

Published in final edited form as:

Cogn Behav Neurol. 2007 March ; 20(1): 48–61. doi:10.1097/WNN.0b013e31803141dd.

A Case-Controlled Study of Altered Visual Art Production in Alzheimer's and FTL D

Katherine P. Rankin, Ph.D.¹, Anli A. Liu, M.D.¹, Sara Howard, M.A.¹, Hilary Slama, B.A.¹, Craig E. Hou, M.D.¹, Karen Shuster, B.A.¹, and Bruce L. Miller, M.D.¹

¹ University of California San Francisco

Abstract

Objective—To characterize dementia-induced changes in visual art production.

Background—While case studies show altered visual artistic production in some patients with neurodegenerative disease, no case-controlled studies have quantified this phenomenon across groups of patients.

Method—Forty-nine subjects [18 Alzheimer's disease (AD), 9 Frontotemporal Dementia (FTD), 9 Semantic Dementia (SD), 15 healthy older controls (NC)] underwent formal neuropsychological testing of visuospatial, perceptual, and creative functioning, and produced four drawings. Subjective elements of drawings were rated by an expert panel that was blind to diagnosis.

Results—Despite equal performance on standard visuospatial tests, dementia groups produced distinct patterns of artistic features that were significantly different from NCs. FTDs used more disordered composition and less active mark-making ($p < 0.05$). Both FTDs and SDs drawings were rated as more bizarre and demonstrated more facial distortion than NCs ($p < 0.05$). Also, SDs drastically failed a standardized test of divergent creativity. ADs artwork was more similar to controls than to FTDs or SDs, but showed a more muted color palette ($p < 0.05$) and trends toward including fewer details, less ordered compositions, and occasional facial distortion.

Conclusions—These group differences in artistic style likely resulted from disease-specific focal neurodegeneration, and elucidate the contributions of particular brain regions to the production of visual art.

Keywords

frontotemporal lobar degeneration; dementia; visual art; creativity

INTRODUCTION

We have an increasingly precise grasp of the neuroanatomic substrates of vision and visuospatial perception; however, our understanding of the neuropsychology of visual artistic production, and its evolution in the setting of brain injury, remains fairly unsophisticated. Thus far, the bulk of research consists of case reports describing the art of individuals who have suffered localized brain injury. Following the natural history of established artists has provided a rich understanding of the neurological substrate of art-making^{1, 2}, partly because pre- and post-morbid comparisons can be readily made in this cohort. Additionally, there have been

Address for correspondence and reprint requests: Katherine P. Rankin, Ph.D., Memory and Aging Center, UCSF Department of Neurology, 350 Parnassus Avenue, Suite 706, San Francisco, CA 94143-1207, Phone: (415) 502-0619, Fax: (415) 476-4800, Email: krankin@memory.ucsf.edu.

numerous case reports of non-artists, usually with left frontal or temporally predominant brain degeneration, who demonstrate a newfound interest in the visual arts³⁻⁷. Recent research suggests that a subset of patients with frontotemporal lobar degeneration (FTLD) or Alzheimer's disease (AD) continue artistic and musical pursuits in the context of their disease⁷. Furthermore, there have been several case reports of increased creativity⁴⁻⁶.

Past research involving patients with dementia and other forms of brain injury has enriched our understanding of regional contributions to art-making and the nature of visual creativity itself. Thus far, the body of research on art and the brain demonstrates that linguistic and graphic abilities largely exist independently. Furthermore, the non-dominant hemisphere seems to be responsible for understanding the essence of a visual form, whereas the dominant side appears engaged with details^{1, 8}. For example, from numerous case studies, it appears that patients with left-sided injury (i.e. retained right-sided function), when asked to draw a still life, produce simplified drawings that favor contour and form over details. In contrast, patients with spared left-sided function produce drawings that favor detail over the gestalt, such that the subject is often unrecognizable^{1, 8}. Furthermore, when asked to group others' artwork, patients with preserved right-sided function identify work by the style of the artist, whereas left-sided patients group by the subject of the work⁹. Such hemispheric differences may help explain why some regional variants of dementia allow visual creativity to flourish while other variants do not. Kapur's concept of paradoxical functional facilitation suggests that dysfunction in one sphere may allow the development of ability in another sphere because cognitive resources are redirected^{10, 11}.

Visual Art Production in Patients with FTL D

Frontotemporal lobar degeneration (FTLD) is a progressive neurodegenerative disease primarily affecting the frontal and anterior temporal lobes. The relative distribution of the pathology in FTLD determines the associated clinical syndrome. In the frontotemporal dementia (FTD) subtype, comprising approximately 57% of FTLD cases¹², the frontal lobes are disproportionately but often fairly symmetrically affected. The illness commonly presents dramatically in the fourth or fifth decade with changes in personality and social conduct, as patients lose motivation and become socially disinhibited. Patients become emotionally blunted and practice stereotyped and perseverative behaviors. Late in the disease, speech output may diminish into an echolalia, although an outpouring of speech may be seen in patients with extreme disinhibition. Because of executive dysfunction, patients display deficits in the domains of attention, abstraction, planning, and problem solving, with relative sparing of language, memory, and visuospatial ability¹³⁻¹⁸.

In the semantic dementia (SD) subtype of FTLD, atrophy often begins unilaterally, typically spreading to the contralateral hemisphere later in the disease course. The anterior temporal and orbitofrontal neocortices are disproportionately affected, while the dorsolateral frontal areas are relatively spared. Approximately twenty percent of FTLD patients begin as temporal variant¹². SD patients with left temporal damage manifest language difficulty in the realms of naming, semantics, and word comprehension. Right-temporal variant patients are more likely to present with social deficits such as lack of empathy and sociopathic behavior¹⁹⁻²¹.

These anatomic subtypes of FTLD provide a window into investigating the neurological basis of the artistic process. As mentioned earlier, lesion studies advance our understanding of hemispheric and regional contributions to art-making, particularly the relationship between language and visual creativity⁹. A growing number of reports of artistically creative FTLD patients exist in the literature. One case series of five FTLD patients demonstrated a newfound interest in art and preferred making representational drawings of landscapes, animals, and people. Abstract or symbolic art was notably absent^{3, 4}. In a second study, a 57-year-old right-handed female artist's left-sided frontal and temporal atrophy correlated with her deteriorating

language and social skills but increasing looseness in her art-making. Unlike the prior case series, her painting evolved from more traditional landscapes and representational art to freer, more expressive, and abstract forms with the progression of her dementia¹⁸. In a third study, a 56-year-old right-handed businessman with no previous interest in art began painting for the first time with the onset of FTLD. He displayed heightened visual awareness of his environment, especially light and sound, while his language and behavior deteriorated⁶.

One 53-year-old FTLD patient, a non-artist presenting with behavioral change and memory, language, and executive deficits, developed a preoccupation with making art²². His artwork was characterized by the bizarre representation of faces and a resulting sense of disconnection between the subjects in his work. In parallel with his disinhibited behavior, his paintings were filled with wildly clothed characters, the suggestion of sexual relationships, and use of profanity. Along with profound deficits in his ability to recognize subtleties in human emotion and a lack of empathy for other people and animals, he drew faces with bizarre expressions. This patient resembles a cohort of artists described by Mendez and Perryman who draw increasingly distorted and “alien” faces in association with degeneration of the right temporal lobe²³. Across all of these case studies, the association between right anterior temporal lobe involvement and artistic distortions of faces and facial emotions demonstrates how the perceptions of the face, which are likely to be impaired by right temporal damage, may manifest itself through artwork. Despite the existence of these isolated patients with increased artistic production, however, apathy leading to diminished creativity is more clinically typical of patients with FTLD, suggesting that these case studies may be the exception rather than the rule⁴.

Visual Art Production in Alzheimer’s Dementia Patients

The most common form of dementia in the aging population, Alzheimer’s disease (AD) is characterized by deterioration in memory, language, and visuospatial ability^{24, 25}. The inability to recognize faces or to read an analog clock represent some of the everyday deficits that result from AD-associated loss of visuospatial function. In a comparison of thirty AD patients with controls, Mendez and colleagues found that AD patients showed preserved visual acuity and color recognition, but decreased ability to visually recognize common objects and famous faces, make figure-ground distinctions, and evaluate complex figures²⁶. The deterioration of AD patients’ drawing abilities has been well-documented^{27, 28}. Case reports of artists with AD reveal a declining ability to represent subject matter in a representational fashion^{29–32}. Without necessarily diminishing in artistic quality, art becomes more abstract. Some of the painter Willem de Kooning’s (1904–1997) most celebrated works were made after the onset of his AD³⁰. While it is difficult to quantify the effect that de Kooning’s illness had on his art, later paintings made during the advanced stages of his AD were composed of formless sheets of color and lines. Cummings and Zarit also report the course of an artist with AD over a thirty month period³¹. The patient’s work became more simplified and primitive. His color palette became increasingly restricted while advanced techniques such as shading and perspective were lost.

In summary, these case studies suggest that disintegrating spatial relationships, regression, distortion, and stereotypy may characterize the art of progressive AD³². Such trends reflect the decline in visuospatial ability, face recognition, and severe apraxia and agnosia characteristic of the dementia, but require validation through case-controlled studies.

Comparative Research in the Study of Visual Creativity

While there exist a number of qualitative case studies on patients with various lesions and types of dementia, the field of research on art and the brain is notably deficient in either retrospective or prospective case-controlled studies that employ quantitative methods with groups of

patients. To this end, we compared the performance of FTD, SD, and AD patients to that of healthy older controls on neuropsychological tasks of visuospatial function and open-ended visual art production sessions. We hypothesized that in comparison to normal controls and FTLT patients, the art of Alzheimer's patients would show decreased representational form and would become more abstract. In contrast, we predicted that the art of patients with FTLT would appear more representational and rigid, and that their depictions of human faces would be more bizarre.

MATERIALS AND METHODS

Participants

Thirty-four patients diagnosed with one of three neurodegenerative diseases were recruited into the study from a university-based dementia specialty clinic. These included 16 patients who met the NINDS-ADRDA criteria³³ for Alzheimer's Disease, and 18 patients who met Neary research criteria¹⁵ for FTLT (9 Frontotemporal Dementia, 9 Semantic Dementia). Patient diagnosis was derived by a multidisciplinary team consisting of neurologists, neuropsychologists, psychiatrists, and nurses, who performed extensive behavioral, neuropsychological, and neuroimaging assessments.

Fifteen age-matched healthy control subjects were also recruited through advertisements in local newspapers and recruitment talks at local senior community centers. Interested individuals underwent telephone screening for a history of problems with their physical or psychiatric health, including a substance abuse history. Participants who passed the telephone screen were then brought in for a 1 1/2 hour neuropsychological evaluation, routine labs, and a brain MRI. Following this initial evaluation, a multidisciplinary team consisting of a neurologist, a neuropsychologist, and a nurse reviewed the data to determine if the patient met criteria to be a healthy control. For inclusion as a healthy control subject for this study, subjects had to meet the following criteria: 1) normal neurologic exam, 2) Clinical Dementia Rating Scale (CDR) score=0, 3) MMSE score equal to or greater than 28/30, and 4) delayed memory performance equal to or greater than the 25th percentile in both verbal and visuospatial domains.

Patients seen at the clinic represented a broad sample of the population in terms of ethnicity, sex, education level, and socioeconomic status, and an attempt was made to recruit all available consecutive patients for this study. However, successfully recruited patients were almost entirely of Caucasian ethnicity (93%), with 2 Chinese patients (4%), and 1 African American patient (2%). Statistically significant differences were seen across groups in both age and sex, so these variables were used as covariates in all analyses. While all patient groups had significantly lower MMSE scores than normal controls, they did not differ from each other on MMSE scores. Demographic data are summarized in Table 1.

Procedure

All subjects and patient caregivers signed an institutional review board-approved research consent form to participate in the study and to have their clinical neuropsychological testing used for research purposes. Subjects underwent a two-part assessment of their artistic creativity. These included 1) a structured component made up of formal neuropsychological testing of the subject's visuospatial, perceptual, and creative functioning, and 2) a drawing component, in which participants were asked to create four pictures assessing different aspects of artistic ability. Patients were tested either in an office at the medical center in which the dementia clinic operated, or in their homes. There were no group differences in percentage of patients tested at a particular location, so location was not used as a variable in further data analysis.

Structured Component—Data from the subjects' general neuropsychological screening, which was performed for diagnostic purposes prior to their enrollment in this study, was used to characterize their cognitive functioning. Subjects' general cognitive characteristics can be found in Table 1. Tests included general functional measures, including the Clinical Dementia Rating Scale (CDR)³⁴, the Mini-Mental State Examination (MMSE)³⁵, as well as a self-report assessment of mood, the Geriatric Depression Scale (GDS)³⁶. Tests of visuospatial functioning included the Wechsler Adult Intelligence Scales Third Edition's (WAIS-III)³⁷ Block Design subtest, designed to assess subjects' ability to perform logical visuospatial manipulations of 3-dimensional stimuli to match a 2-dimensional stimulus; the Visual Object Space Perception Battery's³⁸ Number Location subtest, designed to assess subjects' ability to precisely locate a stimulus on a 2-dimensional plane; the Condition 1 of the Delis-Kaplan Executive Function System's³⁹ Design Fluency subtest, designed to assess subjects' ability to rapidly draw novel designs on a 5-point field using 4 lines each; a modified version of the Rey-Osterreith Complex figure copy simplified for a geriatric population, designed to assess subjects' visuoconstruction of a two-dimensional drawing. In the language domain, subjects underwent evaluation with the Boston Naming Test⁴⁰, designed to assess their capacity for confrontation naming of progressively more difficult objects; the Animal Fluency test, assessing subjects' ability to rapidly generate verbal material to a categorical prompt; and the D-word Fluency test, assessing subjects' ability to rapidly generate verbal material to a phonemic prompt. Memory for verbal material was tested with the California Verbal Learning Test – Mental Status Edition⁴¹, in which a 9-item word list with 3 sub-categories is learned by the subject over 4 trials, then is freely recalled both after a 30-second interference trial and a 10-minute delay, after which a yes-no recognition trial is performed. Nonverbal memory was tested by evaluating patients' free recall of the modified Rey-Osterreith figure 10 minutes after copying it, followed by a 4-item multiple-choice trial. Measures of executive functioning included the span of digits backward from the WAIS Digit Span test, designed to assess working memory; a version of the Trailmaking test requiring subjects to rapidly draw lines alternating between sequences of numbers and days of the week, designed to more appropriately test set-shifting and sequencing in a geriatric population; and the Color-Word Interference subtest of the Stroop, in which the subject must inhibit a prepotent verbal response and name the ink color of mismatched color-word pairs.

Subjects also underwent testing with a battery of standardized neuropsychological tests designed to measure their nonverbal-creativity, their color discrimination, and their color preferences. Nonverbal creativity was tested using the Picture Completion subtest from the Figural battery of the Torrance Tests of Creative Thinking (TTCT)⁴². The TTCT has been designed and revised over the past 25 years to assess individuals' ability to engage in different aspects of creative thinking, including abilities that are required in both daily life and creative breakthroughs. It is designed for use with adults and children as young as kindergarten age, making it appropriate for use with a sample of individuals with dementia. On this test, subjects are given a page with 10 meaningless incomplete figures, and are asked to add lines to them in order to sketch interesting objects or pictures. They are told to try to think of unique, unusual objects or pictures, and are asked to tell the examiner what they have drawn. Though standard instructions ask subjects to make up an interesting title for their pictures, and these titles can be scored for originality and humor, we did not include this element in our testing because of the significant language deficits in some of our subjects with dementia. Only the nonverbal elements of this subtest were scored according to standardized TTCT criteria, including Fluency (the number of drawings out of 10 that met minimal criteria to be scored), Originality (the degree to which subjects avoided making conventional, obvious choices in their drawings), Elaboration (the amount of detail subjects included in their drawings), Resistance to Premature Closure (the degree to which subjects were able to transcend the demands of the initial incomplete figure and could create drawings that diverged from the original stimulus). Subjects' drawings were also scored using elements from the TTCT Checklist of Creative

Strengths, including Emotional Expressiveness of the subjects depicted in the drawings, the subjects' degree of Movement or Action, Synthesis of Incomplete figures in which 2 or more of the original stimuli are combined into a single drawing, Unusual Visualization of visual perspective in the drawing (i.e., diverging from the typical static, upright, straight-on viewpoint), Internal Visualization in which pictures depict the internal, dynamic workings of the subject, Humor in the drawing itself (again, in a departure from standard administration, humor in captions or titles was not elicited or scored), Richness of Imagery (i.e., drawings showing an unusual level of variety, vividness, liveliness and intensity), Colorfulness of Imagery (i.e., drawings that directly appeal to the 5 senses, or are spooky or fantastic), and Fantasy (i.e. when drawings explicitly include characters from established or original fables, myths, or science fiction).

Color discrimination testing was performed based on stimuli derived from the Swedish Natural Color System (NCS) (Scandinavian Color Institute AB, Stockholm, Sweden, 2000, www.ncscolourusa.com) in. According to the NCS, all colors can be described by three qualities, which include hue (gradations of yellow, orange, brown, red, purple, blue, and green), saturation (the location of the hue between 100% white and 100% black), and chromaticity (the location of the hue between 100% color and 100% grayscale). Subjects' color discrimination was tested in a manner similar to a procedure described by Wijk⁴³, using a 21-item test divided into 3 7-item subtests, each measuring ability to discriminate gradations of hue, saturation, and chromaticity for each of the 7 major colors. Items consisted of a white page printed with 3 2-inch blocks of color, 2 mm apart, in which one of the 3 squares differed from the other 2 by a 10% gradation of hue, saturation, or chromaticity. Test pages were placed flat in front of the subject under bright artificial light. Subjects were asked to identify which of the 3 color squares did not match the others.

Color preference was also tested using color blocks representing the 7 major hues from the NCS. White cards with 4-inch blocks of yellow, orange, brown, red, purple, blue, and green were placed in front of the examinee, who was asked to order the colors by preference from most to least. Their ranking of each color was recorded.

Drawing Component—Participants were asked to create 4 different pictures assessing different aspects of artistic ability. For each drawing, subjects were given a sheet of white drawing paper measuring 18 inches by 24 inches, a black drawing pencil, and 10 wax pastel crayons (red, orange, yellow, green, blue, purple, brown, black, white, and gray). They were told they had a maximum of 15 minutes to perform each drawing, though subjects generally used far less than the allotted time.

The drawing tasks included the following: Drawing 1: A clear cylindrical vase of realistic artificial flowers of various colors and species was placed in front of the subjects, and they were asked to draw it. This activity was designed to assess subjects' ability to create a representational drawing based on immediate visual cues. Drawing 2: Patients were told to visualize a room in their home and to draw that room from memory. This activity was designed to assess subjects' ability to draw a scene based on internal visualization rather than on direct visual cues. Drawing 3: An 8 inch diameter mirror was placed in front of the patients, and they were asked to draw their self-portrait. This activity was designed to assess patients' ability to create a representational drawing of a human face based on direct visual cues. Drawing 4: Patients were asked to visualize the emotion they were currently feeling, and to depict that emotion in their drawing. This activity was designed to assess subjects' ability to represent abstract material without any environmental cues.

Objective descriptions of the drawings were derived by scoring the non-subjective elements of each picture. The variety and number of colors used for each drawing was recorded. For the

still life of flowers, presence or absence of blooms, stems, leaves, water, and the vase itself was scored, and a total count of these details was scored. For the drawing of the room in the house, the presence of furniture, windows, people, and decorative objects was scored, the total count of these details was derived, as well as whether or not the subject chose to draw a floorplan rather than a perspectival drawing of the room. For the self-portrait, the presence of brows, eyes, nose, mouth, hair, ears, wrinkles, teeth, a torso, clothing, arms, legs, digits on the hands or feet, and secondary sex characteristics was noted, and a total count of these details was derived.

The more subjective aesthetic and creative aspects of the drawings were evaluated by a panel of raters. The panel included one neurologist, one neuropsychologist, one psychology graduate student, and two research coordinators who were selected because they all had amateur experience producing visual artwork. Members of the panel each completed a structured checklist evaluating the subjective features of each drawing. These raters were blinded to subject identity and diagnostic group at the time they performed their ratings. Ratings for each of the 4 drawings were averaged across the 5 raters to derive 12 individual element scores for each drawing. Element scores were also averaged across each of the 4 drawings to derive an overall score for each of the 12 elements. Group analyses were then performed to determine if patient drawings differed significantly from normal control drawings on any of the elements from individual drawings or on overall element scores across all drawings.

The structured checklist of artistic elements was designed to allow raters to rank their impressions of each drawing in the categories of Overall Impressions, Content, and Technique on a 5-point scale. Detailed, precise instructions for rating drawing elements were provided in a written manual to ensure greater inter-rater reliability. The individual elements of each of the three categories, with excerpts from the manual, include the following:

Overall Impressions—1) Creativity (1=none, 5=very much): Do you think that the person solved the assigned problem in a unique way or that they responded in a way that didn't require much thought beyond what would fill the requirement? 2) Level of apparent effort (1=low, 5=high): Does it look like they put work into the drawing? Or does it appear that they completed it in a hasty manner that does not represent their best effort? 3) Fidelity to the intended subject (1=true to subject, 5=diverges significantly from subject): Please rate in conjunction with the patient's statement about the work. Essentially, does this drawing look like what the patient says it is? This would apply to representational work as well as abstract work. 4) Bizarreness (1=none, 5=extremely odd): There is a sense that something about the drawing is incongruent, strange or odd.

Content—1) Movement of subject (1=none, 2=postural tension, 3=moderate, 4=active, 5=vigorous): Is there any sort of movement of the subject in the piece? A chair in its place will have no movement, but chair that looks like it is falling over would have moderate movement. If the chair were doing aerobics, it would be vigorous movement. 2) Abstract (1=concrete, 5=abstract): The drawing does not depict a recognizable scene, but instead is made up of forms and colors that exist for their own expressive sake. The drawing is made up of formal qualities that exist independent of subject matter.

Technique—1) Composition / use of space (1=none/disordered, 3=neither disordered nor composed, 5=intentional/balanced): Are dominant lines of composition visible? How does the eye engage with the work? With intentional or balanced compositions, are the elements actually placed in a thoughtful manner that encourages your eye to move all over the surface of the drawing? With a disordered composition, you would not have this clarity of eye movement; it would feel difficult to look at the picture for an extended period of time. 2) Form (1=representational, 5=non-representational/no form): The objects in the drawing have a

consistent form and can be identified with a noun that brings to mind a specific form, though this form may have some variations to it. 3) Perspective (1=2D, 5=3D): 3D gives the illusion of 3 dimensions on a flat surface, while 2D is a picture that has no viewpoint or perspective and is entirely flat. 4) Patterning (1=none, 3=repeated shapes, 5=ornamental detail): Are there any repeated marks, shapes or designs in the drawing? A high score on patterning would be obtained from a drawing where there is a significant amount of ornamental detail in an area of the drawing. 5) Movement in technique, strokes (1=none, 3=active, 5=rapid): When this drawing was made, did the person make slow, deliberate marks to realize the volume and surface of the object, or did they work quickly, making fast marks that appear to indicate all, the form, the space, and the composition? 6) Facial features (0=n/a; 1=human, 3=some distortion, 5=grotesque or stereotyped): If there are facial features in the drawing, are they realistically human, or are they distorted, looking more cartoon-like or manipulated to look deformed? 7) Rendering (1=none, 5=very much): Is there any shading in the picture? Are there tonal values produced by density of line in the drawing?

Statistical Analyses

Each of the variables from the structured and drawing components of the test was analyzed using a general linear model to determine whether diagnosis remained a significant predictor of art score after the effects of sex and age were removed. For each analysis, post-hoc group comparisons were derived using a Dunnett-Hsu test, again controlling for age and sex, to determine which of the three patient groups (FTD, SD, AD) differed significantly from the NC group.

RESULTS

General Cognitive Testing

In the visuospatial domain, all patient groups performed within normal limits. Patients were not significantly different from NCs on VOSP Number Location or the Complex Figure Copy. Though both AD and FTD patients did perform significantly worse than the control group on the WAIS-III Block Design test ($p < 0.05$), all patient groups' scores were still in the normal range compared to standardized normative samples. Patients' performance in all other cognitive domains can be seen in Table 1.

Color Discrimination and Preference

None of the patient groups showed any impairment relative to healthy control subjects on total score for color discrimination testing. Analyses of subscale scores for discrimination of hue, saturation, and chromaticity showed no significant differences between patients and the NC group (Table 2).

A multivariate analysis of variance procedure, controlling for sex and age, failed to reveal divergent patterns of color preference across the groups. Univariate GLMs suggested that the patient groups did not differ significantly from NCs on their ratings of color preference, though AD subjects showed a trend towards ranking the color purple lower than NCs. All four groups rated yellow, orange, and brown as their least preferred colors, in that order. The NC group ranked their top colors as purple, blue, red, and green; the FTD group's top ranked colors were purple, green, red, and blue; the SD group's top colors were green, red, blue, and purple; and the AD groups top colors were blue, green, red, and purple.

Nonverbal Creativity Testing

SD patients performed very poorly on standardized testing of their nonverbal artistic creativity (Table 2). They produced fewer acceptable drawings, and the drawings they did produce were

more conventional and less original in content, they were elaborated with fewer details, and they failed to resist premature closure based on the visuospatial characteristics of the original stimulus. FTD patients also failed to resist premature closure in their drawings, but otherwise performed similarly to NC subjects. AD patients scores on creativity testing were statistically indistinguishable from normal controls (Figure 1).

Drawing Ratings

Drawing 1: Flowers Still-Life—The flowers drawing task was designed to permit a comparison of patients' responses to the same visual stimulus (Figure 2). Perhaps what appears most striking is the richness of detail in the normal subjects' drawings. Qualitatively, the drawings of the normal control subjects contained more visual information, including details such as buds, leaves, stems, and vase. A sense of three dimensional space was often communicated by representing the vase as a cylinder and by an occasional reference to the background. Regarding composition, almost all of the drawings represented the entire subject matter, placed centrally on the page and filling almost all of the space. They were also distinguished by the wide spectrum of colors used. In fact, in most of the normal subjects' drawings, the entire palette of color was employed. When this was quantified, normal subjects used an average of 6 out of 7 possible colors. A wide variety of markmaking methods were used—both in line and shading, loose and controlled. In general, the drawings of the normal controls communicate a fairly representative, but conventional image of the vase of flowers.

In comparison, the drawings of the frontotemporal dementia subjects were characterized by their relative abstraction of the subject matter. These drawings were rated as significantly more bizarre ($p < 0.05$) and less representational of subject matter ($p < 0.05$) than those of the NC group. FTD patients were the only group to include significantly fewer details in their flower drawings than NCs ($p < 0.05$). Indeed, many of the flowers and leaves were excluded, and the subject matter was distilled to its essence. Often, the buds were simplified to oval shapes, with straight lines used to depict stems. No reference to background was made in any of the drawings and the resulting space became flattened. In comparison to normal subjects' drawings, these drawings demonstrated less variety in mark-making, and they used significantly fewer colors from the available color palette ($p < 0.05$), with choices of hue often limited to three or four colors (mean 4.0 ± 1.6) out of seven possible options. FTD patients also demonstrated a qualitative difference in composition compared to NCs, with the flowers reduced in size and eccentrically placed on the page, though this difference did not reach significance across the group based on objective ratings.

The flower drawings of the Alzheimer's group were also judged to be more bizarre ($p < 0.05$) and less representational of subject matter ($p < 0.05$) than those of NCs. However, there existed no statistical difference in the number of details that AD patients included. Qualitatively, these drawings appeared to vary more within the group. There were a number that very closely resembled those of the normal control group, with more detail and variety of markmaking; and another set that more closely represented the simplified, abstracted qualities of the FTD group. Drawings in the latter category were also characterized by the relatively muted colors (i.e. decreased saturation) in the drawings, and the AD patients chose to use significantly fewer colors than control subjects (4.5 ± 1.6 out of seven; $p < 0.05$).

The flower drawings of the SD patients were also rated as more bizarre than those of the NC group ($p < 0.05$), and showed a non-significant trend toward decreased fidelity to subject matter compared to NCs ($p < 0.10$). Qualitatively, these drawings most closely resembled those of the normal control group. With a few exceptions, they were fairly richly detailed, including buds, stems, leaves, and vase; utilized the entire spectrum of color (5.2 ± 1.6 colors out of 7); demonstrated a variety of markmaking. However, a subset of the SD patients focused in on one or two isolated aspects of the bouquet, failing to represent any other aspect of the stimulus.

Interestingly, 3 of the SD patients' drawings consisted of the same sprig of blue flowers with yellow centers. Composition was fairly conventional, with central placement of the subject matter on the page.

Drawing 2: Imagined Room—From a qualitative perspective, the room drawings of the normal controls were typically full of detail, with each room containing multiple items of furniture, decorations, windows, curtains, pets, and plants. They are a combination of floor plan schematics (40%) and perspective drawings (60%). The drawings fill the entire compositional space, and utilize a variety of brushstrokes. Though as a group, controls utilized fewer colors than they had used in the flower still-life, subjects who did not choose to draw simple floorplans did employ a broad spectrum of color. Because they contained so much information, these drawings conveyed a very specific, personalized space.

In comparison, FTD patients' room drawings tended to show significantly more disordered, unintentional composition than the drawings of NC subjects ($p < 0.05$), and used significantly less active strokes in their drawing technique ($p < 0.05$), difference that only appeared in this dementia group. There were no other abnormalities in the way the patient groups approached this drawing, though AD patients showed a nonsignificant trend ($p < 0.10$) towards including fewer details than NCs. Though the other patient groups showed no statistically significant differences in the overall number of details they included, there was a quantifiable difference specifically in the number of decorative objects included in the drawings, with fewer SD patients (38%) including such adornments, compared to 50% of FTD drawings, 53% of AD drawings, and 93% of NC drawings. Qualitatively, when compared NCs, the drawings of the dementia patients communicate a more generic, less personalized space. Overall, based on the relatively poorer quality of all the demented and normal subjects' drawings compared to their still lifes and self-portraits, this task was more difficult to complete. The demand for internal visualization of the subject matter appreciably reduced the richness of the visual art that all subjects produced, and created a greater homogeneity across demented and normal groups' drawings.

Drawing 3: Self-Portrait—The self-portraits of the normal controls, like their drawings of the flowers and room, contained a great amount of personalized detail (Figure 3). Drawings conveyed a large amount of information, including hair and eye color, glasses, jewelry, clothing, makeup, and wrinkles. With a few exceptions, these drawings tended to be specific and representational, such that individuals might be identified by their own drawings. The drawings maintained fairly accurate proportions between various facial features and body parts (i.e. most heads are connected to a neck and sometimes shoulders). Again, from a technical standpoint, these drawings tended to be large and fill the whole page, and used a variety of color and markmaking. They employed both frontal and three-quarter profile views.

FTD patients' self-portrait drawings significantly diverged from the assigned subject matter ($p < 0.05$) in such a way that it would be difficult to identify any of the subjects based on their drawings, a trend that was only observed in this dementia group. FTD self-portraits were rated as significantly more bizarre than NCs, showing more facial distortion and stereotypical facial features ($p < 0.05$). FTD drawings were seen as more abstract and less representational than those of NCs ($p < 0.05$). Indeed, FTD features tended to be generic and geometric (i.e. rounded eyes, triangle noses, oval or square shaped faces). Facial features are not drawn in proportion, with eyes drawn twice as large as the nose, or with ears drawn extended from the head. Heads are often depicted as disembodied, floating in space, or attached to the body without a neck. While the self-portraits of the normal controls use a fairly natural color palette, those of FTD patients are more monochromatic and use unnatural colors, such as green hair. Furthermore, FTD drawings were also significantly more spatially disordered with respect to the boundaries of the page and were rated as demonstrating less intentional aesthetic composition ($p < 0.05$).

The drawings of the SD patients were also rated to be significantly more distorted than those of NCs ($p < 0.05$). Like the drawings of the FTD patients, SD facial features were geometric and utilized an unnatural color palette. Heads were disembodied and floating in space, and in multiple SD drawings the subjects drew large eyes that lacked pupils, a feature not seen in the other diagnostic groups. These drawings also showed non-significant trends ($p < 0.10$) toward greater bizarreness and less representational form compared to NCs. Despite the fact that they were given a small mirror that reflected only their faces, a number of SD patients chose to draw their entire bodies for this task, sometimes naked but without genitalia. Almost half of the SD self-portraits explicitly represented some aspect of their head or body as being in pain or dysfunctional in some way. However, the collection of work from this group included a few portraits that were similar to NCs in the amount of detail they depicted.

Finally, the drawings of the AD subjects showed significantly greater facial distortion and a more disordered composition compared to NCs ($p < 0.05$). However, these drawings did not demonstrate the bizarre quality and tendency toward abstraction that characterized the drawings of FTD and SD patients. Like other drawings made by these subjects, the color choice and markmaking is muted and relatively washed out, and AD subjects were the only dementia group that used significantly fewer colors (1 to 2) for their drawings than normal controls (3 to 5 colors out of 7 options). However, as in the SD group, there are a few drawings that resemble those of normal controls in the amount of detail and variety of markmaking and color used.

Drawing 4: Emotion—There were no significant differences in the way that any of the patient groups approached this task when their drawings were compared to healthy controls. In general, subjects tended to either approach the task in a very concrete, representational manner, often drawing a second self-portrait, or they drew an abstract collection of colors and symbols. Again, however, AD subjects chose to use significantly fewer colors than NC subjects ($p < 0.05$). This imaginative and abstract task may have been too artistically demanding for both the normal controls and the patients in our subject sample, since most of them had little formal art training.

Overall Artistic Style—Some aesthetic elements showed a significant diagnostic group difference overall regardless of the subject matter or drawing task (Table 3). Both FTD and SD patients' drawings consistently appeared more bizarre and had more facial distortion than those of normal controls. Additionally, FTD patients consistently had more disordered composition to their drawings, and tended to use a technique that included less active strokes than NCs. The only significant difference across all AD patients' drawings was that they used significantly fewer colors than NCs, and chose a muted color palette made up of grays, browns, and blacks over the rainbow colors that the other groups used.

DISCUSSION

The primary finding of this study is that dementia patients with different clinical diagnoses show distinct styles of visual art production that can be characterized both quantitatively and qualitatively. Drawings produced by patients with the frontal (FTD) subtype of frontotemporal lobar degeneration (FTLD) tended to have more disordered composition, use less active mark-making, have more facial distortion, and were rated as more bizarre than the drawings of age-matched healthy controls. Patients with semantic dementia (SD), or the temporal variant of FTLD, also produced drawings that were rated as significantly more bizarre with more facial distortion, and performed poorly on standardized visual creativity testing. Alzheimer's patients' (AD), whose disease is predominantly posterior in the brain, produced artwork that was more similar to controls than either FTLD group, though they used a more limited color palette and demonstrated trends toward the inclusion of fewer details, difficulty with composition, and

occasional facial distortion. These group differences in art-making are likely to have resulted from disease-specific patterns of focal neurodegeneration, and provide novel information about the contributions of particular brain regions to the production of visual art.

Frontotemporal Dementia

Across all types of drawings we tested, FTD patients tended to create drawings with more haphazard, disorganized composition, and the objects and people they depicted were rated by blinded judges as more subjectively “bizarre” and showing more facial distortion. When asked to produce drawings from subject matter directly in front of them, a task which pulls for a representational drawing style, their drawings tended to be less representational, less detailed, and more abstract compared to drawings by other subjects.

The drawings of FTD subjects help illustrate some aspects of art-making mediated by the frontal lobes of the brain, recognized to be responsible for planning and organizational ability. Our results suggest that despite the fact that visuospatial processing is preserved as a result of early sparing of the temporal and parietal lobes, FTD patients’ drawings reflect a deficit of spatial organization. Visual composition reflects the ability to plan a drawing on a page, such that elements have a relationship to each other and to the whole. The difference in composition between normal and FTD subjects is best illustrated by the flower drawings and self-portraits.. While the drawings of the normal subjects tend to fill the entire space on the page and reflect an awareness of the edge of the paper, those of the FTD patients tend to “float” on the page, or demonstrate a lack of awareness of the space and outer boundaries. While on the whole, the subjects in this study were not trained artists, i.e. had no explicit teaching on composition, some degree of attention to object placement appeared to be innate in our normal subjects. In contradistinction, the fact that FTD patients did not manifest this natural inclination suggests that the frontal lobes may partly mediate composition of space in visual art.

Furthermore, FTD subjects’ drawings showed a significant divergence from the explicit, representational content of the subject matter, choosing abstracted and often simplified depictions instead. This characteristic style did not appear to result from an inability to accurately depict visuospatial stimuli, both because visuoperceptual functioning has been shown to be preserved in FTD and because none of our patient groups were impaired on standard neuropsychological tests of visuospatial skills (See Table 1). Instead, the frontal lobe damage seen in these FTD patients appears to have loosened their adherence to visual “reality” and permitted them to deviate from social expectations of “what the drawing should look like.” Instead, they were free to produce figures based on personalized internal representations. This disorganization and loosening of associations may have contributed to the greater subjective “bizarreness” seen in these drawings, particularly in regard to drawing human faces.

Additional characteristics of FTD visual art that may result from frontal damage are their decreased mark-making vigor, tendency towards premature closure on formal visuospatial creativity testing, and inclusion of fewer details in their drawings compared to other dementia groups. Each of these characteristics could be partly explained by the significantly higher levels of apathy seen in patients with medial frontal atrophy {Liu, 2004 #4354}. Though judges estimated the amount of effort subjects appeared to have put into each drawing, and these estimates showed no significant group differences, these more subtle and specific measures of effort did distinguish FTD patients as more passive and less directly engaged in the art-making task.

Semantic Dementia

A number of significant cases studies have been reported in which patients with predominantly left anterior temporal damage have developed a novel interest in producing art as a result of

their disease. In special cases, their art production takes on an obsessive, repetitive, extremely prolific quality in which patients will spend hours every day producing very similar pieces of art, even late into their disease. These patients typically are diagnosed with the Semantic Dementia variant of FTLD. While one of the patients in our SD group had developed this type of novel obsession with visual art, and is the subject of a case study published elsewhere²², the majority of patients in our SD group did not show heightened postmorbidity art production.

The visual art created by the SD group was characterized by significant facial distortion and overall bizarreness compared to normal control drawings, regardless of whether they depicted people or objects. The resemblance of drawings of SD subjects to those of the FTD group raises the issue of how FTLD-related decline in emotional intelligence may affect visual art production. Studies of both FTD and SD patients suggest that their ability to comprehend facial expressions of emotion becomes impaired, probably as a result of damage to orbitofrontal and right temporal cortical areas^{44–47}. The right temporal lobe, particularly the superior temporal sulcus region, is involved in a number of aspects of social cognition, such as interpretation of lip and mouth movement, eye gaze, body movement, and hand gestures⁴⁸. One case series of artists who developed predominantly right-sided FTLD showed that their drawings of people had become “less human,” i.e., distorted in such a way that they seemed menacing or alien, even though these patients had preserved emotion recognition on cognitive testing²³. While all four of their patients showed bilateral frontal hypometabolism, only the three with prominent right temporal lobe damage showed this altered artistic representation of faces.

While this may help explain why our FTLD patients, including both the FTD and SD subtypes, produced artwork in which human faces were more distorted or grotesque, it may also shed light on why FTLD drawings struck judges as significantly more bizarre, even when they contained only inanimate objects. The ventral, temporal lobe stream of visuospatial processing is involved in the identification and representation of objects, and focal lesions to this circuit are well-documented to result in clinical agnosia. While frank visuospatial processing is preserved in FTLD, particularly those aspects related to the parietal lobe, or dorsal stream (the “where” circuit), patients show two kinds of alterations in visuoconstruction ability that may contribute to the bizarreness of their drawings. First, temporal lobe damage in SD patients causes semantic loss, or the inability to associate meaning with objects or people. This causes many percepts to become isolated from their significance. Second, frontal lobe damage (particularly on the right) can disrupt FTLD patients’ ability to plan and organize their drawings, even when the visuospatial information coming from the temporal and parietal lobes is intact.

The SD group also showed an unexpected pattern in their approach to standardized visuospatial creativity testing. When presented with a series of incomplete, meaningless doodles and asked to incorporate them into creative drawings, SD patients were more likely than any other group to produce drawings without meaning or depicted an obvious, conventional choice. They elaborated on their drawings less, and produced figures that had less movement or action. This may well have occurred because one of the primary symptoms of SD is loss of semantic meaning for both words and objects in the world. This cognitive symptom probably made it more difficult for this group of patients to think divergently and imagine atypical objects. Perhaps this lack of conceptual semantic content was also indirectly responsible for another significant characteristic of their drawings, a failure to diverge from the original stimulus. More than any other group, SD patients tended to simply “complete” or “close” the initial doodle, demonstrating a stimulus-boundedness that may reflect a focus on the physical features of a visual stimulus in the absence of the conceptual associations normally elicited by it. This phenomenon is consistent with much of the art described in case studies of obsessive-productive artists with left anterior temporal damage. Often in the initial stages of their disease, their art depicts familiar, common content (boats, birds, animals) in a visually striking, intense

manner, perhaps reflecting an intensification of their preserved visuo-perceptual and visuo-spatial functions in the context of semantic loss. Objects may lose their meaning, but their perceptual salience is heightened. This can be seen to an even more dramatic degree late in these SD-artists' disease process, when they may paint vibrant lines and colors onto objects without any reference to their actual appearance or function in the world, perhaps signifying a complete loss of semantic knowledge about the object in question²².

SD patients' art may, in some cases, be characterized by intense productivity, but they may no longer be capable of the divergent conceptual thinking that is one important element of creativity⁴². Importantly, however, the types of "bizarre" choices that were significantly more typical of SD patients might be considered another aspect of creativity that should not be overlooked. Many of the SD patients approached their somewhat concrete and conventional subject matter with very unusual, creative aesthetic choices. The use of unusual, often brightly contrasting colors, the emphasis of one isolated aspect of a subject to the exclusion of other elements, and the use of unusual visual perspective in which objects or people are floating or oddly truncated, all are creative choices in themselves. This creativity of aestheticism is exaggerated in SD art in a manner that is inversely proportionate to their loss of creativity with respect to content. These results reiterate the need for a more nuanced definition of visual creativity, one that includes both a conceptual and aesthetic component. SD patients most clearly demonstrate how a decline in linguistic ability permits a kind of aesthetic disinhibition, perhaps consistent with Kapur's theory of functional facilitation¹⁰. In particular, on Torrance Creativity Testing, SD patients demonstrated decreased fluency, originality, and elaboration, as well as a tendency toward premature closure. On the other hand, SD drawings were judged to be more bizarre and distorted, and less representational compared to works of NCs. SD drawings are aesthetically creative in the sense that they are freed from representational constraints and social expectations of what art should look like. The example of SD patients' artwork also suggests that preservation of semantic ability may be somewhat necessary for conceptual flexibility, to move beyond a concrete, representational version of the immediate visual task. While language and graphic ability remain neuroanatomically distinct, they seem to be complementary and synergistic for creative work.

Alzheimer's Disease

Prior case reports have demonstrated that artwork of AD patients becomes more abstract and formless with the progression of disease. Studies of artists with AD have revealed a declining ability to represent subject matter in a representational fashion²⁹⁻³². For example, the self-portraits of London-based professional artist William Ütermohlen offer a rare and insightful perspective on the progression of his Alzheimer's disease. His large repertoire of paintings, his wife's profession as an art historian, and longitudinal neuropsychological testing permit a veridical interpretation of his artistic evolution. The structure and relative positioning of the features on his face and head in these self-portraits became increasingly distorted over the course of his disease²⁹. Such distortion was consistent with his declining visual-spatial testing performance and other drawings made at the time. Stylistically, his brushwork became coarser and more simplified through the course of his illness. His last portraits were extremely abstract, showing virtually no distinctive features betraying the subject's identity. While the trajectory of his work demonstrates a decline, color remained vivid in his late paintings. The characteristic evolution of the artwork of patients with Alzheimer's disease, such as inclusion of fewer details and a tendency toward abstraction, likely results from the selective degeneration of the parietal lobe and the resulting decline in visuo-spatial function. For instance, in a comparison of thirty AD patients with controls, Mendez found that AD patients showed preserved visual acuity and color recognition, but decreased ability to visually recognize common objects and famous faces, make figure-ground distinctions, and evaluate complex figures²⁶.

Our statistical analysis of AD patients' art production did not show any consistent differences from the art produced by our healthy normal control subjects, except in their use of fewer, more muted colors in their drawings. This was contrary to our expectations, given the existing literature on artists with AD. The wider variation in drawing quality across the AD patients in this study may have obscured any group differences. However, our patients did show trends towards more disorganized composition, which we have suggested may be due to frontal-executive dysfunction in the areas of visuospatial planning and organization. Indeed, on neuropsychological testing, AD patients performed the worst of all groups in almost all cognitive domains. Their drawings also demonstrated distortion of facial features, which may be due to damage to the fusiform face area, the posterior structure in the inferior temporal gyrus that is involved in the differentiation and characterization of facial details. The drawings of the AD patients were both quantitatively and qualitatively more simplified and contained fewer details compared to normal controls, which is consistent with the literature on artwork of patients with AD. Importantly, the AD subjects in our study were tested quite early in the course of their disease, with an average MMSE of 22 and an average Clinical Dementia Rating score of less than 1.0. More pronounced changes towards distortion and loss of form might become evident in a group of AD patients at a later stage in disease progression.

The AD subjects in our study also chose to use significantly fewer colors than controls, particularly in their representational drawings of the still life and the self-portraits, and a large proportion of the group's drawings were characterized by very light markmaking and decreased saturation of color, such that the details of the drawings were difficult to see from just a few feet away. Their more limited, subdued color palette is difficult to explain, as both this study and previous research suggest AD patients show no differences in color perception or preference²⁶. Perhaps the use of more muted markmaking relates to previously documented deficits in visual association, particularly in their ability to recognize common objects and make figure-ground distinctions²⁶. Another possible explanation for the decreased intensity of our AD patients' drawings is based on evidence that individuals with AD undergo personality changes consistent with loss of assertiveness and increased insecurity⁴⁹. This more self-conscious attitude may have produced a more cautious, hesitant approach to the novel and challenging artistic tasks in this study.

Conclusions

This study is the first to use semi-quantitative methods to compare the visual art of groups of dementia patients and healthy older adults. Though rich, detailed case studies of artists have suggested that different patterns of change in visual art production emerge from anatomically diverse dementia types, this study had the advantage of directly comparing the art of patients with AD, FTD, and SD. The inherently subjective nature of evaluating artwork required that we create an idiosyncratic scoring rubric and derive a consensus of opinion across a panel of raters. However, this is a necessary first step in the process of clearly defining operationalizing artistic production in order to make meaningful statements about its neuroanatomic substrates.

Though this study was based only on behavior and inferred links between art and the brain from clinical diagnosis, it is our hope that future studies will be able to incorporate neuroimaging in order to more directly analyze these brain-behavior relationships. Additionally, longitudinal investigation of the visuospatial and visual creative ability of dementia patients over time, and evaluation of the effects of behavioral and pharmacological interventions on visual art production over the course of these diseases, could further elucidate the open question of how the brain makes art.

Acknowledgements

This research was supported in part by the National Institute on Aging (NIA) grant AG19724-01A1, the State of California Alzheimer's Disease Research Center of California (ARCC) grant 01-154-20, and the Pfizer Inc. grant H10189-20187-01.

References

1. Kaplan, JA.; Gardner, H. Artistry after unilateral brain disease. In: Boller, F.; Grafman, J., editors. *Handbook of Neuropsychology*. 1989. p. 141-155.
2. Marsh GG, Philwin B. Unilateral neglect and constructional apraxia in a right-handed artist with a left posterior lesion. *Cortex* 1978;23:149–155. [PubMed: 3032514]
3. Miller BL, Boone K, Cummings JL, et al. Functional correlates of musical and visual ability in frontotemporal dementia. *Br J Psychiatry* 2000;176:458–63. [PubMed: 10912222]
4. Miller BL, Cummings J, Mishkin F, et al. Emergence of artistic talent in frontotemporal dementia. *Neurology* 1998;51(4):978–82. [PubMed: 9781516]
5. Miller BL, Hou CE. Portraits of artists: Emergence of visual creativity in dementia. *Arch Neurol* 2004;61:842–844. [PubMed: 15210520]
6. Miller BL, Ponton M, Benson DF, et al. Enhanced artistic creativity with temporal lobe degeneration [letter]. *Lancet* 1996;348(9043):1744–5. [PubMed: 8973469]
7. Mendez MF. Dementia as a window into the neurology of art. *Med Hypotheses* 2004;63:1–7. [PubMed: 15193339]
8. Gardner, H. *Art, Mind, and Brain: A Cognitive Approach to Creativity*. Basic Books; New York: 1982. Artistry after brain damage; p. 318-335.
9. Gardner, H. *Academy of Aphasia*. Victoria; British Columbia: 1975. Artistry following aphasia.
10. Kapur N. Paradoxical facilitated function in brain-behaviour research. A critical review. *Brain* 1996;119:1775–1790. [PubMed: 8931597]
11. Gordon N. Unexpected development of artistic talents. *Postgrad Med J* 2005;81:753–755. [PubMed: 16344297]
12. Johnson JK, Diehl J, Mendez MF, et al. Frontotemporal lobar degeneration: demographic characteristics of 353 patients. *Arch Neurol* 2005;62(6):925–930. [PubMed: 15956163]
13. Kramer JH, Jurik J, Sha SJ, et al. Distinctive neuropsychological patterns in frontotemporal dementia, semantic dementia, and Alzheimer's disease. *Cogn Behav Neurol* 2003;16(4):211–218. [PubMed: 14665820]
14. Neary D, Snowden JS, Mann DM. Classification and description of frontotemporal dementias. *Ann N Y Acad Sci* 2000;920(51–52):46–51. [PubMed: 11193176]
15. Neary D, Snowden JS, Gustafson L, et al. Frontotemporal lobar degeneration: a consensus on clinical diagnostic criteria. *Neurology* 1998;51(6):1546–54. [PubMed: 9855500]
16. Rosen HJ, Gorno-Tempini ML, Goldman WP, et al. Patterns of brain atrophy in frontotemporal dementia and semantic dementia. *Neurology* 2002;58(2):198–208. [PubMed: 11805245]
17. Snowden JS, Bathgate D, Varma A, et al. Distinct behavioural profiles in frontotemporal dementia and semantic dementia. *J Neurol Neurosurg Psychiatry* 2001;70(3):323–332. [PubMed: 11181853]
18. Mell JC, Howard SM, Miller BL. Art and the brain: The influence of frontotemporal dementia on an accomplished artist. *Neurology* 2003;60:1707–1710. [PubMed: 12771276]
19. Rankin KP, Gorno-Tempini ML, Allison SC, et al. Structural anatomy of empathy in neurodegenerative disease. *Brain*. 2006In press
20. Gorno-Tempini ML, Rankin KP, Woolley JD, et al. Cognitive and behavioral profile in a case of right anterior temporal lobe neurodegeneration. *Cortex* 2004;40:631–644. [PubMed: 15505973]
21. Miller BL, Chang L, Mena I, et al. Progressive right frontotemporal degeneration: clinical, neuropsychological and SPECT characteristics. *Dementia* 1993;4(3–4):204–13. [PubMed: 8401793]
22. Liu AY, Rankin KP, Werner K, et al. A case study of an emerging visual artist with frontotemporal dementia. *Neurocase*. 2007In press

23. Mendez MF, Perryman KM. Disrupted facial empathy in drawings from artists with frontotemporal dementia. *Neurocase* 2003;9(1):44–50. [PubMed: 16210224]
24. Knopman DSBBF, Petersen RC. Essentials of the proper diagnoses of mild cognitive impairment, dementia, and major subtypes of dementia. *Mayo Clinic Proceedings* 2003 Oct;78(10):1290–308. [PubMed: 14531488]2003
25. Cummings JL. Alzheimer's Disease. *N Engl J Med* 2004;351:56–67. [PubMed: 15229308]
26. Mendez MF, Mendez MA, Martin R, et al. Complex visual disturbances in Alzheimer's disease. *Neurology* 1990;40:439–443. [PubMed: 2314585]
27. Kirk A, Kertesz A. On drawing impairment in Alzheimer's disease. *Arch Neurol* 1991;48:73–77. [PubMed: 1986729]
28. Henderson VW, Mack W, Williams BW. Spatial disorientation in Alzheimer's disease. *Arch Neurol* 1989;46:391–394. [PubMed: 2705898]
29. Crutch S, Issacs R, Rossor MN. Some workmen can blame their tools: artistic change in an individual with Alzheimer's disease. *Lancet* 2001;357:2129–2133. [PubMed: 11445128]
30. Espinel CH. De Kooning's late colours and forms: dementia, creativity, and the healing power of art. *Lancet* 1996;347:1096–1098. [PubMed: 8602064]
31. Cummings JL, Zarit JM. Probable Alzheimer's disease in an artist. *JAMA* 1987;258(19):2731–2734. [PubMed: 3669242]
32. Maurer K, Pruculoli C. Paintings of an artist with Alzheimer's disease: visuoconstructural deficits during dementia. *J Neural Transm* 2004;111:235–245. [PubMed: 14991452]
33. McKhann G, Drachman D, Folstein M, et al. Clinical diagnosis of Alzheimer's disease: report of the NINCDS-ADRDA Work Group under the auspices of Department of Health and Human Services Task Force on Alzheimer's Disease. *Neurology* 1984;34(7):939–44. [PubMed: 6610841]
34. Berg L. Clinical Dementia Rating Scale (CDR). *Psychopharmacol Bull* 1988;24:637–639. [PubMed: 3249765]
35. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state": A practical method for grading the mental state of patients for the clinician. *J Psychiatr Res* 1975;12:189–198. [PubMed: 1202204]
36. Yesavage JA, Brink TL, Rolse TL, et al. Development and validity of a Geriatric Depression Scale: A preliminary report. *J Psychiatr Res* 1983;17:37–49. [PubMed: 7183759]
37. Wechsler, D. Wechsler Adult Intelligence Scale-Third Edition (WAIS-III). San Antonio, TX: The Psychological Corporation; 1997.
38. Warrington, EK.; James, M. The Visual Object and Space Perception Battery. Bury St Edmunds: Thames Valley Test Company; 1991.
39. Delis, D.; Kaplan, EB.; Kramer, J. The Delis-Kaplan Executive Function System. The Psychological Corporation; 2001.
40. Kaplan, E.; Goodglass, H.; Wintraub, S. The Boston Naming Test. Philadelphia: Lea and Febiger; 1983.
41. Delis, DC.; Kramer, JH.; Kaplan, E., et al. California Verbal Learning Test, 2nd Edition. San Antonio, TX: The Psychological Corporation; 2000.
42. Torrance, EP.; Ball, O.; Safter, HT. Torrance Tests of Creative Thinking. Bensenville, IL: Scholastic Testing Service, Inc; 1992.
43. Wijk H, Berg S, Sivik L, et al. Color discrimination, color naming, and color preferences in 80-year olds. *Aging Clin Exp Res* 1999;11:176–185.
44. Lavenu I, Pasquier F. Perception of emotion on faces in frontotemporal dementia and Alzheimer's disease: a longitudinal study. *Dement Geriatr Cogn Disord* 2005;19(1):37–41. [PubMed: 15383744]
45. Lavenu I, Pasquier F, Lebert F, et al. Perception of emotion in frontotemporal dementia and Alzheimer disease. *Alzheimer Dis Assoc Disord* 1999;13(2):96–101. [PubMed: 10372953]
46. Keane J, Calder AJ, Hodges JR, et al. Face and emotion processing in frontal variant frontotemporal dementia. *Neuropsychologia* 2002;40(6):655–65. [PubMed: 11792405]
47. Rosen HJ, Pace-Savitsky C, Perry RJ, et al. Recognition of emotion in the frontal and temporal variants of frontotemporal dementia. *Dement Geriatr Cogn Disord* 2004;17(4):277–281. [PubMed: 15178936]

48. Allison T, Puce A, McCarthy G. Social perception from visual cues: role of the STS region. *Trends Cogn Sci* 2000;4(7):267–278. [PubMed: 10859571]
49. Rankin KP, Kramer JH, Mychack P, et al. Double dissociation of social functioning in frontotemporal dementia. *Neurology* 2003;60(2):266–271. [PubMed: 12552042]

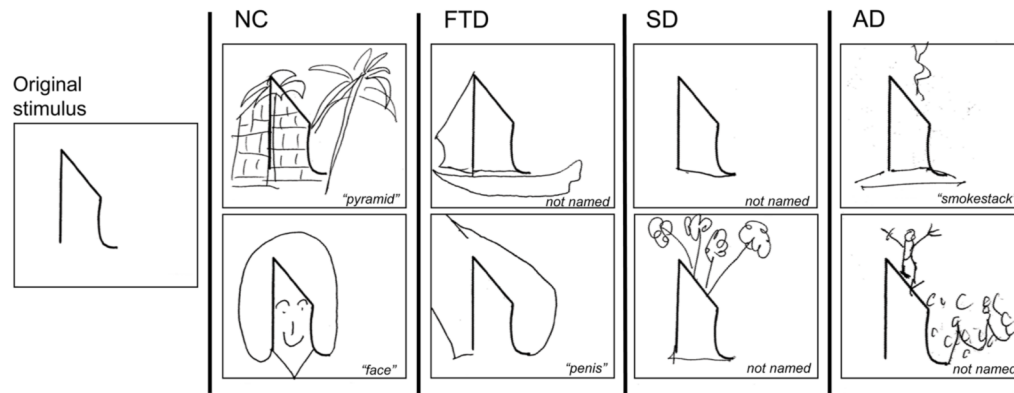


FIGURE 1.

Examples of subjects' responses to one item on the Torrance Test of Creative Thinking (TTCT) – Figural Activity 2: Picture Completion task, organized by diagnostic group. Subjects were asked to add lines to the incomplete figure (far left) in order to draw an “interesting object or picture,” and were told to “make it as complete as possible.” After completing their drawings, subjects were asked to identify the drawing for the examiner, and the subjects' responses are provided in the lower-right-hand corner of each drawing. [NC=normal control; FTD=frontotemporal dementia; SD=semantic dementia; AD=Alzheimer's disease]



FIGURE 2.

Examples of subjects' responses to a freeform drawing activity, *Drawing 1: Flowers Still-Life*, organized by diagnostic group. A clear cylindrical vase of realistic artificial flowers of various colors and species was placed in front of the subjects, and they were asked to draw it. This activity was designed to assess subjects' ability to create a representational drawing based on immediate visual cues. [NC=normal control; FTD=frontotemporal dementia; SD=semantic dementia; AD=Alzheimer's disease]

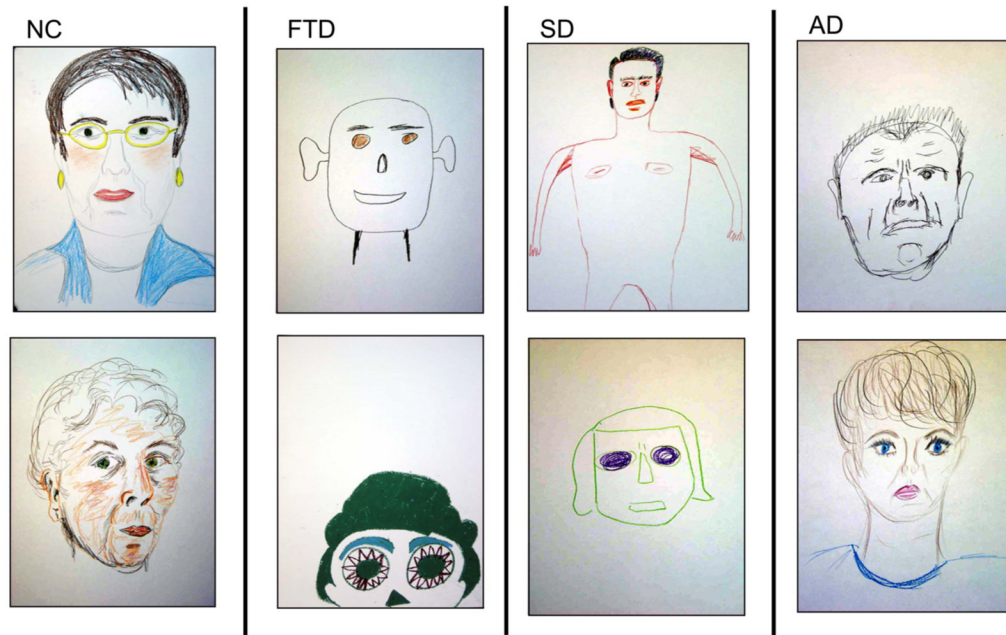


FIGURE 3.

Examples of subjects' responses to a freeform drawing activity, *Drawing 3: Self-Portrait*, organized by diagnostic group. An 8 inch diameter mirror was placed in front of the subjects, and they were asked to draw their self-portrait. This activity was designed to assess subjects' ability to create a representational drawing of a human face based on direct visual cues.

[NC=normal control; FTD=frontotemporal dementia; SD=semantic dementia; AD=Alzheimer's disease]

TABLE 1

Subject demographic, functional, and neuropsychological characteristics. Data are represented as mean (standard deviation). F-values and p-values represent the significance of overall general linear model comparison across all subject groups, controlling for age, sex, and education. Scores from patient groups that showed a significant difference from NCs based on pairwise post-hoc Dunnett-Hsu testing at $p < 0.05$, controlling for age, sex, and education, are shown in bold. [NC=normal control; FTD=frontotemporal dementia; SD=semantic dementia; AD=Alzheimer's disease]

(max)	FTD	SD	AD	NC	F-value**	p-value**
GENERAL						
Age	57.00(5.96)*	63.67(6.87)	71.00(11.24)	66.73(9.37)	1.71	n.s.
Education	16.33(1.41)	16.55(2.70)	15.94(2.08)	16.7 (3.22)	0.92	n.s.
Sex (M/F)	8/1	6/3	7/8	2/13	$\chi^2=14.52$	0.0023
MMSE (30)	23.11(6.09)*	22.63(5.83)*	22.00(4.56)*	29.64(0.67)	4.77	0.0067
CDR Total	1.28(0.57)*	0.75(0.53)*	0.77(0.26)*	0.00(0.00)	17.63	<0.0001
CDR Box Scores	7.22(2.20)*	3.56(2.23)*	4.81(2.17)*	0.00(0.00)	22.93	<0.0001
GDS (30)	7.20(7.46)	9.50(6.55) [†]	7.07(4.70)	4.71(5.18)	2.03	n.s.
VISOSPATIAL						
Block Design (SS)	9.00 (4.53)*	10.44(2.46)	6.50 (3.13)*	12.64(2.20)	7.46	0.0006
VOSP Num Loc (10)	9.14(1.46)	9.67(0.50)	8.07(2.43)	9.36(0.92)	--	n.s.
Figure Copy (16)	14.86(3.58)	15.44(2.01)	13.93(2.37)	15.14(1.46)	--	n.s.
LANGUAGE						
BNT (60)	42.50(17.36)	8.50(10.13)*	46.13(16.55)	57.71(3.75)	21.23	<0.0001
Animal Fluency (words/min)	12.78(7.55)*	4.78(3.19)*	11.00(5.30)*	23.21(6.02)	15.91	<0.0001
Phonemic Fluency (D-words/min)	9.14(6.01)	4.00(4.06)*	9.78(6.38)	14.00(4.45)	4.34.133	0.0125
MEMORY						
California Verbal Learning Test - MS						
Trials 1–4 (36)	18.67(10.05)*	13.00(6.5)*	17.25(6.65)*	29.64(2.68)	9.75	<0.0001
30' Free Recall (9)	3.67(2.55)*	2.00(2.12)*	2.27(1.84)*	7.79(1.31)	17.39	<0.0001
10' Free Recall (9)	2.44(3.32)*	1.22(2.16)*	1.16(1.47)*	7.57(1.16)	22.12	<0.0001
Recognition Hits (9)	8.00(0.76)	5.75(2.91)*	6.17(2.08)*	8.5(0.76)	5.79	0.0025

(max)	FTD	SD	AD	NC	F-value**	p-value**
Recognition FPs (18)	5.37(4.71)*	5.38(4.53)*	4.35(3.79)*	0.35(0.74)	4.17	0.0123
Figure 10' Recall (16)	5.71(5.88)*	7.22(5.36)	4.80(4.13)*	10.43(3.11)	4.09	0.0128
EXECUTIVE						
D-KEFS Design						
Fluency Filled (SS)	7.14(1.77)*	8.75(2.60) [†]	7.71(3.10)*	12.64(2.44)	7.68	0.0004
Digit Span Backward	4.42(1.99)	5.00(1.20)	3.8(1.15)*	5.36(1.15)	3.30	0.0304
Modified Trails (# lines/min)	14.86(3.58)*	19.47(16.18)*	9.44(8.19)*	35.94(11.28)	11.34	<0.0001
Stroop (# words/min)	30.67(23.53) [†]	36.14(10.60)	23.17(16.5)*	52.29(9.17)	7.52	0.0006

* p<0.05 compared to NC group using Dunnett-Hsu test for multiple comparison corrections controlling for effects of sex, age, and education

[†] p<0.10 nonsignificant trend compared to NC group

Scores for creativity, color discrimination, and color preference. Data are represented as mean (standard deviation). F-values and p-values represent the significance of overall general linear model comparison across all subject groups, controlling for age, sex, and education. Scores from patient groups that showed a significant difference from NCs based on pairwise post-hoc Dunnett-Hsu testing at $p < 0.05$, controlling for age, sex, and education, are shown in bold. [NC=normal control; FTD=frontotemporal dementia; SD=semantic dementia; AD=Alzheimer's disease]

TABLE 2

	FTD	SD	AD	NC	F-value**	p-value**
TORRANCE CREATIVITY TEST						
Fluency	9.86(0.38)	4.71(4.19)*	9.47(1.06)	10.00(0.00)	12.83	<0.0001
Originality	3.29(1.60)	2.29(2.75)*	5.13(1.55)	5.36(1.69)	4.16	0.0132
Elaboration	9.86(0.38)	3.14(3.80)*	9.40(1.06)	10.00(0.00)	31.60	<0.0001
Resistance to Premature Closure	10.29(2.98)*	6.13(5.51)*	11.53(3.56)	13.92(2.75)	10.66	<0.0001
Movement or Action	0.86(0.69)	0.00(0.00) [†]	0.93(0.96)	1.33(1.37)	2.31	0.0938
Synthesis of Incomplete Figures	0.14(0.38)	0.00(0.00)	0.00(0.00)	0.00(0.00)	--	n.s.
Unusual Visualization	0.86(1.07)	0.43(1.13)	0.60(0.74)	1.17(0.83)	--	n.s.
Internal Visualization	0.00(0.00)	0.29(0.76)	0.13(0.35)	0.25(0.45)	--	n.s.
Humor	0.43(0.79)	0.00(0.00)	0.60(0.83)	0.17(0.39)	--	n.s.
Richness of Imagery	0.14(0.38)	0.29(0.76)	0.27(0.59)	0.25(0.45)	--	n.s.
Colorfulness of Imagery	0.29(0.76)	0.00(0.00)	0.87(1.30)	0.50(0.52)	--	n.s.
Fantasy	0.71(0.95)	0.00(0.00)	0.27(0.59)	0.50(0.67)	--	n.s.
COLOR DISCRIMINATION						
Hue	6.50(0.58)	5.71(1.25)	6.22(0.67)	5.60(1.26)	--	n.s.
Saturation	6.50(0.58)	5.86(0.69)	6.44(1.01)	5.60(1.26)	--	n.s.
Chromaticity	7.00(0.00)	6.86(0.38)	6.89(0.33)	6.40(0.84)	--	n.s.
TOTAL	20.00(0.82)	18.43(1.81)	19.55(1.51)	17.60(3.03)	--	n.s.
COLOR PREFERENCE						
Red	3.50(1.29)	3.14(1.86)	4.11(1.96)	3.50(1.72)	--	n.s.
Orange	4.25(1.71)	4.29(1.25)	4.33(1.58)	5.00(1.56)	--	n.s.
Yellow	5.50(2.38)	4.29(1.60)	4.22(1.86)	4.30(1.57)	--	n.s.
Green	3.00(1.41)	2.57(1.40)	3.11(1.96)	3.80(2.15)	--	n.s.
Blue	4.25(1.71)	3.29(1.70)	2.89(1.83)	3.10(1.73)	--	n.s.

	FTD	SD	AD	NC	F-value ^{**}	p-value ^{**}
Purple	1.50(1.00)	3.86(2.54)	4.11(2.20) [†]	1.90(1.37)	2.74	0.0657
Brown	5.75(1.89)	5.14(2.85)	5.22(2.33)	5.10(2.23)	--	n.s.

* p<0.05 compared to NC group using Dunnett-Hsu test for multiple comparison corrections controlling for effects of sex, age, and education

[†] p<0.10 nonsignificant trend compared to NC group

TABLE 3

Consistent differences in artistic style across all drawings. Data are represented as mean (standard deviation). F-values and p-values represent the significance of overall general linear model comparison across all subject groups, controlling for age, sex, and education. Scores from patient groups that showed a significant difference from NCs based on pairwise post-hoc Dunnett-Hsu testing at $p < 0.05$, controlling for age, sex, and education, are shown in bold. [NC=normal control; FTD=frontotemporal dementia; SD=semantic dementia; AD=Alzheimer's disease]

	FTD	SD	AD	NC	F-value**	p-value**
OVERALL IMPRESSIONS						
Creativity	2.45(0.75)	2.55(0.37)	2.64(0.67)	2.67(0.58)	--	n.s.
Apparent Effort	2.72(1.10)	2.95(0.65)	3.11(0.85)	3.04(0.70)	--	n.s.
Fidelity to Subject	2.69(0.71)	2.70(0.76)	2.83(0.71)	2.40(0.57)	--	n.s.
Bizarreness	2.80(0.93)*	2.87(0.60)*	2.80(0.83)	2.26(0.47)	2.86	0.0489
CONTENT						
Activity of Subject	1.41(0.33)	1.56(0.31)	1.52(0.34)	1.69(0.38)	--	n.s.
Abstract	2.01(0.81)	2.13(0.80)	1.98 (0.58)	2.13(0.51)	--	n.s.
TECHNIQUE						
Composition	3.08(0.67)*	3.53(0.46)	3.12(0.67) [†]	3.58(0.49)	3.53	0.0235
Representational form	3.25(0.92)	3.20(0.65)	3.34(0.77)	3.41(0.56)	--	n.s.
Perspective	2.04(0.99)	1.85(0.52)	2.17(0.75)	2.39(0.86)	--	n.s.
Patterning	2.10(0.56)	2.20(0.29)	1.84(0.40)	2.13(0.32)	--	n.s.
Movement in Strokes	1.68(0.43)*	2.00(0.49)	2.10(0.61)	2.49(0.73)	2.12	n.s.
Facial Distortion	3.94(0.74)*	3.31(1.11)*	3.13(0.93) [†]	2.51(0.65)	5.95	0.0020
Shading	1.76(0.51)	1.59(0.52)	1.75(0.67)	1.99(0.66)	--	n.s.
Total # colors	12.71 (4.1)	17.83 (5.8)	10.58(4.9)*	18.13 (5.7)	3.51	0.0260

* $p < 0.05$ compared to NC group using Dunnett-Hsu test for multiple comparison correction, controlling for effects of sex, age, and education

[†] $p < 0.10$ nonsignificant trend compared to NC group