia. Visuo-cognitive skills are a combination of very different cognitive functions being performed by the visual system. These skills are impaired in both AD and dementia with Lewy bodies (DLB). The aim of this review is to evaluate various studies for these visuo-cognitive skills. An exhaustive internet search of all relevant medical databases was carried out using a series of key-word applications, including The Cochrane Library, MEDLINE, PSYCHINFO, EMBASE, CINAHL, AMED, SportDiscus, Science Citation Index, Index to Theses, ZETOC, PEDro and occupational therapy (OT) seeker and OT search. We reviewed all the articles until March 2013 with key words of: Visual skills visual cognition dementia AD, but the direct neurobiological etiology is difficult to establish., Dementia of Lewy body disease. Although most studies have used different tests for studying these abilities, in general, these tests evaluated the individual's ability of (1) visual recognition, (2) visual discrimination, (3) visual attention and (4) visuo-perceptive integration. Performance on various tests has been evaluated for assessing these skills. Most studies assessing such skills show that these skills are impaired in DLB as compared with AD. Visuo-cognitive skills are impaired more in DLB as compared with AD. These impairments have evident neuropathological correlations, but the direct neurobiological etiology is difficult to establish.

Key Words

Alzheimer's disease, Lewy body disease, visuo-cognitive skills

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Introduction

Dementia is a chronic neurodegenerative disorder characterized by progressive cognitive loss. Alzheimer's disease (AD) and the Lewy body disease are the two most common causes of age-related degenerative dementia. Impairment of visuo-cognitive skills is a common component of both these forms of dementias.[1] Visuo-cognitive skills are a combination of very different cognitive functions being performed by the visual system. Presence of these skills is pivotal for performance of day-to-day activities. However, these skills are much more important from the perspective of a clinician who often encounters the challenge of treating neurodegenerative dementia patients. A clinical neurologist not only requires this knowledge to properly guide the patient through treatment, but also to diagnose this disorder in the first place. From this clinical stance, the implications of understanding these visual neuropsychological abilities of such dementia patients can be categorized into three important categories. The first category is the role of visual skills in performing day-to-day activities that are impaired in Lewy body disease. In advanced cases of AD, there is a loss of navigational skills. These navigational skills constitute an important part of day-to-day activities, especially in out-of-the-home circumstances. The second category is the diagnostic implications of such visual skills for dementia with Lewy bodies (DLB) that are often a priority, given reports of severe neuroleptic sensitivity and a preferential response to cholinesterase inhibitors in these patients. There have been

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suggestions that constructional apraxia is prevalent in DLB and may provide a sensitive marker of the disease.[2]

In fact, visuo-constructional (VC) tasks, in combination with other tests, can differentiate DLB from normal aging and from AD with sensitivity in excess of 80% and specificity in excess of 90%.[3] Because impairment of visual abilities in DLB is a consistent finding, it has also been suggested that visuo-spatial deficits may actually be a particularly salient biological marker of DLB.[1] The third and perhaps the clinically most important, category is the implications of these skills in evaluating the severity and prognosis of DLB. It has been suggested that visuo-cognitive skill deficits are related to the presence of other symptoms of the disease, especially the visual hallucinations (VHs). Studies have shown that perceptual deficits evident in DLB may be responsible for some misperceptions (i.e., illusions) and delusional misidentification (i.e., not recognizing family, reduplicative paramnesia). Interestingly, DLB patients with VHs tend to perform more poorly on visual tasks than the subset of patients not having VHs.[3,4] Identification of visual spatial impairment is important not only for designating individuals whose clinical syndrome is impacted more by Lewy body formation than AD pathology, but also for predicting, which patients with DLB will have a more malignant disease course.[5] Throughout this review, we will evaluate the impairments in the background of these three dimensions.

Methodology

For assessing the visuo-cognitive deficits in AD and DLB, an exhaustive internet search of all relevant medical databases was carried out using a series of key-word applications including The Cochrane Library, MEDLINE, PSYCHINFO, EMBASE, CINAHL, AMED, SportDiscus, Science Citation Index, Index to Theses, ZETOC, PEDro and occupational therapy (OT) Seeker and OT search. We reviewed all the articles until March 2013 with the key words of: visual skills, visual cognition, dementia, AD, dementia of Lewy body disease. Our search revealed that the visual skills being studied in dementia patients can be divided into four categories:

1. Deficits in visuo-perceptive skills
2. Deficits in visuo-spatial skills
3. Deficits in visuo-constructive skills
4. Deficits in other visual cognitive functions.

Deficits in visuo-perceptive skills

Perceptual abilities are the results of very dynamic interactions between several of our basic visuo-perceptive skills. These perceptual skills have been classified in various was across many studies. Most studies have used different tests for studying these abilities. In general, the domains of these tests can be divided into

1. Visual recognition
2. Visual discrimination
3. Visual attention and
4. Visuo-perceptive integration.[4,6,7]

Thus visual perception needs much more complex processing as compared to the visual spatial skills, which are actually based on visual attention. However, a major challenge of reviewing the studies evaluating visuo-spatial skills is that different studies have used different tests for evaluating visuo-perceptual abilities. These tests often tap more than one of the above-mentioned abilities. Thus, for the purpose of this review, we will evaluate one study at a time to focus on the individual deficits, which these studies have assessed separately. A focused study assessing Visuo-perceptive skills was conducted by Simard *et al*.,[8] whereby the Benton judgment of line orientation (BJLO) test was administered to 4 DLB patients with predominant psychosis (DLB-psy), 4 DLB subjects with predominant parkinsonian features (DLBPD) and 13 patients with AD. An analysis of error types was applied to the results of the BJLO with visual attention errors, as well as visual-spatial perception errors. The results showed that DLB patients with psychosis committed more significant errors of visual attention and visuo-spatial perception than AD patients. However, no difference on the total score of the BJLO was found suggesting severe visuo-perceptive impairments in DLB patients in the visual attention and visuo-spatial perception domains. These results suggest that the defective visual perception could actually contribute to the development of VHs in such patients.

Calderon *et al*.[4] used the screening (figure-ground discrimination) test from the visual object and space perception (VOSP) to differentiate the performances of patients with DLB, AD and normal controls. All three groups performed equally well indicating that patients with AD and those patients with DLB were able to understand the task and both of them retained basic low level visuo-perceptual abilities. On three subtests of the VOSP, namely (a) fragmented letters (b) object decision and (c) cube analysis, there were, however, highly significant group differences with *post-hoc* analyses showing impairment in the DLB group relative to both controls and patients with AD. The DLB patients showed more severe impairments than the AD patients on tests tapping both ventral stream (fragmented letters and object decision) and dorsal stream (cube analysis) aspects of visual perception. However, no difference was observed between controls and the AD group. The silhouette identification task requires subjects to name or identify the silhouette profile of objects and animals viewed from unusual perspectives and it represents both the perceptual and semantic abilities. On the silhouette identification test, the AD and DLB groups were equally impaired relative to control tasks. The simple recognition of a silhouette as a real (vs. unreal) object or animal is thought to require an intact structural description that has been linked to the right temporal lobe. Naming and other forms of accurate item specific identification require additional semantic processes that are associated with the left temporal lobe. The other tests from the VOSP that were failed by patients with DLB do not require semantic processes for their completion and can be considered, pure tests of perceptual ability. In contrast to the findings of Calderon *et al*.,[4] Mori *et al*.[6] found that not only higher-order visual perceptual functions, but also elementary visual perception (size discrimination task) are affected in DLB. They also found that patients with DLB performed significantly worse on both elementary and complex visuo-perceptual tasks than did those patients with probable AD. The DLB patients performed poorly on tests of elementary visual perception (size discrimination), Complex visuo-perceptual functioning requiring analysis of 2-dimensional visual stimuli (form discrimination), the ability to actively extract concrete shapes and to recognize objects (overlapping figure identification) and the ability to identify the spatial relation of visual stimuli (visual counting tests).

Mosimann *et al*.[7] found that DLB and Parkinson disease dementia (PDD) patients showed more severe impairments than AD patients on tests tapping both ventral stream (tests of the object and form perception) and dorsal stream functioning (tests of dot position and motion perception). They found significant impairments in both Parkinsons Disease and Lewy body dementia (LBD) patients on tasks requiring visual discrimination, space-motion and object form perception in patients with PDD, DLB and AD. These comparisons of bottom-up visual spatial processing suggest severe posterior cortical dysfunction in LBD.

Although these studies focus on predominant deterioration of visuo-perceptive skills in LBD, the fact remains that even AD can impact most aspects of visual processing, consistent with the impact of the disease on both dorsal and ventral stream areas. Similar to LBD patients, AD patients are impaired in both dorsal stream functions, such as angle discrimination and motion perception,[9-12] and ventral stream functions, such as the perceptual discrimination and recognition of faces, colors and objects (Rizzo *et al*., 2000; Cronin-Golomb *et al*., 1995).[11,13] Enhancing the strength of stimuli has been shown to ameliorate performance on tests of letter identification, word reading, picture naming and face discrimination.[14]

With this background of the visuo-perceptive skill deficits in LBD and AD, their implications in day-today life seems to be obvious. Visuo-perceptive skills are needed for identification of the person and objects, which are lost in DLB. Similarly, visual discrimination involves the ability to detect the difference between two similar looking visual stimuli, such as two different roadways. Thus, DLB patients have more chances to get lost outside the home or even inside the home as compared with AD patients and would need more training in these issues.

To summarize, both simple and higher order perceptual abilities are impaired in LBD as well as in AD. Most studies depict that the impairment is more severe in LBD as compared with AD. These deficits are also found very late in the course of AD, whereas they appear quite early in LBD. However, few studies evaluate this issue and the sample sizes have been small. Better studies with larger sample sizes are needed for improved evaluations in this domain.

Deficits in visuo-spatial skills

Visuo-spatial skills are a distinct group of visuo-cognitive abilities that are needed for visual attention to work in a three-dimensional space. Compared with AD patients, DLB patients show more severe deficits on tests of visuo-spatial skills, especially ones requiring visual tracking and visual attention shifting.[15,16] Hansen *et al*.[17] found that the Lewy body variant (LBV) and AD patients exhibited equivalent deficits in cognitive abilities usually affected by AD (e.g., memory, confrontation naming), but that the LBV patients displayed disproportionately severe deficits in attention, fluency and visuo-spatial processing. Visual search tasks are another group of important visuo-spatials skills impaired in dementia. Sahgal *et al*.[18] found that although both DLB and AD groups were impaired, the DLB groups visual search matching-to-sample performance was however, worse than that seen in AD patients (who performed at nearly control levels). In the study by Shimomura *et al*.,[19] the group with probable DLB scored significantly low on the picture arrangement, block design, object assembly and digit symbol substitution test and Raven colored progressive matrices test as compared with the probable AD group. However, this DLB group scored significantly higher on the mini-mental state examination (MMSE) locational orientation subtest, because of poor performance on even untimed measures like the AD assessment scale construction subtest and the raven colored progressive matrices. Therefore, they concluded that the results were unlikely to be explained by psychomotor slowing in these patients and thus, were better explained by visuo-perceptive skill deficits in such patients. They also found that Wechsler Adult Intelligence Scale Revised (WAIS-R) block design scores were amongst the best discriminant factors. Block design, which is one of the most commonly used test for the visuo-spatial ability, was also among the best discriminant factors in this study.

Similar results on the block design subtest were obtained by Salmon *et al*.[16] where they found that four of the five patients were at floor performance on the on this test and the fifth patient, although not at floor, demonstrated severe impairment. Their findings also revealed severe impairment on the performances of parts A and B of trail making test (TMT) for all the five patients. They also concluded that this impairment was mainly visuo-spatial rather than impaired executive functions as patients performed adequately on other executive function tests of WAIS-R.

An important difference between DLB and AD was provided by Gnanalingham *et al*.[20,21] who pointed out the usefulness of the clock face test that assesses both executive and visuo-spatial functioning in differentiating DLB from AD. Patients with AD do well on the copy part of the test despite doing poorly on the draw part while patients with DLB do equally poorly on both parts of the test. A tendency to get lost is a common and often early symptom of AD (Monacelli *et al*., 2003; Pai and Jacobs, 2004),[22,23] consistent with the critical role of the medial temporal lobes and parietal cortex in navigation learning and spatial memory (Astur *et al*., 2002; Burgess, 2008; Morris *et al*., 1982). [24-26] Navigation learning has been extensively studied in transgenic mouse models of AD. For example, transgenic human amyloid precursor protein mice with hippocampal damage are impaired in the use of allocentric cues on a Morris Water Maze task (Deipolyi *et al*., 2008).[27,28] By translating findings from the rodent literature, researchers have been able to design tests to evaluate navigation learning in AD in an anatomically-focused manner. Deipolyi *et al*. (2007)[27,28] tested patients with mild AD on a real-world test of navigation learning. Compared with controls, patients were more likely to get lost and were deficient at learning the locations of landmarks, and these impairments were associated with smaller right posterior hippocampal and parietal volumes. New virtual reality techniques are showing promise in translational research for refining our understanding of navigation impairments in AD and tests that emphasize allocentric navigation may be particularly sensitive (Bohbot *et al*., 2007; Burgess *et al*., 2006; Cushman *et al*., 2008; Ishii *et al*., 2005).[29-31] In the study by Noe *et al*.,[32] patients with DLB performed significantly slower than patients with AD-P on both (shape and TMX) forms of the cancellation test and showed a greater number of omission errors on the Shape version of this test. Because DLB patients performed poorly not only in the timed aspect of the tasks, but also demonstrated

increased omission errors, it reflects a difficulty in processing visuo-spatial information.

Deficits in visual constructional skills

The inclusion of VC abilities in the cognitive profiling of neurodegenerative dementias is especially important to address two questions:

1. How important are visuo-constructive tests in distinguishing severe cases of LBD and AD?

This question is important because in later stages of all forms of cortical dementias, there is impairment in the constructional abilities. Therefore, detecting impairment in the constructional abilities can become a tool to differentiate the dementias in the early stages as compared with the later stages. Cormack *et al*.[2] examined the pentagon drawings of 100 DLB patients, 50 AD patients, 81 PD patients, with 36 of them suffering from dementia (PDD). Performance on this task was correlated with cognitive performance on the MMSE and Cambridge Cognitive Examination (CAMCOG) scales. Patients with DLB were found to draw significantly worse pentagons than patients with AD or PD, but not patients with PDD. Drawing scores were significantly correlated with MMSE scores for the AD and PDD groups, but not patients with DLB. More detailed analysis of the neuropsychological correlates of constructional performance for patients with AD and DLB revealed that patients with AD showed a broad cognitive basis to their impairment, but drawing was linked only to perception and praxis in DLB patients. Thus this test has the potential of acting as an important contributor to the diagnostic clarification of AD and DLB patients, especially in the background of other cognitive test scores.

2. Does the impairment in VC tests indicate cortical/subcortical involvement?

The deterioration of constructive abilities in LBD is indicated by the finding of poorer construction subscale performance in patients with PD than in patients with AD.[33] This finding was also demonstrated by other studies[17,34] showing visuo-spatial and constructional deficits in patients with LBV. The absence of this difference in the group with moderate to severe dementia appears to be because it could be an indicator of severity of the disease. Interestingly, one of the most difficult items from the Initiation/Perseveration subscale that taps both constructional and executive abilities (i.e., copying the ramparts figure) was significantly more impaired in patients with LBV than in patients with pure AD across the full MDRS range. Therefore, the cognitive deficits of patients with LBV appear to express characteristics of both subcortical and cortical dysfunctions. It has been suggested that the neuropathological changes in the substantia nigra of patients with diffuse Lewy body disease and the corresponding depletion of dopaminergic input to the striatum,[35] most likely contribute to the neuropsychological deficits that are usually associated with subcortical dysfunction, such as impaired learning, attention, visuo-constructive abilities and psychomotor performance (for review, see Cummings, 1990).[36] Visuo-spatial praxis is a general term given to all the cognitive abilities involved in constructional abilities several studies have documented impairment in visuo-spatial praxis in both AD and DLB.[15,16,19,37] Most investigators,[2,8,21,38-41] have recorded greater visuo-spatial/constructional (and visual-perceptual) deficits in patients with DLB as compared with patients with AD. Walker *et al*.[42] demonstrated that patients with DLB performed worse than patients with AD who were similar in overall degree of cognitive impairment on the praxis subtest of the CAMCOG , including visuo-constructive tasks. Furthermore Gnanalingham *et al*.[20] pointed out the usefulness of the clock face test that assesses executive and visuo-spatial functioning in differentiating DLB from AD: Whereas, patients with DLB do equally poorly on both the parts, patients with AD perform adequately on the "copy part" of the test despite doing poorly on the "draw" part.

Whereas these studies have evaluated general praxis, other studies have evaluated individual components of visuo-spatial praxis, such as copying and drawing. Copying a diagram requires a coordinated function of various cognitive functions. It seems that this coordination is lost in both AD and DLB, but worse performance by DLB patients has been universally found. Ala *et al*.[39] found significant differences between pentagon copying of AD and DLB patients with an unacceptable copy of the pentagon being associated with DLB with a sensitivity of 88% (95% confidence interval [CI] 0.64-0.99) and specificity of 59% (95% CI 0.39-0.78). Similarly, in the study by Tiraboschi *et al*.,[1] visuo-spatial/constructional functioning was rated on the basis of MMSE intersecting pentagons and/or dementia rating scale (DRS) construction subscale (DRS-C), which involves copying. Each patient's copy of the intersecting pentagons was regarded as acceptable only when all 10 angles were present and two of them intersected (Folstein *et al*., 1975).[43] Ratings on the DRS-C, which is composed of six tasks including a copy of two dimensional figures, were also dichotomized, because each patient's performance was considered acceptable only when the maximal score was obtained. Testing procedures were modified in that all six subscale items were administered to all patients. As opposed to less restrictive original criteria (Mattis, 1976),[44] patient was given maximum credit when he/she accomplished all of the tasks, not the first one alone (reproduction of a diamond within a square). Presence/recent history of VH were the most specific (99%) to DLB. As a result, early VH emerged as the best positive predictor of DLB (positive predictor value: 84% vs. 32% or less for all other variables), while lack of visuo-spatial/constructional impairment on the DRS-C was the best negative predictor value (NPV) (NPV: 90%). They found that differences in the frequency of flawed MMSE pentagon copying between DLB and AD patients only approached statistical significance (30% vs. 16%, $P = 0.1$), an impaired performance on the DRS-C subscale was significantly more common in the DLB group (74% vs. 45%, $P = 0.01$). An erroneous "vertical lines" reproduction was by far the most frequent mistake in both groups. Fewer DLB subjects (30%) experienced the difficulty with the MMSE pentagon copy, suggesting that the DRS-C may be more sensitive to visuo-spatial/constructional impairment early in the course of the disease. They suggested that early visuo-spatial deficits should be considered as a core clinical feature of DLB and that clinical history plus a brief assessment of visuo-spatial function may be of the greatest value in correctly identifying DLB early in the course of the disease.

Drawing is another ability, which seems to be particularly impaired in DLB. Salmon *et al*.[16] comparing the neuropsychological

deficits of 5 patients with neuropathologically confirmed diffuse Lewy body disease with the neuropsychological deficits of 5 patients with neuropathologically confirmed pure AD matched by dementia severity found poor visuo-constructive functioning on both the command and copy conditions of the clock drawing test. Similarly, in the study by Noe *et al*.,[41] the DLB group performed significantly worse on the Rosen Drawing Test than AD patients.

Deficits in other visual cognitive skills

As we mentioned in the introduction, there are several visuo-cognitive skills that could be impaired in various forms of dementia. In addition to the specific visual skills mentioned in the previous sections, there are several other domains of visuo-cognitive skills that are impaired in various forms of dementia. However, few studies have explored these domains. Here, we present only a brief report of the studies that have evaluated other complex visual skills in addition to the visuo-perceptive and visuo-spatial skills mentioned previously. These skills mainly include higher cognitive modulation of visual attention such as divided visual attention, visual integration, visual set shifting and visual memory.

Tests of visual cognition that require the integration of visual information processed by separate regions in visual association cortex can be particularly sensitive to the effects of AD (e.g., tests of complex figure copy, mental rotation and visual organization (Festa *et al*., 2005; Freeman *et al*., 2000; Lineweaver *et al*., 2005; Paxton *et al*., 2007),[45-48] perhaps due to the effects of the disease on multiple visual areas that are compounded by these integration tasks.

In the study by Doubleday *et al*.,[49] inattention, visual distractibility, impairment in establishing and shifting mental set, incoherent line of thought, confabulation, perseveration and intrusions were all significantly more common in the DLB group than in the AD group and many of the features were specific to DLB. However, these findings are contrast the findings of Sahgal *et al*. [18] where the authors found that visual set-shifting abilities were equally impaired in both DLB and AD patients. Divided attention has been more specifically studied by Kraybill *et al*.,[50] who found that Part A of the TMT did not differ among groups, but DLB patients performed much more poorly on Part B of the TMT than did the AD patients. These findings suggested that LBP patients were actually more impaired in terms of divided attention and not overall just slow-performers due to their motor slowing.

Visual retention or short-term visual memory is another aspect of visual cognition that has been only rarely studied in dementia patients. In the comparative study by Noe *et al*.,[41] the DLB group performed significantly worse than the AD patients on the matching and recognition subtests of the Benton visual retention test.

Discussion: Neuropathological Correlation of Visual Skill Deficits

The basis for the visual deficits in DLB and AD needs to be understood not only for clarifying their underlying neuroanatomic mechanisms, but also for the purposes of improving diagnostic assessment of DLB and helping to develop specific neurobiological treatments for these individual cognitive deficits. Various studies have correlated visuo-cognitive deficits in DLB and AD. However, these correlations suffer from non-specificity. These correlations can at best be carried out with the disease condition rather than individual neuropsychological deficits because the disease consists of many symptoms and signs in addition to neuropsychological deficits. Therefore, these correlations can only be considered as indirect and presumptive at the best.

In spite of the fact that all the lobes of the brain have been implicated in its neuropathology, some important areas can be highlighted in these studies. For example, the unique visual-perceptual and attentional-executive impairments that characterize DLB are consistently associated with the locations of Lewy bodies in frontal, cingulate and inferior temporal cortex and may be related to the characteristic VHs and clinical fluctuations of this disease. However, these findings have been mostly deducted from retrospective meta-analytic studies by Collerton *et al*.[40] and they need to be confirmed in prospective, longitudinal, clinico-pathological studies.

Although originally conceived in terms of right versus left hemispheric function, the cognitive abilities underlying performance on the spatial and perceptual abilities can be better understood in terms of ventral (what) versus dorsal (where) visual processing streams (Goodale and Milner, 1992; Ungerleider and Mishkin, 1982-FONT).[51,52] According to this accepted dichotomy, the ventral pathway or stream of information, proceeds from primary visual to visual association areas in the inferior-temporal region and underlies object recognition by the association of visual information with semantic knowledge about the perceived objects. In the subtests of the VOSP, the tests that depend on ventral processing are, therefore, the object decision, silhouette identification and fragmented letters subtests. The dorsal stream is responsible for computing the location of objects in space, the guidance of hand movements during grasping and complex visuo-spatial analysis. These abilities are included in the cube analysis subtest of the VOSP draws heavily on the dorsal pathway. Based on the current findings, it seems that patients with DLB have severe deficits in both dorsal and ventral processing streams. Impairments of this type are seen in AD, but typically occur at a later stage of the disease (Hof *et al*., 1989; Mendez *et al*., 1990).[53,54]

Recently, radio-nuclear studies have demonstrated that glucose metabolism and blood flow are significantly decreased in the occipital lobes, including the primary visual cortex and the visual association areas in DLB as compared with the AD (Imaura *et al*., 1997; Ishii *et al*., 1998; Ishii *et al*., 1999).[55-57] The involvement of the visual cortex may, thus, be the cause for dysfunction of the elementary visual sensation that may be involved in development of visual cognitive deficits and vision-related behavioral symptoms. These findings are consistent with the findings of Mosimann *et al*.,[7] who demonstrated that both DLB and AD patients showed hypoperfusion and hypometabolism in the parietal and temporal lobes, but only DLB patients showed hypoperfusion and hypometabolism in the occipital lobes, including the primary visual cortex (Lobotesis *et al*., 2001; Inoshima *et al*., 2001; Sato *et al*., 2007;

Shimizu *et al*., 2008),[58-68] which is the most critical cortical region for early aspects of bottom-up visual processing. Abnormalities in morphology and synuclein expression in the retina may also impact visual perception in DLB (Maurage *et al*., 2003). In DLB, the ventral temporal lobe is also heavily burdened by prominent Lewy body pathology and spongiosis that occurs well before the onset of Lewy body pathology in other cortical regions (Braak *et al*., 2003; Byrne *et al*., 1989; Dickson *et al*., 1987). The inferior and ventral temporal lobe plays a fundamental role in the perception of patterns, objects and complex visual stimuli (Haxby *et al*., 1991; Ishai *et al*., 1999; Logothetis *et al*., 1995; Mishkin *et al*., 1983; Tanaka, 1996; Newcombe *et al*., 1987). Because this region may be responsible for grouping, segmentation, and integration of visual percepts needed for object recognition (Sheinberg and Logothetis, 1997), the misperception of ambiguous visual input may occur due to the breakdown of these subsystems. Thus, the presence of contextual cues may help to explain why object naming (and hence identification) is relatively preserved in early DLB (Ferman *et al*., 1999, 2002), while tasks that involve more abstract visual material are impaired.

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