The neuropsychological profile and phenomenology of late onset psychosis: A cross-sectional study on the differential diagnosis of very-late-onset schizophrenia-like psychosis, dementia with Lewy Bodies and Alzheimer's type dementia with psychosis

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Neuropsychology and phenomenology of late onset psychosis

Abstract

Objective: Late onset psychosis may occur as a prodromal symptom to neurodegeneration, but it can also be associated with a non-progressive mild cognitive deficit. Studying the phenomenology of psychotic symptoms and the neuropsychological profile may serve as sensitive and non-invasive tools for differential diagnosis.

Method: We compared 57 individuals with very-late-onset schizophrenia-like psychosis (VLOSLP), 49 participants with Dementia with Lewy Bodies (DLB) and 35 patients with Alzheimer's type Dementia and psychosis (AD+P) concerning the phenomenology of psychotic symptoms and the neuropsychological profile using several measures of cognitive function in a cross-sectional study.

Results: Participants with DLB exhibited more visual hallucinations, especially those involving animals, and less partition/paranoid delusions than both other groups. VLOSLP showed more partition delusions and auditory hallucinations of human voices than both other groups. Hence, patients with DLB and VLOSLP showed greater dissimilarity in the phenomenology of psychosis, whereas individuals with AD+P held an intermediate position. Processing speed and executive function were comparably impaired among the three groups, as was expected considering a common underlying set of neurobiological abnormalities for psychosis. However, AD+P showed more strongly reduced learning and consolidation skills, whereas DLB was associated with prominent visuoconstructive deficits.

Conclusions: Phenomenology of psychosis may prove especially informative when comparing individuals with DLB to those with VLOSLP. Neuropsychological profiles are able to further aid differential diagnosis of the three groups.

Keywords: Alzheimer’s disease; Dementia with Lewy Bodies; Schizophrenia; Mild cognitive impairment; Elderly

The first onset of psychosis in late life is more common than previously assumed (Fischer & Aguera-Ortiz, 2017), presenting in approximately 10 to 62% of nursing home residents, 5 to 15% of elderly psychiatric inpatients and 27% of psychiatric outpatients (Reinhardt & Cohen, 2015). Many of these older individuals exhibit psychosis as a prodromal symptom to dementia (Kørner, Lopez, Lauritzen, Andersen, & Kessing, 2009; Savva et al., 2009), often associated with Alzheimer's type Dementia (AD) or Dementia with Lewy Bodies (DLB) (Van Assche, Morrens, Luyten, Van de Ven, & Vandenbulcke, 2017). However, in more than half of these cases, there is a non-progressive mild cognitive deficit (Brodaty, Sachdev, Koschera, Monk, & Cullen, 2003). An international consensus refers to this condition – an incidence of psychotic symptoms after the age of 60 years in the absence of major affective disorder or neurologic disease – as very-late-onset schizophrenia-like-psychosis (VLOSLP) (Howard, Rabins, Seeman, Jeste, & The International Late-Onset Schizophrenia Group, 2000). The community prevalence for VLOSLP ranges from 0.1% to 0.5%. However, the annual incidence of VLOSLP increases by 11% with each 5 year increase in age (van Os, Howard, Takei, & Murray, 1995). Hence, differential diagnosis between neurodegeneration and VLOSLP may prove especially challenging in the oldest segments of the population. Still, it is highly valuable with respect to early treatment possibilities.

Phenomenology of late onset psychosis

Irrespective of the etiopathology, psychosis with onset in late life is less frequently accompanied by negative symptoms such as affective flattening or disorganized thought (Holt & Albert, 2006). Typically, misidentification delusions and delusions of a persecutory nature such as paranoid, jealousy or partition delusions are reported in late onset psychosis (Migliorelli et al., 1995). Partition delusions encompass the belief that people, substances, objects or radiation can pass through what would normally be a barrier (Howard, Castle,

O'Brien, Almeida & Levy, 1992). Visual and auditory hallucinations are also frequently observed (Jellinger, 2012). Moreover, there are associations with specific illnesses. For instance, patients with DLB frequently exhibit complex visual hallucinations (68-73%) and misidentification delusions (56%) (Ballard et al., 1999). Hallucinations of animals, people or detailed three dimensional objects are characteristic (Ferman & Boeve, 2007). Delusions in individuals with DLB are generally less common than hallucinations (Nagahama et al., 2007) and they are paranoid in nature (25-28.5%) (Jellinger, 2012). Many individuals with AD+P experience either paranoid (71%) or misidentification delusions (29%) with associated (often visual or auditory) hallucinations (Mizrahi, Starkstein, Jorge, & Robinson, 2006). It is not clear yet whether there are two subgroups of individuals with AD+P, one group experiencing persecutory delusions and the other misidentification, or whether both types of delusions may occur in one person depending on the progression of the illness (Reeves, Gould, Powell, & Howard, 2012). The overall prevalence of delusions in AD+P is greater than that of hallucinations (Bassiony et al., 2000). Finally, VLOSLP seems to predispose particularly to the development of partition and paranoid delusions as well as multimodal hallucinations (Hanssen et al., 2015). Paranoid symptoms often seem more bizarre and elaborate than those in AD+P (Jellinger, 2012). Even though a slightly differing presentation of psychotic symptoms may already prove useful in differential diagnosis, an overlap in the phenomenology of psychosis in different diseases is still important, creating the need for further investigation.

Neurobiological and (neuro)psychological underpinnings of late onset psychosis

Interestingly, the onset of both delusions and hallucinations in late life reflects disturbances in the frontal-subcortical-temporal brain systems transdiagnostically (Holt & Albert, 2006). Indeed, schizophrenia-like illnesses in late life are associated with increased

ventricle-to-brain ratio (VBR), white matter (WM) pathology as well as functional and structural abnormalities in the frontal, subcortical and temporal brain regions compared to normally aging individuals (Van Assche et al., 2017). Additionally, frontotemporal abnormalities in the most frequently occurring neurodegenerative conditions in late life such as AD or DLB with psychotic symptoms also supersede those observed in AD or DLB without such symptoms (Jellinger, 2012). Some authors suggest a lateralized effect, as they have noticed associations between left lateralized abnormalities and persecutory delusions as opposed to right lateralized abnormalities and misidentification delusions. Others have observed more pronounced cognitive impairment in individuals who experience misidentification as opposed to persecutory delusions (Holt & Albert, 2006; Reeves et al., 2012). They speculate that severe cognitive deficiency would preclude sustainability of paranoid delusions (Bassiony & Lyketsos, 2003), whereas misidentification might result from further deterioration of the occipital and/or parietal cortices – the primary visual cortex or visual association areas – combined with frontal abnormalities. Visual (or auditory) hallucinations appear to co-occur with misidentification delusions in some cases, and they are also assumed to arise in part as a result of (right) parietal or (medial) temporal abnormalities – which suggests the involvement of the dorsal and ventral visual pathways – combined with frontal dysfunction (Kotrla, Chacko, Harper, Jhingran, & Doody, 1995; Sanchez-Castaneda et al., 2010).

The mechanism underlying the occurrence of hallucinations is hypothesized to be inefficient suppression of (personal) memory recall and reality monitoring, suggesting an interplay between executive and memory function coinciding with a frontotemporal neurobiological set of deficiencies (Jellinger, 2012). In line with the hypothesis of impaired memory functioning in hallucinations, some authors have described a memory impairment in delusions (Schneider et al., 2003). They speculate that delusions might be linked conceptually

to memory deficits because a failure to recall accurate information enables the development of inaccurate beliefs in order to explain the current reality (Abdel-Hamid & Brüne, 2008). For instance, a patient with AD who forgot where he left his wallet, may suspect the cleaning lady of stealing it as this might reasonably explain its absence, rather than remembering that he left it in the hall. Still, the importance of additive impairments, specifically concerning executive functioning, cannot be underestimated as this prevents the individual from changing his mind leading to a ('delusionally') stern conviction rather than a confabulation which can be corrected. Indeed, a comparison of imaging results in patients with AD with and without paranoid beliefs showed more reduced metabolism in the right superior dorsolateral frontal cortex, the right inferior frontal pole and the right lateral orbitofrontal cortex, as well as a decreased brain volume in orbitofrontal and medial frontal areas in individuals with paranoid beliefs (Engelborghs et al., 2006; Jellinger, 2012; Koppel & Greenwald, 2014; Sultzer et al., 2003; Sultzer et al., 2014). This hypothesized combination of memory and executive deficits is in line with the two-factor theory of the development and sustenance of delusions (Coltheart, 2010). According to this cognitive theory, explaining the manifestation of a delusion requires the presence of neuropsychological impairment that initially prompts the delusional belief and the presence of a second neuropsychological impairment that interferes with processes of belief evaluation, located in the right lateral prefrontal cortex. Additionally, one might speculate that the first requirement could be interpreted more broadly as psychosocial stressors and personality characteristics may also trigger a faulty interpretation of events (Giblin, Clare, Livingston, & Howard, 2004) rather than a (mere) neuropsychological deficit.

Still, it is clear that frontotemporal abnormalities seem crucial as an underlying neurobiological change, lowering the threshold for the development of psychotic symptoms in late life. Consequently, there is assumed to be an overlap in cognitive impairment in different

conditions associated with late onset of psychosis. Specifically, memory, language and executive function are expected to be deficient. Interestingly however, there is no linear association between cognitive decline and the frequency or nature of psychotic symptoms in late life (Jellinger, 2012). Moreover, cognitive profiles in individuals with a first incidence of psychosis later in life are heterogeneous. This is probably the result of slightly differing patterns of brain abnormality directly caused by the specific disease a person is diagnosed with and some of these changes may be unrelated to the psychotic symptoms. Therefore, we expected a certain degree of overlap in the cognitive profile of individuals with late onset psychosis transdiagnostically, as a result of a common underlying set of neurobiological alterations related to the development of psychosis. However, we also hypothesized that there were disease-specific differences in the profiles that are irrelevant to the development of psychotic symptoms. We were interested in the comparison of VLOSLP to DLB and AD+P as these groups show a clear overlap in clinical presentation at the first stages of the illness where onset of psychotic symptoms may coincide with mild cognitive deficits. Moreover, a direct comparison of phenomenology and neuropsychological function of VLOSLP and the other two groups has not been reported yet (Van Assche et al., 2017).

Neuropsychological profiles of VLOSLP, DLB and AD+P

Research focussing on AD versus DLB shows that in AD there is predominantly memory and language dysfunction (Fichman, Oliveira, & Fernandes, 2011; Kelley & Petersen, 2007), which is associated with temporal atrophy and/or hypometabolism in the early stages of the disease leading to impairments in semantic networks. DLB, on the other hand, is initially characterized by executive dysfunction, reduced processing speed, impaired (visual) attention and visuospatial perceptual/constructive deficits (Belden, Kahlon, Malek-Ahmadi, Tsai, & Sabbagh, 2015; Calderon et al., 2001; Collerton, Burn, McKeith, & O'Brien, 2003; Cormack,

Aarsland, Ballard, & Tovee, 2004; Crowell, Luis, Cox, & Mullan, 2007; Guidi, Paciaroni, Paolini, De Padova, & Scarpino, 2006; Kawai et al., 2013; Park et al., 2011).

Although sometimes quantitative measures of neuropsychological task performance are comparable, there may be qualitative differences. For instance, memory function is characterized by retrieval problems in DLB, whereas both encoding/storage and retrieval are affected in AD (Ballard et al., 1999; Cagnin et al., 2015; Ferman et al., 2006; Goldmann Gross, Siderowf, & Hurtig, 2008; Oda, Yamamoto, & Maeda, 2009; Walker, Allen, Shergill, & Katona, 1997; Yoon, Kim, Moon, Yong, & Hong, 2015). Coincidently, a measure of recognition shows more rapid decline in AD than in DLB at follow up (Stavitsky et al., 2006). Visuo-constructive deficits are also different in nature in patients with AD and DLB. Even though both groups are equally impaired in drawing from memory, the patients with DLB are usually more impaired in copying (Metzler-Baddeley, 2007). Such a pattern confirms that a primary memory/semantic problem interferes with visuo-constructive abilities in AD, whereas a perceptual problem interferes with visuo-construction in DLB. In line with this, quantitative measures of object recognition skills appear similar in both conditions but an analysis of the nature of mistakes in a naming task showed that patients with AD displayed more semantic paraphasias, whereas individuals with DLB showed more visuoperceptual mistakes when asked to recognize and name an object (Cagnin et al., 2015; Goldmann Gross et al., 2008; Williams et al., 2007). Psychomotor slowing is comparable in both disorders, though its origin differs (Bailon, Roussel, Boucart, Krystkowiak, & Godefroy, 2010). Specifically, patients with AD show impairment in perceptuomotor and decision processes leading to psychomotor slowing, whereas patients with DLB exhibit visual and attention deficits that contribute to psychomotor slowing. Additionally, patients with DLB exhibit more severely reduced letter fluency than individuals with AD (Petrova et al., 2016).

There has been research comparing AD without psychosis and VLOSLP, showing that patients with VLOSLP have more pronounced executive dysfunction, comparable language function and better performances in consolidation rather than learning. Importantly, however, in AD+P we expect a more pronounced frontal dysfunction than in AD without psychosis, perhaps also leading to greater executive deficits (Van Assche et al., 2017).

Surprisingly, there is no research directly comparing VLOSLP to AD+P and/or DLB, whereas it is clear that individuals with VLOSLP or either of these neurodegenerative conditions may present similarly at a clinical facility. Hence, differential diagnosis of VLOSLP as opposed to DLB or AD+P may prove especially difficult and important as prognosis and (medical) treatment differ. Therefore, we compared these three groups using neuropsychological assessment as a noninvasive and sensitive diagnostic tool that provides insight into the characteristic cognitive profiles in VLOSLP as opposed to neurodegeneration (Frith, 1996; Zakzanis, Kielar, Young, & Boulos, 2001). We also controlled for general cognitive level of functioning. This allowed us to discern specific profiles rather than, for instance, confirm that one group of individuals is globally more impaired, resulting in more impairment on all neuropsychological subdomains in further assessment using more sensitive measures. The three groups were hypothesized to perform dissimilar on cognitive domains of functioning that could not be linked to frontal abnormalities as these constitute a common underlying set of changes associated with the onset of psychosis. Specifically, we expected patients with VLOSLP and AD+P to perform similarly on language tests, whereas individuals with DLB were expected to do better. Individuals with AD+P were hypothesized to show more pronounced impairment on consolidation (memory) skills than both other groups. Finally, patients with DLB were likely to perform slightly worse on tasks involving perceptual abilities such as visuospatial perception or visuo-construction compared to both

other conditions. Additionally, we expected the phenomenology of psychotic symptoms to differ to some extent in the three groups, further aiding differential diagnosis.

Method

Procedure

Clinical records from the University Hospitals Leuven were systematically screened for older individuals with mild cognitive dysfunction exhibiting psychotic symptoms as a result of neurodegeneration (AD, DLB) between 2010 and 2015. The files were retrieved with the permission of the Ethics Committee of the University Hospitals only when there was a clear diagnosis and when there was neuropsychological and phenomenological data. Additionally, neuropsychological and phenomenological data was gathered prospectively in a group of VLOSLP individuals over the past five years (2012-2017). Importantly, the study was monocentric and neuropsychological data across the groups was collected by the same three neuropsychologists upon initial presentation at the clinic. Moreover, the percentage of individuals receiving antipsychotic medication at the time was similar in all groups (DLB: 22%; AD+P: 24%; VLOSLP: 26%), which suggests that there would be a similar effect of medication on cognitive performance in all groups. However, elaborateness of the phenomenological data depends on the protocol – scientific or clinical – that was adhered to.

Participants

There were 49 patients with DLB, all diagnosed with probable DLB according to the revised consensus criteria as they show progressive cognitive decline which interfered with their daily activities, and they all exhibited two or more core clinical features - fluctuating cognition, visual hallucinations, Rapid Eye Movement (REM) sleep behaviour disorder, parkinsonism - with the presence of indicative biomarkers such as reduced dopamine

transporter uptake in basal ganglia as demonstrated on [123I]-2β-carbometoxy-3β-(4-iodophenyl)-N-(3-fluoropropyl) nortropane (^{123}I-FP-CIT) Single Photon Emission Computed Tomography (SPECT) or occipital hypometabolism on 18F-fluorodeoxyglucose (^{18}F-FDG) Positron Emission Tomography (PET) in 27 cases (McKeith et al., 2017). The 35 participants with AD+P all showed psychotic symptoms and they were diagnosed with probable AD according to the revised National Institute on Aging and the Alzheimer's Association work group diagnostic guidelines (McKhann et al., 2011) as they all fulfilled clinical criteria of progressive cognitive decline with insidious onset as reported heteroanamnestically and observed in formal testing. In 30 cases there was also evidence of an AD pathophysiological process based on amyloid-beta (Aβ) 42, total tau and phosphorylated tau levels in cerebrospinal fluid, decreased ^{18}F-FDG uptake in temporo-parietal cortex on PET or disproportionate medio-temporal atrophy on Magnetic Resonance Imaging (MRI). Finally, 57 individuals with VLOSLP participated in the current study. They fulfilled the consensus criteria proposed by the International Late-Onset Schizophrenia Group with first onset of psychosis after the age of 60 and no evidence of neurologic or major affective disorder (Howard et al., 2000). Non-neurological medical (e.g., metabolic or ophthalmological) conditions that might explain the occurrence of psychotic symptoms were also absent. According to the fifth version of the Diagnostic and Statistical Manual (DSM 5) (*Diagnostic and Statistical Manual of Mental Disorders*, 2013) there were 30 individuals with unspecified schizophrenia spectrum and other psychotic disorders of whom five also received an additional diagnosis of a mild neurocognitive disorder (not otherwise specified), ten individuals were diagnosed with a mild neurocognitive disorder (not otherwise specified) with psychosis, two were diagnosed with schizophrenia, 11 individuals had a delusional disorder of whom six were also showing a mild neurocognitive disorder (not otherwise specified), one individual was diagnosed with a brief psychotic disorder, two were diagnosed with an

adjustment disorder (not otherwise specified), and finally one individual was initially described as having an anxiety disorder. As this last participant did not present with clear symptoms of anxiety and exhibited persisting psychosis at readmission, the diagnosis was changed to unspecified schizophrenia spectrum and other psychotic disorders.

Measures

The neuropsychological battery used in the current study consists of several tests assessing different cognitive domains such as processing speed (Stroop I), the attention span (Digit Span forward), executive function such as sensitivity to interference (Stroop Interference Factor) or working memory (Digit Span backward), memory acquisition (Rey Auditory Verbal Learning Test trial 1, sum), recall (Rey Auditory Verbal Learning Test delayed recall, retention) and recognition (Rey Auditory Verbal Learning Test recognition), language skills such as confrontation naming (Boston Naming Test), semantic word fluency (Animal Verbal Fluency), letter fluency, perceptual abilities (Visual Object and Space Perception subtasks Object decision for object identification, Number location and Cube analysis for visuospatial perception) and finally drawing and copying of a house from the COTESS battery (Cognitieve Testbatterij voor Senioren) to estimate visuoconstructive skills. All tests were administered by trained psychologists in a standardized way according to the published test manuals. Additionally, a thorough search of the clinical files of all the participants resulted in an extensive documentation of the different psychotic symptoms in each patient at the initial presentation at the clinic.

Data analysis

We have conducted Pearson Chi square tests to determine whether there were significant differences in the three groups concerning the presence of hallucinations and delusions.

Fischer's exact test was used instead of the Pearson Chi square test if the expected number of observations was smaller than 5 in more than 20% of the cells. The standardized residuals were explored in order to determine the nature of the difference and Cramer's V was used as an effect size. Multinomial logistic regression was conducted to assess whether phenomenological differences between groups were able to predict group membership.

Next, we conducted univariate AN(C)OVA's as a means to assess significant differences in test scores on the several cognitive tasks. We corrected for multiple comparisons using Gabriel's post hoc test so as to decrease the possibility of Type I as well as Type II errors in relatively small and unequal groups. The Games-Howell procedure was used as an extra check. We calculated Cohen's d as an effect size for each of the significant differences as well as a common languages effect size (CL), which can be interpreted as the percent chance that in randomly selected pairs of individuals the participant from one group would score higher than the participant from another group. To further delineate the relative strengths of differentiating factors and profiles across groups, additional multivariate approaches were considered in a follow-up fashion. Specifically, we have conducted a MANOVA with discriminant function analysis.

Finally, we have explored biserial correlations between the most prevalent types of psychotic symptoms and neuropsychological measures across and within groups.

Results

Sample characteristics

As table 1 shows, the three patient groups were matched for age, years of formal education, and general cognitive functioning as assessed using the Mini Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975). However, gender was significantly different among the groups with a majority of male participants in the DLB

group as opposed to a majority of female participants in both other groups. As zero order correlations showed a significant association between gender and some of the cognitive outcome variables, we have included gender as a covariate in further analyses on cognitive measures.

Phenomenology of psychotic symptoms

Clinical records were not all equally detailed. Therefore, we have not conducted extensive qualitative analysis. Instead, we have dichotomized presence and absence of symptoms after thorough inspection of the different types of delusions and hallucinations in all files. Also, we have described the content of different types of symptoms according to diagnosis in a separate table (Table 2 and 3).

Delusions and hallucinations in DLB. A large majority of the participants with DLB showed visual hallucinations, mainly of humans or animals (Table 2 and 3). Another common theme was transport. Auditory hallucinations comprised of noises, animals sounds or human voices. Only two participants experienced tactile hallucinations, and there were no instances of olfactory or gustatory hallucinations. Almost half of all participants with DLB experienced multimodal hallucinations. Many also reported paranoid delusions, whereas only three individuals with DLB described solely misidentification delusions.

Delusions and hallucinations in AD+P. Patients with AD+P all experienced delusions, the majority being paranoid (Table 2 and 3). Only one person experienced solely a misidentification delusion. Many individuals with AD+P also showed hallucinations, with approximately half of these being multimodal. Again, visual hallucinations were reported most commonly. Auditory hallucinations were more rare and they usually consisted of knocking, indistinct noises from people and human voices. Only two instances of tactile

hallucinations occurred. Again, there were no individuals who experienced olfactory or gustatory hallucinations.

Delusions and hallucinations in VLOSLP. Almost all individuals with VLOSLP experienced delusions, the majority being paranoid and partition delusions (Table 2 and 3). Typically these were quite detailed and elaborate. There were links with real experiences (e.g., rash as result of laser beams, dizziness because of drugs, scars as a result of being restrained forcefully), and there were clear associations with hallucinations. These were multimodal in more than half of all individuals with VLOSLP. Remarkably, although the large majority of hallucinations was visual or auditory, hallucinations were present in all modalities. Visual hallucinations usually presented as people known to the individual. Animals were also prominent. Finally, beams of light or laser beams were often noticed in participants with VLOSLP. Auditory hallucinations consisted of human voices or indistinct noises deliberately made by neighbors in order to disturb the patient. Tactile hallucinations were also unpleasant (electrical shock, an itch, heat, a pressure, pain, …). One person felt her bed moving. In this instance, we could not exclude the possibility of more common hypnagogic or hypnopompic hallucinations. However, the patient was not excluded from the study as this was not the only psychotic symptom reported. Gustatory hallucinations comprised of a weird taste in food or coffee as a sign of poisoning. Olfactory hallucinations were chemical smells that were suspected to have been pumped into the apartment through the ventilation.

Differences in phenomenology of psychosis in DLB, AD+P and VLOSLP. A Pearson Chi square test revealed significant differences between groups concerning the presence of delusions and hallucinations (Table 2). Specifically, paranoid and partition delusions showed significant group differences. Also, the number of individuals experiencing visual hallucinations differed in the three groups. Finally, the content of visual and auditory

hallucinations showed significant differences as the occurrence of visual hallucinations comprising of animals and humans was not equally prominent in all three groups, as well as auditory hallucinations of voices. Inspection of standardized residuals showed that the participants with DLB reported less (paranoid and partition) delusions than the other two groups, whereas they experienced more (visual) hallucinations than both other groups. Individuals with DLB saw significantly more animals and humans than both other groups. The VLOSLP group experienced significantly more partition delusions than both other groups and they heard more human voices than both other groups.

Classification of individuals in diagnostic groups. Multinomial logistic regression, including the variables that showed significant group differences, demonstrated that the presence of paranoid and partition delusions predicted VLOSLP rather than DLB. Additionally, the presence of auditory hallucinations of human voices predicted VLOSLP rather than AD+P (Table 4).

Differences in neuropsychological profiles of DLB, AD+P and VLOSLP

Comparison of neuropsychological variables in VLOSLP, AD+P, DLB. Table 5 shows means and standard deviations of the neuropsychological tasks. Notably, the number of individuals is not the same for each test as not every patient was administered all neuropsychological tasks. An ANCOVA with gender as covariate showed significant differences in performance on RAVLT trial 1, RAVLT sum, RAVLT delayed recall, RAVLT retention, RAVLT recognition, AVF, drawing and copying of a house between the three groups. This suggested differences in memory performance, verbal fluency and visuo-constructive abilities.

Gabriel's post hoc test and the Games-Howell procedure for post hoc contrasts showed that participants with VLOSLP performed better than individuals with AD+P and DLB on

RAVLT 1, RAVLT sum and RAVLT delayed recall. Patients with VLOSLP also performed better than those with AD+P on RAVLT retention and recognition. Individuals with DLB, in their turn, scored higher than those with AD+P on RAVLT sum, delayed recall, retention and recognition. This suggested more efficient learning in VLOSLP compared to both other groups and more efficient consolidation in VLOSLP and DLB compared with AD+P. The VLOSLP group outperformed the participants with AD+P on the BNT. VLOSLP also scored higher than AD+P and DLB on AVF, which indicated better language function in VLOSLP compared to both other groups. Finally, individuals with DLB performed worse on copying a house than participants with AD+P and VLOSLP. There was a significant contrast between the VLOSLP and DLB groups for drawing a house using Gabriel's post hoc procedure which can be used if population variances are not expected to differ strongly. Both observations suggest a generalized visuo-constructive deficit in DLB, whereas the deficit in AD+P is limited to spontaneous production but not copying of figures. Participants with VLOSLP outperformed both other groups on tasks involving visuo-construction. All contrasts had medium to large effect sizes (Table 5).

Differentiating neuropsychological factors and profiles in VLOSLP, AD+P and DLB. Using Pillai's trace, there was a significant effect of diagnosis on neuropsychological results $V = (0.54)$, $F(18, 114) = 2.32$, p = .004. A MANOVA was followed up with discriminant analysis, which revealed two discriminant functions. The first explained 68.9% of the variance, canonical $R^2 = 0.35$, whereas the second explained 31.1% of the variance, canonical $R^2 = 0.19$. In combination these functions significantly differentiated the diagnostic groups, $\Lambda = 0.53$, χ^2 (18) = 38.15, $p = .004$, but removing the first function indicated that the second function did not significantly differentiate the diagnostic groups $\Lambda = 0.81$, χ^2 (8) = 12.78, $p = .120$. The correlations between outcomes and the discriminant functions revealed that copying of a house ($r = .78$) loads fairly heavy on the first function, whereas RAVLT recognition ($r =$

.73), RAVLT sum (r = .72), RAVLT delayed recall (r = .60), AVF (r = .57) and RAVLT retention (r = .45) load more highly on the second function. BNT (r = .36 on function 1, r = .27 on function 2), drawing of a house (r = .52 on function 1, r = .35 on function 2) and RAVLT trial 1 (r = .52 on function 1, r = .38 on function 2) loaded similarly on both functions. The first function discriminated the DLB group from both other groups and the second function differentiated the AD+P group from both other groups.

Correlations between phenomenology and neuropsychological variables

An exploration of the correlations between phenomenological variables and neuropsychological measures showed that impaired attention and processing speed, executive function, animal verbal fluency, naming and visuospatial perception were positively associated with visual hallucinations of animals across groups (Table 6). Partition and paranoid delusions, contrarily, were associated with better attention and executive function, as well as more adequate visuoconstructive skills. Partition delusions were also associated with better memory performances. Within the DLB group, reduced processing speed remained positively associated with visual hallucinations of animals. Also, increased sensitivity to interference was associated with visual or auditory hallucinations of humans. Additionally, memory deficits were associated with visual hallucinations of humans. Paranoid delusions showed a positive association with attention span, whereas partition delusions were negatively associated with visuoperceptual abilities. In the group of participants with AD+P negative associations between attention, executive function, naming, visuospatial perception and visual hallucinations of animals remained. Also, visuoconstructive skills showed a strong negative association with these types of hallucinations. Memory deficits were associated with visual hallucinations of humans. Partition delusions, on the other hand, were positively associated with drawing from memory. In the VLOSLP group, finally, negative associations between

attention, processing speed and visual hallucinations of animals remained. There was a negative association between visuospatial perception and auditory hallucinations of human voices. Partition delusions were positively associated with letter fluency and memory function.

Discussion

Differential diagnosis of late onset psychosis is very challenging to the clinician, specifically when discerning neurodegenerative diseases often associated with psychosis such as AD and DLB from schizophrenia-like conditions, as there is a large overlap in phenomenology as well as types of cognitive dysfunction. However, carefully studying the clinical profile may still aid differential diagnosis.

Depending on the underlying illness, neurodegenerative or schizophrenia-like, the phenomenology differs slightly. The current study shows that all individuals with late onset psychosis indeed display primarily visual or auditory hallucinations and mostly paranoid delusions. However, visual hallucinations of animals and humans specifically predicted a diagnosis of DLB. Additionally, individuals with VLOSLP more often experienced partition delusions that caused a feeling of vulnerability (Hanssen et al., 2015; Howard et al., 2000; Nagahama et al., 2007). Interestingly, there were links with real experiences. For instance, the delusional conviction that a laser beam shines through a solid wall and onto the legs of the patient, is associated with rash on these legs that is actually observed by health professionals. There were also clear associations with multimodal hallucinations. Furthermore, hallucinations of human voices predicted a diagnosis of VLOSLP rather than AD+P. Interestingly, the presence of auditory hallucinations of human speech in VLOSLP is reminiscent of observations in average onset schizophrenia (AOS, onset of before 40 years). Moreover, delusions are mainly persecutory in nature in VLOSLP as well as AOS. However,

grandiosity, external control, having thoughts inserted or withdrawn from one's head, ideas of reference and mind-reading seem less prominent in VLOSLP than in AOS (Wong & Van Tol, 2003).

Misidentification delusions, finally, do not appear very often in any of the groups, which would suggest that these are indeed associated with more pronounced cognitive decline as all groups in the current study exhibited only mild cognitive deficits (Holt & Albert, 2006).

Mild cognitive deficits described in VLOSLP as opposed to healthy older adults are reduced processing speed, executive deficits, learning impairment and language dysfunction (Van Assche et al., 2017). These cognitive impairments may partly reflect abnormalities that are the neurobiological underpinnings of psychosis, combined with stress-related accelerated brain aging. Indeed, when VLOSLP and Late Onset Schizophrenia (LOS, onset after the age of 45 years) is compared to AOS, there are similar deficits in memory, language and executive function. However, the impairment described in VLOSLP or LOS is milder and more diffuse, which is suggestive of a relatively higher contribution of age-related changes compared to neurodevelopmental predisposition.

A direct comparison of VLOSLP with the two neurodegenerative diseases AD+P and DLB demonstrated comparable impairments in the domains of processing speed, attention and executive function which was to be expected, considering the importance of frontal and subcortical dysfunction for the inefficient suppression of memory recall leading to hallucinatory experiences, or the inability to re-evaluate wrong beliefs predisposing to the development of delusions (Holt & Albert, 2006; Jellinger, 2012). However, neuropsychological profiles may still advance differential diagnosis. Specifically, the combined presence of learning and consolidation deficits as well as language impairment in the absence of a global visuo-constructive dysfunction predicted a diagnosis of AD+P as opposed to DLB or VLOSLP. On the other hand, impaired visuo-construction but better

preserved memory and language function predicted DLB as opposed to AD+P and VLOSLP. As the three groups displayed similar general levels of cognitive functioning, it was unlikely that a more pronounced cognitive deficit in the neurodegenerative conditions could sufficiently explain superior performances in VLOSLP as opposed to DLB and AD+P.

An exploration of the associations between neuropsychological measures and psychotic symptoms showed that worse performances on attention, processing speed, executive function, animal fluency, naming, and visual perception were all associated with greater likelihood of animal hallucinations or hallucinations of humans. Partition or paranoid delusions were associated with better attention, executive and memory function. This seemed to be in line with the speculation that severe cognitive deficiency would preclude sustainability of delusions (Bassiony & Lyketsos, 2003), whereas hallucinations might result from further deterioration of the occipital and/or parietal cortices – the primary visual cortex or visual association areas – combined with frontal abnormalities. (Kotrla et al., 1995; Sanchez-Castaneda et al., 2010). Still, as all participants did show comparable executive dysfunction, it is possible that a lack of differentiation between the participants is responsible for reduced power in the detection of significant correlations. Also, as we have dichotomized phenomenological data and dichotomized variables are known to reduce power in correlational research (MacCallum, Zhang, Preacher & Rucker, 2002). Hence, the use of psychosis as a continuous variable or comparing individuals with psychotic symptoms to healthy older adults and older adults with mild cognitive dysfunction but no psychosis could further enlighten the association between the phenomenology of late onset psychosis and neuropsychological profiles. Moreover, it is possible that neuropsychological instruments used in the current study insufficiently tap into the cognitive processes that explain the onset of psychosis. Hence, an experimental design may provide further insight into the neuropsychological mechanisms associated with the onset of psychosis. Finally, possible time

lags between initial symptom evaluation and cognitive testing may have existed, that might have masked other existing associations.

Even though the findings are largely in line with our predictions, there are certainly limitations to the current study. First, there are relatively small sample sizes, possibly reducing statistical power and thus increasing the risk for type II errors, suggesting that there are no significant differences when in fact there are. Therefore, we believe that the current study can only be regarded as exploratory, laying out possible research lines for future investigation. Next, the current study has a cross-sectional design, whereas it might be interesting for future research to have multiple assessments in order to be able to better predict which individuals will show a conversion to dementia associated with either AD or DLB as opposed to those individuals displaying a non-progressive cognitive impairment. On the other hand, we were able to track the further evolution and final diagnosis by screening all of the clinical files of the patients, many of whom were first tested five to seven years earlier. Third, although our groups were matched for age, educational level and general level of cognitive function, there is an important difference in gender. As it was associated with certain cognitive measures, we have included gender as a covariate in further analyses on cognitive data. However, it might be interesting to conduct further analysis using gender as a moderator in order to assess potential gender related differences in neurocognition or phenomenology of late onset psychosis. As the number of males in the VLOSLP group and the number of females in the DLB group in the current study was too small to consider these effects, we have not conducted such analyses. Moreover, it was not the primary aim of the study to investigate gender differences. Still, future research may view gender as a variable of interest. Also, we used MMSE scores to match groups for general level of cognitive function, whereas a more valid and sensitive global measure of cognition might be better for the purpose. Fourth, the description of phenomenological data through different protocols – scientific and

clinical - lead to clinical records that were not all equally detailed. It might be interesting to further explore the phenomenology of psychotic symptoms using (multidimensional) qualitative techniques after systematically exploring psychotic symptoms in a semi-structured interview. Next, even though the multivariate analyses provided interesting results, it is appreciated that some analyses may be underpowered. Still, given the already preliminary nature of the study, this option seemed worth exploring. Finally, all participants presented at the hospital, perhaps limiting the generalizability of findings towards groups of community dwelling older individuals who are experiencing a late onset of psychosis and who have not been in contact with psychiatric or neurological services. Hence, the current study offers interesting findings, which appear to be in line with prior results from empirical studies and with theoretical predictions but need to be replicated and expanded.

To summarize, the clinical presentation in individuals with psychosis associated with AD or DLB may prove similar to that in VLOSLP. Still, examination of phenomenological aspects of psychosis and the neuropsychological profile may offer useful clues for differentiation and it may provide arguments for additional, more thorough investigations that can confirm the hypothesized diagnosis with greater certainty such as imaging that demonstrates reduced dopamine transporter uptake in basal ganglia in DLB or amyloid imaging in AD+P. Importantly, we believe that this process might promote a stepped care approach to diagnosis that is ultimately less invasive for the patient and that might reduce societal cost.

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Table 1
Demographic characteristics of patient groups

	DLB	AD+P	VLOSLP	F (df)	p - value
	M (SD) Range	M (SD) Range	M (SD) Range		
Age (years)	76.20 (6.955) 61-91	78.80 (6.286) 63-91	79.25 (7.484) 62-92	2.719 (2, 138)	.069
Education	10.92 (3.181) 6-19	9.80 (2.167) 6-15	9.96 (2.790) 6-23	2.145 (2, 138)	.121
MMSE	24.86 (3.195) 19-30	24.20 (2.677) 19-30	24.82 (2.233) 19-30	0.729 (2, 137)	.484
				χ^2 (df)	
Gender	67.3% male	37.1% male	22.8% male	21.903 (2)	<.001

Note. DLB = Dementia with Lewy Bodies, AD+P = Alzheimer's type Dementia with Psychosis, VLOSLP = Very-Late-Onset Schizophrenia-Like Psychosis.

Table 2

Psychotic symptoms in DLB, AD+P and VLOSLP

	DLB (n=49)	AD+P (n=35)	VLOSLP (n=57)	χ^2 (df)	p	Effect size: C V
	Subjects with symptom (% within group)	Subjects with symptom (% within group)	Subjects with symptom (% within group)			
Delusions	32 (65.3%)	34 (97.1%)	55 (96.5%)	25.959 (2)	<.001	.429
Misidentification*	7 (14.3%)	3 (8.6%)	2 (3.5%)	3.861 (2)	.142	
Partition	3 (6.1%)	5 (14.3%)	21 (36.8%)	16.345 (2)	<.001	.340
Paranoid	24 (49%)	28 (80%)	52 (91.2%)	25.236 (2)	<.001	.423
Jealousy	4 (8.2%)	3 (8.6%)	9 (15.8%)	1.880 (2)	.391	
Poverty	5 (10.2%)	1 (2.9%)	0 (0%)			
Somatic	3 (6.1%)	1 (2.9%)	3 (5.3%)			
Reference	3 (6.1%)	2 (5.7%)	2 (3.5%)			

Guilt	2 (4.1%)	0 (0%)	0 (0%)			
Imperative	1 (2%)	0 (0%)	0 (0%)			
Religious	1 (2%)	2 (5.7%)	2 (3.5%)			
Sexual content	1 (2%)	2 (5.7%)	2 (3.5%)			
Grandiose	0 (0%)	0 (0%)	1 (1.8%)			
Hallucinations	47 (95.9%)	20 (57.1%)	43 (75.4%)	18.267 (2)	<.001	.360
Visual	46 (93.9%)	19 (54.3%)	34 (59.6%)	20.407 (2)	<.001	.380
Human	35 (71.4%)	16 (45.7%)	25 (43.9%)	9.315 (2)	.009	.257
Specific/known	11 (22.4%)	6 (17.1%)	31 (54.4%)			
General/unknown	31 (63.3%)	12 (34.3%)	16 (28.1%)			
Animal	21 (42.9%)	4 (11.4%)	9 (15.8%)	14.644 (2)	.001	.322
Plant	0 (0%)	0 (0%)	2 (3.5%)			
Transport	6 (12.2%)	0 (0%)	3 (5.3%)			
Specks	6 (12.2%)	0 (0%)	8 (14%)			
Beams	0 (0%)	0 (0%)	8 (14%)			
Auditory	20 (40.8%)	8 (22.9%)	31 (54.4%)	8.891 (2)	.012	.251
Voices	8 (16.3%)	4 (11.4%)	20 (35.1%)	8.042 (2)	.018	.239

Music	2 (4.1%)	0 (0%)	2 (3.5%)		
Noises	3 (6.1%)	5 (14.3%)	12 (21.1%)		
Animals	2 (4.1%)	0 (0%)	0 (0%)		
Tactile*	2 (4.1%)	1 (2.9%)	8 (14.0%)	4.413 (2)	.112
Gustatory*	0 (0%)	0 (0%)	2 (3.5%)	1.967 (2)	.341
Olfactory*	0 (0%)	0 (0%)	2 (3.5%)	1.967 (2)	.341
Multimodal	20 (40.8%)	9 (25.7%)	25 (43.9%)	3.223 (2)	.200

Note. * Fisher's exact was used instead of Pearson chi squared as the expected number of observations was smaller than 5 in > 20% of the cells; DLB = Dementia with Lewy Bodies, AD+P = Alzheimer's type Dementia with Psychosis, VLOSLP = Very-Late-Onset Schizophrenia-Like Psychosis.

Table 3

Content of different types of hallucinations and delusions according to diagnosis

		DLB	AD+P	VLOSLP
Hallucinations				
Visual				
Humans				
	Known/specific	family members, a politician, a witch, Japanese people	(dead) husband (n=3), the deceased sister (n=1), the son in law (n=1) or the architect (n=1), Lilliputian creatures, people whose faces were shaped wrongly	father, sister, nephew, husband, wife, daughter, son, or grandchildren, leprechauns, (fat) Asians, Africans, small and yellow people, malevolent alien creatures (n=1)
	Unknown/general	blurred figures (dressed in beige)	clearly formed human beings or parts of human beings	men wearing black clothes or a shirt, a naked woman, three children, babies, ghosts, shadows, reflections or

				blurry figures
	Location	in the house, garage, garden, attic, or wardrobe	on the roof, in the house (downstairs, upstairs, in the attic or in the living room, wandering through the hallway or squeezed between the couch), at the front door, outside by the window, by the walls outside and in the garden	in the house, in bed, garden or broader surroundings of the house, at the elevator in a larger building (residence)
	Action	sit down, lay down in bed or pass by, come floating in through a closed window wearing	knock, spy, walk, sit, steal	sit down, stand, hide, harass

		a parachute, move or hide objects such as keys, close doors or damage things (electric wires, plants), put fire to the garden or house, hide themselves or steal objects, are involved in a car accident		
Animals				
	Type	cats (n=4), dogs (n=4), birds (n=4), chickens (n=1), pigs (n=1), ducks (n=1), elephants (n=1), spiders (n=2), butterflies (n=1), bees (n=1), larvae (n=1), worms (n=1), caterpillars	small creatures, spiders, cat	small creatures, fleas, mice, crows, cats, goats

		(n=1), other small insect-like creatures		
	Location	around the lighter, on walls, ceilings, plates, curtains and trousers	on the person, on the ceiling, in the house, in the room	in the house, on the walls, on the wardrobe, in the attic, before the window and outside in the garden
	Action	fly, crawl, sit	bite, crawl, fly	sit, run
Plants				plants, flowers (n=2)
Transport		cars (n=2), trucks (n=2), the Titanic (n=1), planes (n=1), a space ship (n=1)		cars (n=2), vans (n=1)
Less elaborate		specks of dust, (curved) lines, dots, dirt, hairs, raindrops		(blood) stains, dots, white or black dust, powder, sand (n=8); beams of light, laser beams
Auditory				

	Voices	human voices (n=8) uttering simple sounds (‘kwevedete’, ‘fltanidifaln’), words that are not clearly articulated, words repeated from the radio, conversations that are not related to the patient, condescending comments on what a patient is doing, who he/she is or what he/she is thinking, voices that address the patient, warnings, or imperative hallucinations	indistinct noises from people and human voices speaking in different languages	human voices that converse, or talk in an negative way about the patient, mock, threaten directly or give orders; anonymous (n=12) or voices of son, grandson, daughter, nurse, psychologist, doctor, neighbor, acquaintances (n=12)
	Indistinct noises	knocking,	knocking,	noises made by

		moving furniture, closing doors (n=3)	moving of furniture or other objects, noises from party downstairs	neighbours (n=7) such as knocking, machine that zooms or blows; other noises (n=5)
	Music	music (n=2)		songs from childhood, mocking songs, nice music
	Animal noises	spiders growling or birds singing (n=2)		
Tactile		feeling insects crawl on arm	feeling a pressure on his chest that was the result of his dead sister's weight laying on it which occurred as he was awake and sitting at the table; insect bites	feeling an electrical shock, an itch, heat, a pressure, pain, feeling manipulated (grabbed, pushed)

Gustatory				weird taste in coffee or food
Olfactory				chemical smells (e.g., paint) that are suspected to have been pumped into the apartment through the ventilation
Delusions				
	Paranoid	people who want to break into their houses, steal things, rob them or harm them physically by restraining them, otherwise manipulating them (e.g. partaking in a game against their will), or	people breaking in and/or stealing things, spying with a camera, harming the patient or loved ones, and wanting to murder the patient; the perpetrators are usually known	people wanting to steal from them, harm or kill them or their loved ones

	murdering them	to the patient, such as neighbors (n=7), family (n=6), doctors (n=3) or religious figures (n=1)	
Partition		pink air coming in through ceiling or through hole from lighter, gas coming in through the wall	dust coming in through ventilation, lights or (laser) beams shining through windows or walls

Note. DLB = Dementia with Lewy Bodies, AD+P = Alzheimer's type Dementia with Psychosis; VLOSLP = Very-Late-Onset Schizophrenia-Like Psychosis

Table 4
Multinomial logistic regression model: phenomenology of psychosis predicting diagnosis
Note. R^2 = .34 (Cox & Snell), .39 (Nagelkerke). Model $\chi^2(10) = 58.82$, $p < .001$. * $p < .05$, ** $p < .01$, *** $p < .001$.

		95% CI for Odds Ratio		
Included	B (SE)	Lower	Odds Ratio	Upper
DLB vs. VLOSLP				
Intercept	-1.44 (0.89)			
Visual hallucinations of humans	-1.47 (0.51)***	0.09	0.23	0.62
Visual hallucinations of animals	-1.01 (0.54)	0.13	0.37	1.05
Auditory hallucinations of human voices	0.99 (0.60)	0.83	2.69	7.74
Paranoid delusions	2.20 (0.60)***	2.76	9.02	29.48
Partition delusions	1.53 (0.76)*	1.03	4.60	20.51
AD+P vs. VLOSLP				
Intercept	-2.63 (0.94)**			
Visual hallucinations of humans	-0.22 (0.47)	0.32	0.80	1.99
Visual hallucinations of animals	0.56 (0.67)	0.48	1.76	6.49
Auditory hallucinations of human voices	1.27 (0.63)*	1.03	3.57	12.33
Paranoid delusions	0.89 (0.66)	0.66	2.43	8.89
Partition delusions	0.81 (0.59)	0.70	2.24	7.13

Table 5

Comparison between neuropsychological performances in DLB, AD+P and VLOSLP

Task	Group	N	Mean	SD	Range	F (df)	p	Post ho
Stroop I	DLB	34	74.79	29.432	40-180	1.819 (2, 106)	.167	
	AD+P	27	67.15	18.106	48-126			
	VLOSLP	48	85.29	54.457	46-420			
Stroop IF*	DLB	29	178.69	157.328	38-708	1.854 (2, 45.370)	.168	
	AD+P	25	142.720	107.523	34-456			
	VLOSLP	46	121.370	72.933	-4-364			
DS forward	DLB	46	4.74	0.976	3-7	0.111 (2, 131)	.895	
	AD+P	33	4.64	0.859	2-6			
	VLOSLP	55	4.69	0.998	3-7			
DS backward	DLB	46	3.17	0.709	2-5	0.239 (2, 131)	.788	
	AD+P	33	3.30	0.810	2-5			
	VLOSLP	55	3.25	0.966	0-6			
Story detail*	DLB	34	5.21	3.960	0-14	2.719 (2, 60.925)	.074	
	AD+P	24	4.08	2.448	0-10			
	VLOSLP	47	5.66	3.164	0-14			

Story general	DLB	34	2.53	1.354	0-5	1.614 (2, 102)	.204	
	AD+P	24	2.08	1.100	1-5			
	VLOSLP	47	2.64	1.241	0-5			
RAVLT 1	DLB	46	2.65	1.609	0-6	11.555 (2, 132)	<.001	VLOSL
	AD+P	35	2.34	1.259	0-5	ω = .37		t(87) =
	VLOSLP	54	3.94	2.023	0-11			VLOSL
								t(98) =
RAVLT sum*	DLB	46	23.72	8.007	2-45	18.030 (2,	<.001	VLOSL
	AD+P	35	19.06	7.182	5-35	86.588)		t(98) =
	VLOSLP	54	31.09	11.653	8-62	ω = .45		VLOSL
								t(87) =
								DLB >
								t(79) =
RAVLT delayed recall*	DLB	46	3.39	2.832	0-10	19.251 (2,	<.001	VLOSL
	AD+P	35	1.49	2.035	0-9	87.988)		t(98) =
	VLOSLP	54	5.28	3.858	0-15	ω = .46		VLOSL
								t(87) =
								DLB >
								t(79) =
RAVLT retention	DLB	46	0.51	0.380	0.00-1.17	11.135 (2, 132)	<.001	VLOSL
	AD+P	35	0.27	0.311	0.00-1.00	ω = .36		t(87) =
	VLOSLP	54	0.62	0.344	0.00-1.17			DLB >
								t(79) =
RAVLT	DLB	46	9.54	3.067	3-15	8.982 (2, 74.827)	<.001	VLOSL

recognition*	AD+P	35	5.11	5.593	-10-14	ω = .33		t(87) =
	VLOSL	54	9.11	4.777	-6-15			DLB >
	P							t(79) =
BNT	DLB	45	40.80	10.683	18-57	2.915 (2, 128)	.058	VLOSL
	AD+P	33	38.58	8.675	16-56			t(84) =
	VLOSL	53	43.60	9.153	22-59			
	P							
AVF	DLB	48	11.73	3.774	4-21	4.315 (2, 136)	.015	VLOSL
	AD+P	35	11.54	3.202	6-17	ω = .36		t(89) =
	VLOSL	56	13.62	4.363	5-23			VLOSL
	P							t(102) =
Letter VF	DLB	48	17.60	8.274	0-40	.159 (2, 135)	.853	
	AD+P	35	16.51	7.126	4-36			
	VLOSL	55	17.29	10.168	2-52			
	P							
Object	DLB	22	12.82	3.924	5-18	2.303 (2, 89)	.106	
decision	AD+P	18	14.56	3.203	8-19			
(VOSP)	VLOSL	52	14.58	3.121	9-20			
	P							
Number	DLB	21	7.29	2.704	2-10	1.558 (2, 79)	.217	
location	AD+P	16	7.56	2.683	0-10			
(VOSP)	VLOSL	45	8.36	2.278	0-10			
	P							
Cube	DLB	20	6.65	2.641	1-10	2.525 (2, 78)	.087	
analysis	AD+P	16	7.50	2.556	0-10			

(VOSP)	VLOSLP	45	8.04	2.067	3-10			
House (COTESS)	DLB	12	2.50	1.977	0-6	4.458 (2, 67)	.015	VLOSL
	AD+P	13	2.77	1.922	0-6	ω = .30		t(55) =
	VLOSLP	45	3.89	1.541	2-6			
House copy (COTESS)	DLB	14	2.43	1.910	0-6	14.373 (2, 69)	<.001	VLOSL
	AD+P	13	4.15	0.987	2-5	ω = .52		t(57) =
	VLOSLP	45	4.80	1.392	0-6			AD+P >
								t(25) =

Note. * Welsh's F is used as Levene's test was significant; Gabriel's and Games-Howell procedure was used for post hoc testing; Cohen's d was used to measure effect sizes of the contrasts (Zakzanis, 2001); CL effect size = common language effect size, the % chance that in randomly selected pairs of individuals the participant from group 1 would score higher than the participant from group 2; DLB = Dementia with Lewy Bodies, AD+P = Alzheimer's type Dementia with Psychosis; VLOSLP = Very-Late-Onset Schizophrenia-Like Psychosis; Stroop I = Stroop Colour Word Interference Task Card I; Stroop IF = Stroop Colour Word Interference Task Interference Factor (Interference Card - (Card I + Card II)/2); DS forward = Digit Span forward; DS backward = Digit Span backward; RAVLT 1 = Rey Auditory Verbal Learning Test trial 1; RAVLT sum = Rey Auditory Verbal Learning Test sum of trial 1 to trial 5; RAVLT delayed recall = Rey Auditory Verbal Learning Test delayed recall; RAVLT retention = Rey Auditory Verbal Learning Test retention (delayed recall / trial 5); RAVLT recognition = Rey Auditory Verbal Learning Test recognition (items correctly recognized – false identification); BNT = Boston Naming Test; AVF = Animal Verbal Fluency; Letter VF = Letter verbal fluency; VOSP = Visual Object and Space Perception Battery; COTESS = Cognitieve Testbatterij voor Senioren (Cognitive Test for Seniors).

Table 6

Partial correlations controlling for gender between delusions, hallucinations and neuropsychological measures

		Visual: animal Across Within: (DLB/AD+P/VLOSLP)	Visual: human Across Within: (DLB/AD+P/VLOSLP)	Auditory: human Across Within: (DLB/AD+P/VLOSLP)	Partit Acros Within (DLB/
Executive function	DS fw	-.29*** (-.22/-.51**/-.33*)	.01 (.07/-.19/.06)	.06 (-.17/.15/.15)	.05 (.07/.0
	DS bw	-.20* (-.10/-.29/-.24)	-.05 (.01/-.16/-.01)	-.06 (-.12/.04/-.10)	.01 (.06/.0
	Stroop I	.30** (.38*/.25/.32*)	-.07 (.13/-.02/-.15)	.05 (.19/-.10/.02)	.06 (.33/.1
	Stroop IF	.10 (.00/.43*/-.02)	.12 (.35*/-.20/.01)	.06 (.35*/.01/-.06)	-.16 (-.10/-
	Letter fluency	-.22** (-.21/-.49**/-.23)	-.02 (-.13/.05/.01)	-.04 (.01/.05/-.15)	.21* (.13/.0
Memory	Story general	-.08 (-.13/.00/-.14)	.07 (-.31/.15/.25)	.01 (.02/.17/-.14)	-.04 (-.01/-
	Story detail	-.13 (-.11/-.28/-.19)	-.02 (-.24/-.07/.10)	-.02 (-.15/.29/-.11)	-.03 (.02/-.
	RAVLT 1	-.05 (-.01/-.03/-.03)	-.08 (-.16/.09/-.10)	.01 (-.14/-.04/-.05)	.17* (.05/-.
	RAVLT sum	-.05 (.05/-.03/-.11)	.03 (-.03/.08/.04)	-.03 (-.20/-.11/-.11)	.22* (-.04/-
	RAVLT	-.02 (.01/-.06/-.02)	-.08 (-.27/-.10/-.03)	.06 (-.13/-.23/.04)	.19 (-.11/-

	delayed recall				
	RAVLT retention	.02 (.02/.03/-.04)	-.13 (-.31*/-.15/-.07)	.05 (-.06/-.23/.07)	.06 (-.21/-
	RAVLT recognition	.10 (.10/.07/-.03)	-.07 (.14/-.41*/-.13)	-.04 (-.17/-.02/-.10)	.01 (-.01/-
Language	AVF	-.18* (-.13/-.19/-.21)	-.06 (-.18/.09/.02)	-.03 (-.17/.14/-.12)	.16 (.02/-.
	BNT	-.19* (-.12/-.64**/-.12)	.04 (.10/.07/.02)	.00 (-.13/.09/-.06)	.02 (-.18/-
Perception	Object decision	-.06 (.23/.07/-.17)	-.01 (.20/-.01/-.02)	-.04 (-.13/-.12/-.00)	-.02 (-.15/.
	Number location	-.30** (-.34/-.54*/-.06)	-.03 (-.21/.26/-.01)	-.03 (.17-.15/-.18)	-.01 (-.48*
	Cube analysis	-.27** (.16/-.61*/-.25)	.08 (.04/.36/.08)	-.14 (-.23/-.16/-.30*)	.18 (-.07/.
Visuoconstruction	Drawing a house	.02 (.28/-.39*/.28)	.01 (-.11/.35/.02)	.08 (-.37/.40/.07)	.16 (.24/.6
	Copying a house	-.14 (.16/-.76**/.14)	.05 (-.16/.31/.23)	.06 (-.03/.35/.04)	.27* (.09/.2

Note. DLB = Dementia with Lewy Bodies, AD+P = Alzheimer's type Dementia with psychosis, VLOSLP = Very-Late-Onset Schizophrenia-Like-Psychosis. * $p < .05$, ** $p < .01$, *** $p < .001$.