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Neurodegeneration and Identity

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Abstract

There is a widespread notion, both within the sciences and among the general public, that mental deterioration can rob individuals of their identity. Yet there have been no systematic investigations of what types of cognitive damage lead people to appear to no longer be themselves. We measured perceived identity change in patients with three kinds of neurodegenerative disease: frontotemporal dementia, Alzheimer's disease, and amyotrophic lateral sclerosis. Structural equation models revealed that injury to the moral faculty plays the primary role in identity discontinuity. Other cognitive deficits, including amnesia, have no measurable impact on identity persistence. Accordingly, frontotemporal dementia has the greatest effect on perceived identity, and amyotrophic lateral sclerosis has the least. We further demonstrated that perceived identity change fully mediates the impact of neurodegenerative disease on relationship deterioration between patient and caregiver. Our results mark a departure from theories that ground personal identity in memory, distinctiveness, dispositional emotion, or global mental function.

Keywords

identity, self, neurodegenerative disease, open data, open materials

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When Phineas Gage was penetrated by a tamping iron to his orbitofrontal cortex, his character changed so markedly his friends said he was "no longer Gage" (Macmillan, 2000, p. 13). This case is famous for its demonstration of how a simple and relatively circumscribed mental change can lead to a dramatic shift in whether someone seems like the person they once were. But only a subset of neuropsychological transformations leads to the perception that identity has been compromised (Mathews, Bok, & Rabins, 2009). This raises the question of whether all mental faculties are equally instrumental in creating the impression of a continuous self.

One theory, rooted in philosophy (Locke, 1690/2009; Parfit, 1971; Shoemaker, 1959), proposes that identity is contingent on memory. Support for this theory from Alzheimer's disease (AD) patients is inconsistent (Caddell & Clare, 2010). Some studies find that autobiographical-memory loss can affect the AD patient's sense of self (Addis & Tippett, 2004; Duval et al., 2012), whereas others indicate that amnesia does not affect the sense of self as long as personality traits remain intact (S. B. Klein, Cosmides, & Costabile, 2003; Levitin, 2012). Since AD patients exhibit a heterogeneous constellation of cognitive symptoms with a high degree of individual variation, it has been difficult to disentangle the extent to which memory itself plays a role in identity loss.

An alternative possibility is that moral capacities exert the strongest influence over perceived identity (Prinz, 2014; Strohminger & Nichols, 2014). This view has received indirect support from social-cognition research, which finds that the moral dimension predominates in impression formation (N. H. Anderson, 1968), more than competence (Wojciszke, Bazinska, & Jaworski, 1998) or even warmth (Brambilla, Rusconi, Sacchi, & Cherubini, 2011; Goodwin, Piazza, & Rozin, 2014; Leach, Ellemers, & Barreto, 2007). However, this work primarily addresses social evaluation, rather than perceived personal identity—whether someone seems like the same person as before.

The essential-moral-self hypothesis proposes that moral capacities are the most central part of identity. According to this theory, neurodegenerative diseases that impair moral capacities ought to be the most potent

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source of identity change. Frontotemporal dementia (FTD) is the most common form of dementia after AD (Snowden, Neary, & Mann, 2002). In the behavioral subtype of FTD, prefrontal cortex dysfunction leads to moral impairments, including dishonesty, inappropriate behavior, reduced empathy, and diminished concern for social norms (S. W. Anderson, Bechara, Damasio, Tranel, & Damasio, 1999; Manoochehri & Huey, 2012; McKhann et al., 2001; Mendez, Anderson, & Shapira, 2005). While FTD affects traits that psychologists associate with the core self (Miller et al., 2001), direct evidence that FTD disrupts personal identity exists only in hints from case studies (as when the wife of a patient lamented, "It is as if a different person has crawled into [his] skin"; Mathews et al., 2009, p. 56).

Memories and morality are but two candidates for sources of identity change; many others have been proposed, including depression (Kramer, 1993) and aphasia (Shadden, 2005). It is also possible that overall degree of mental deterioration is all that matters. While previous work has examined the influence of brain damage on identity from the patient's perspective, the present investigation measured a crucial construct that has gone virtually unstudied in neuropsychology: how identity recognition is affected for people observing the brain-damaged patient. In addition to providing a novel perspective on the wider social ramifications of neurodegenerative disease, this measure sidesteps some of the problems of reliability inherent to first-person reports. Anosognosia (lack of disease awareness) is comorbid with dementia (Prigatano & Schacter, 1991), and the ability to compare the current self with past selves is confounded with the severity of memory impairment (Eustache et al., 2013).

The primary aim of this study was to determine the influence of neurodegenerative symptomatology on third-person judgments of personal identity. Rather than focus on one symptom or individual at a time, we compared a variety of mental deficits in order to model the independent contribution of each toward identity persistence. Collecting data from multiple diseases also provides an opportunity to generalize beyond the bounds of a single neurological disorder. Scholarship devoted to the nature of identity tends to be limited to armchair speculation (Locke, 1690/2009; Parfit, 1971) or asking subjects to imagine hypothetical scenarios (Blok, Newman, Behr, & Rips, 2001; Nichols & Bruno, 2010; Strohminger & Nichols, 2014). The present design allowed us to bring these theories to bear on real cases of brain damage.

A subsidiary goal of this investigation was to test the broader impact that identity change has on outcomes related to well-being. In particular, we focused on how relationship quality deteriorates as a function of cognitive impairment. Thus, we not only demonstrated the practical importance of identity persistence, but also identified a new potential risk factor that neurodegenerative disease places on family, caregivers, and communities.

Method

We focused on family members from three patient populations: FTD, AD, and amyotrophic lateral sclerosis (ALS). ALS served as a control condition. While ALS is a neurodegenerative disease, its effects are largely on motor functions (though psychological faculties are sometimes affected; Ringholz et al., 2005).

Participants

Participants were recruited by posting study notices to online support groups for friends and family of those suffering from FTD, AD, and ALS. Two hundred forty-eight volunteers completed the study. For structural equation modeling, a minimum sample of 200 is generally recommended (Kline, 2005; Lei & Wu, 2007); we continued collecting data past this point until the pool of volunteers had been exhausted.

Sixty-six additional participants (21% of the total) started but did not finish the study. This attrition rate likely reflects the study's length and its wholly voluntary nature. An independent samples Kruskal-Wallis test revealed no significant difference in attrition rate across disease type.

Thirty-one percent of patients were diagnosed with FTD (n = 76), 46% with AD (n = 114), and 23% with ALS (n = 58). The pool of participants was an international sample from largely English-speaking countries (81% American, 8% Canadian, 5% British, 2% Australian, 2% other). Participants were 85% female and 15% male; 79% of the patients they described were male, and 21% were female. There were no interaction effects between disease type and participant or patient gender, Fs < 1, n.s.

Seventy-four percent of participants were responding about their spouse or domestic partner; the next most common patient category was parent (8%). Most (79%) participants interacted with the patient on a daily basis, and almost all interacted on a weekly basis (92%). Participants began noticing symptoms an average of 8 years prior to taking the survey (SD = 5), with no significant difference across disease type, Fs < 1, n.s.

Procedure

The study was administered as an online survey. Participants were told that the purpose of the research was to investigate how neurodegenerative disease affected personal relationships. After reporting the patient's primary condition (FTD, AD, or ALS), participants indicated the extent to which the patient exhibited an array of symptoms typical of

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Table 1. List of Symptoms on the Survey Used in Each Neurodegenerative Condition

Frontotemporal dementia	Disorientation or confusion
Amnesia (memory loss)	Distractability/difficulty paying attention
Anosognosia (lack of awareness of their condition)	Episodic (autobiographical) memory loss
Antisocial behavior	Increased agitation/mood swings
Apathy (indifference towards surroundings)	Memory loss for generic information about the world
Aphasia or difficulties with language (smaller vocabulary, decreased word fluency)	Memory loss for information they knew before disease onset
Apraxia (difficulty executing movements)	Memory loss for meanings and concepts (semantic memory)
Blunted (less intense) emotions	Memory loss for personally meaningful information
Changes in eating habits/hyperorality	Paranoia/delusions
Decreased empathy and warmth towards others	Amyotrophic lateral sclerosis
Decreased inhibitions/inappropriate behavior	Amnesia (memory loss)
Decreased motivation	Anosognosia (lack of awareness of their condition)
Decreased personal hygiene	Apathy (indifference towards surroundings)
Depression	Aphasia or difficulties with language not related to muscle degeneration
Distractibility/difficulty paying attention	Clumsiness
Increased agitation/mood swings	Decreased empathy and warmth towards others
Increased sex drive	Decreased inhibitions/inappropriate behavior
Paranoia/delusions	Decreased motivation
Repetitive compulsive behavior	Depression
Alzheimer's disease	Difficulty breathing and swallowing
Agnosia (difficulty recognizing objects, although memory for objects is intact)	Distractibility/difficulty paying attention
Anosognosia (lack of awareness of their condition)	Fatigue
Apathy (indifference towards surroundings)	Increased agitation/mood swings
Aphasia or difficulties with language (smaller vocabulary, decreased word fluency)	Loss of voluntary muscle control
Apraxia (difficulty executing movements)	Muscle weakness
Blunted (less intense) emotions	Pseudobulbar affect (spontaneous, inappropriate laughter or crying)
Depression	Repetitive compulsive behavior
Difficulty planning, problem solving, or thinking abstractly	Slurred speech/difficulty projecting the voice
Difficulty remembering new information	Twitching (fasciculation) and muscle cramping

Note: Participants were presented with all symptoms for the relevant disease type and indicated which symptoms patients exhibited, along with their level of severity.

that disease (Table 1). Participants received a different list of symptoms depending on the primary disease; there was partial overlap in items across disease types, including amnesia, aphasia (language impairment), and apraxia (impairment of voluntary motor control). Depression was included because it often co-occurs with these diseases. Each symptom was rated on a scale from 0 to 4 (*none, mild, moderate, severe*, and, for symptoms where applicable, *complete*).

Participants filled out the Morality-Personality Scale (MoPeS), which is a hybrid of the Virtues Scale (Cawley, Martin, & Johnson, 2000) and the Five Factor Inventory (Costa & McCrae, 1992). The MoPeS consists of 64 individual-difference traits presented as three-adjective clusters, and it has been successfully used in previous work (Strohminger & Nichols, 2014). The traits vary in how closely related to morality they are, as determined by a prior norming study.[1] These ratings were used to divide the traits into the 15 most moralized ("moral") traits and 15 least moralized ("personality") traits. This division allowed us to test whether all dispositional traits play a role in perceived identity or whether moral traits are especially important. In labeling the least moralized traits "personality," we followed the convention that personality represents individual-difference traits that are unrelated to moral character (Allport, 1921, 1927; cf. Peterson & Seligman, 2004).

Participants indicated how much the patient had changed on each trait since the onset of the disease using a bipolar scale from −2 (*exhibits trait much less*) to 2 (*exhibits trait much more*), with 0 (*no change*) at the midpoint. This scale allowed us to measure change on two dimensions: absolute amount of change and valence of change (positive or negative). (For a box plot of MoPeS scores by condition, see Fig. S1 in the Supplemental Material available online.)

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Table 2. Mean Raw Scores for Measures of Identity and Daily Functioning

Question	Condition		
	Amyotrophic lateral sclerosis	Alzheimer's disease	Frontotemporal dementia
"Do you feel like you still know who the patient is?" (still know patient)	4.59 (0.68)	3.77 (1.03)	3.41 (1.09)
"How much has the patient's illness impaired their ability to function in day-to-day activities?" (impact on daily functioning)	4.05 (1.08)	3.81 (0.84)	3.92 (0.83)
"Regardless of the severity of the illness, how much do you sense that the patient is still the same person underneath?" (same person underneath)	4.22 (1.03)	3.37 (1.03)	2.99 (0.93)
"How would you characterize the changes the patient has experienced?" (depth of change)	54.0 (31.8)	75.1 (20.6)	80.6 (18.3)
"Does the patient ever seem like a stranger to you?" (seems like a stranger)	1.41 (0.65)	2.02 (0.80)	2.30 (0.77)

Note: The first three items were rated on a scale from 1 to 5, the fourth was rated from 0 to 100, and the last was rated from 1 to 4. Standard deviations are given in parentheses.

To assess the nature of the relationship between respondent and patient, we asked participants to provide information about how often they see the patient, how they are related to the patient, and how much their relationship had deteriorated since disease onset. Following these were questions designed to measure perceived identity change. Four items were aimed at identity specifically: "Do you feel like you still know who the patient is?" (rated from 1, *not at all*, to 5, *completely*), "How would you characterize the changes the patient has experienced?" (rated from 0, *superficial—they are just surface changes*, to 100, *deep—they fundamentally change who the person is*), "Regardless of the severity of the illness, how much do you sense that the patient is still the same person underneath?" (rated from 1, *not at all*, to 5, *completely*), and "Does the patient ever seem like a stranger to you?" (rated from 1, *no, not at all*, to 4, *yes, all the time*). The degree to which the patient's illness impacted daily functioning was treated as a control (Table 2).

Results

Structural, measurement, and mediation models were run in Amos (Version 22; Arbuckle, 2006). Principal component analysis and reliability analyses were performed in SPSS (Version 22). All other analyses were performed in R statistical software (Version 3.1; R Development Core Team, 2014).

A clear pattern emerges when considering identity change as a function of disease type (Fig. 1 and Table 2). A two-way repeated measures analysis of variance (ANOVA) was conducted to compare the effects of disease type (FTD, AD, ALS) and identity question (the four questions relating to identity) on perceived identity. There was a significant main effect of disease type, $F(2, 245) = 39.63$, $p < .001$. There was no main effect of identity question, nor was there an interaction effect between identity question and disease type, Fs < 1.

Because there was no significant difference between responses across the four identity questions, we computed the mean of the four identity ratings per participant and used this as the dependent measure of perceived identity change for the pairwise comparisons by disease type. These t tests revealed that AD leads to greater identity disruption than ALS, Welch's $t(112) = 6.50$, $p < .0001$, $d = 1.05$, and FTD leads to greater identity disruption than either ALS, $t(115) = 8.75$, $p < .0001$, $d = 1.54$, or AD, $t(170) = 3.04$, $p = .003$, $d = 0.45$. This result cannot be attributed to differences in the severity of the diseases, as an ANOVA showed no correspondence between the dependent measure of daily functioning and the independent measure of disease type, $F(2, 245) = 1.46$, n.s.

This analysis provides initial evidence that the moral faculty contributes to perceived identity more than does memory or nonpsychological neural faculties such as voluntary motor control, and that there are overall differences in how these neurodegenerative diseases affect perceived identity persistence. To examine the role of specific cognitive impairments on perceived identity within and across disease types, we turned to structural equation modeling (SEM).

Main structural equation model

SEM is a hybridization of factor analysis and path analysis (Ullman, 2006; Ullman & Bentler, 2001). SEM has several advantages, including the ability to explicitly account for measurement error, to combine observed and unobserved (latent) variables into the same model, and to resolve multicollinearity by positing latent constructs. SEM measures the effect of multiple independent variables on dependent constructs, establishing not only the existence of their relationship but also quantifying their relative strength. SEM is preferable to multiple, smaller mediation analyses because it allows for direct comparison and control of all variables of interest and is more

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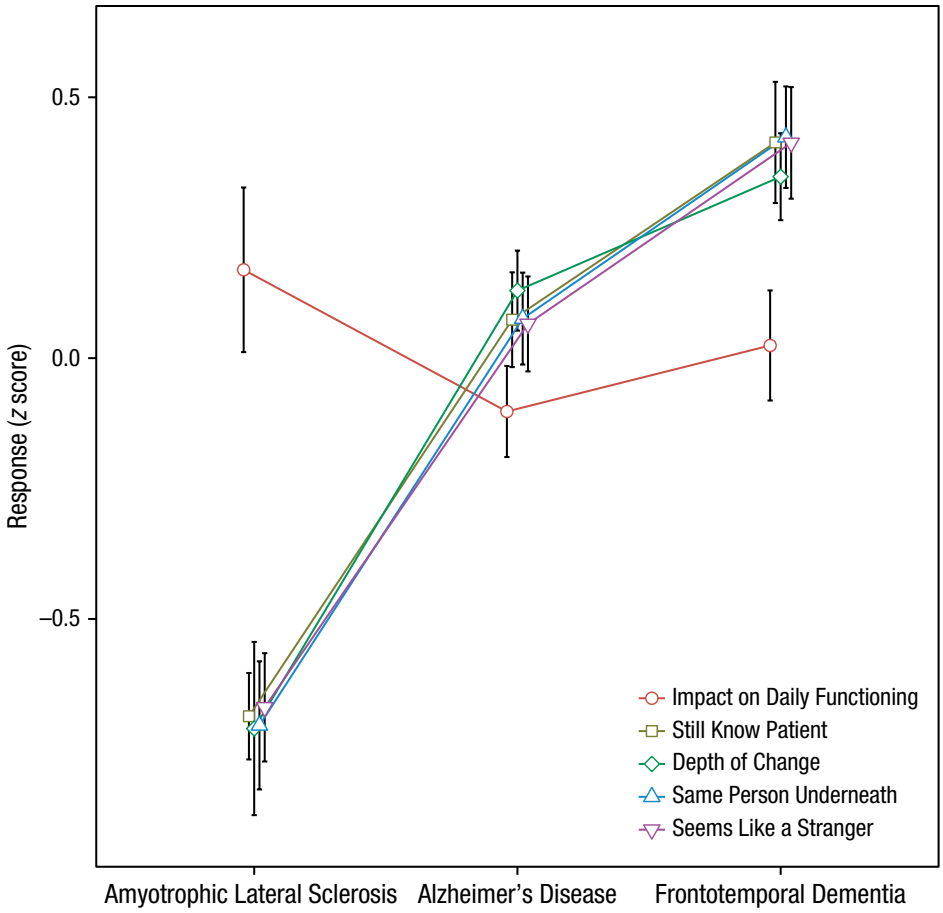

Fig. 1. Mean response to each of five questions regarding changes in patients' identity as a function of neurodegenerative disease type. All responses were standardized and centered as *z* scores. See Table 2 for the full questions. Error bars represent standard errors.

parsimonious (Hayes, 2009). SEM is particularly well-suited to neuropsychology, because patients with the same diagnosis can manifest constellations of symptoms to differing degrees and can exhibit symptoms that would fit under the umbrella of multiple conditions (e.g., many ALS patients also meet the diagnostic criteria for FTD; Ringholz et al., 2005).

Because there were different numerical-scale anchors depending on the item, all variables were standardized and centered (and, where appropriate, reverse-scored) before analysis. Prior research using statistical simulations indicates that a higher number of indicators per construct is preferred, with four or more indicators per factor necessary for proper model fit (Marsh, Hau, Balla, & Grayson, 1998). Thus, there were 15 observed variables each in the latent factors for moral traits and personality traits, and 4 observed variables in the latent factor for perceived identity (Table 3).

A confirmatory factor analysis supported the fit of these three latent factors, $\chi^2(524) = 940$, χ^2/degrees of freedom (CMIN/DF) = 1.79, $p < .001$; comparative fit index (CFI) = .904, root-mean-square error of approximation (RMSEA) = .057. Standardized estimates for indicator variables were generally above 0.5 (Table 3). Tests of Cronbach's alpha revealed that the latent factor for identity exhibited a high level of reliability (4 items; $\alpha = .840$), as did the moral-traits factor (15 items; $\alpha = .935$) and the personality-traits factor (15 items; $\alpha = .913$). There were no items that increased reliability if removed, so all were retained for the analysis.

The structural model treated common shared cognitive-behavioral changes across the three disease types as predictor variables. Five of the predictor variables were observed (apraxia, amnesia, aphasia, depression, disease duration), and the other two were latent variables as established in the measurement model (personality and moral traits). All predictor variables were allowed to covary. The identity factor served as the sole criterion variable. The relationships between the predictor and criterion variables are summarized in Table 4 and Figure 2a.

Structural analysis supported model fit, $\chi^2(679) = 1{,}175$, CMIN/DF = 1.73, $p < .001$; CFI = .894, RMSEA = .054, based on standard cutoff criteria (Hu & Bentler, 1999; Schreiber, Nora, Stage, Barlow, & King, 2006). Together, the independent variables accounted for 65% of all variance (R^2) in identity change.

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Table 3. Standardized Estimates for the Measurement Model of All Three Neurodegenerative Disease Types

Latent variable and observed variable	β
Identity	
Still know patient	0.757
Depth of change	0.686
Same person underneath	0.797
Seems like a stranger	0.786
Morality	
Honesty	0.722
Integrity	0.747
Altruism	0.674
Justice	0.735
Mercy	0.705
Trustworthiness	0.665
Generosity	0.731
Loyalty	0.769
Purity	0.741
Obedience	0.700
Decency	0.667
Duty	0.745
Gratitude	0.582
Compassion	0.648
Humility	0.674
Personality	
Curiosity	0.763
Intelligence	0.720
Creativity	0.779
Sociability	0.598
Imagination	0.659
Artistry	0.616
Leadership	0.683
Austerity	0.536
Unconventionality	0.661
Energy	0.489
Composure	0.638
Humor	0.718
Ebullience	0.614
Adventurousness	0.542
Neophilia	0.589

Note: The p value for all coefficients was .000.

Far and away the most powerful predictor of perceived identity change was moral change, $\beta = 0.73$, $p < .001$ (Fig. 2a and Table 4). Aphasia exhibited a weaker but reliable effect, $\beta = 0.15$, $p = .01$. No other symptom in the model—apraxia, depression, amnesia, personality change—had a measurable impact on perceived identity.

FTD model

Participants in the FTD and AD conditions answered additional scale-based questions about symptoms specific to these respective diseases.[2] Disease-specific models

Table 4. Standardized Estimates (With Significance Levels) for Variables Predicting Personal Identity in the Structural Model of All Three Neurodegenerative Disease Types

Variable	β	p
Morality	0.730	.000
Personality	–0.005	.958
Amnesia	–0.028	.627
Aphasia	0.153	.010
Apraxia	–0.098	.056
Depression	0.033	.504
Duration	–0.015	.770

Note: The structural model is displayed graphically in Figure 2a.

therefore allowed us to examine the influence of morality, memory, and other cognitive systems in richer detail. Specifically for the FTD condition, using a measure of morality that is symptom-based rather than trait-based provided a means for reinforcing our theoretical model that moral change plays a central role in identity disruption.

FTD is accompanied by symptoms relating to loss of executive function. Some of these affect moral behavior (e.g., antisocial behavior, loss of social inhibitions), and some do not (e.g., decreased motivation, repetitive compulsive behavior). We analyzed participants in the FTD condition ($n = 76$) to determine whether an alternative measure of moral change—symptoms related to moral behavior—also influences perceived identity and to determine what general role (if any) frontal lobe dysfunction plays in perceived identity.

Principal component analysis of the FTD-specific symptoms (Table 5) revealed that four symptoms split into a factor related to moral concerns: (a) antisocial behavior, (b) apathy, (c) reduced empathy, and (d) reduced social inhibitions and inappropriate behavior. These served as observed endogenous variables for the morality factor (4 items; $\alpha = .78$). The measurement model for the latent factors (morality and identity) indicated good model fit, $\chi^2(19.1) = 28.7$, CMIN/DF = 1.51, $p = .07$; CFI = .944, RMSEA = .083.

The observed exogenous variables in the FTD structural model were decreased motivation, paranoia and delusions, decreased personal hygiene, hyperorality, increased sex drive, repetitive compulsive behavior, amnesia, and apraxia. Three items that were highly correlated with the morality factor—difficulty paying attention, blunted affect, and agitation—were not included in the model to prevent indeterminacy arising from collinearity. These three symptoms are, however, part of the AD model presented in the following section.

Structural analysis supported model fit, $\chi^2(73.0) = 119$, CMIN/DF = 1.64, $p = .001$; CFI = .833, RMSEA = .092. Moral injury exerted strong and exclusive control over perceived identity in FTD patients, $\beta = 0.80$, $p < .001$. No other FTD symptom had a significant impact on identity (see Table 6

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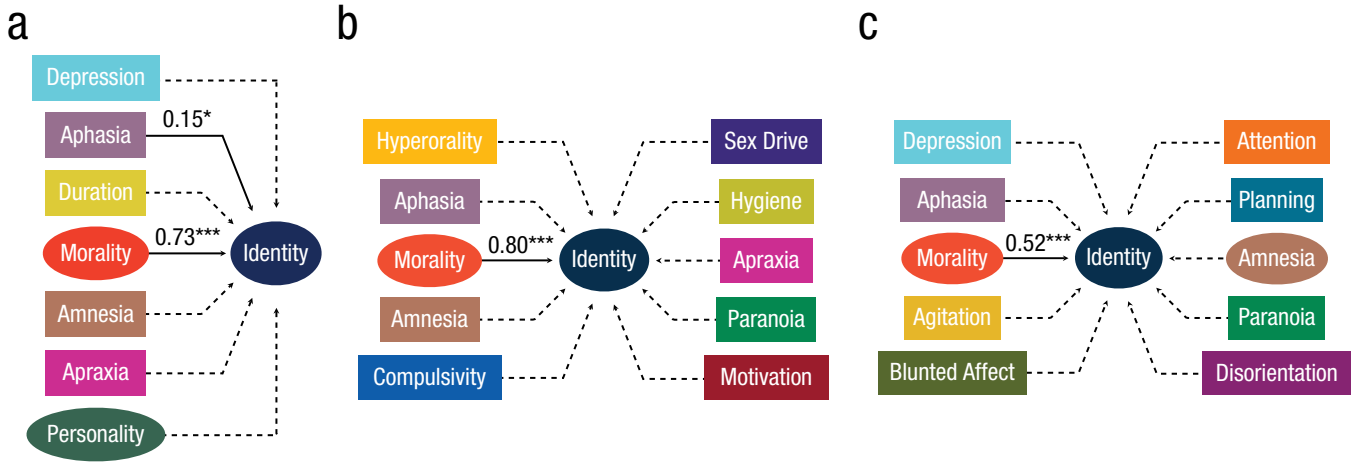

Fig. 2. Path diagrams from the structural models showing the effect of cognitive-behavioral deterioration on perceived identity change, separately for the following disease types: (a) amyotrophic lateral sclerosis, frontotemporal dementia, and Alzheimer's disease combined; (b) frontotemporal dementia only; and (c) Alzheimer's disease only. Ovals represent latent variables, and rectangles represent observed variables. Conceptually overlapping variables are in the same color. Solid lines represent significant relationships between predictors and the criterion variable; dotted lines represent no significant relationship. Values shown are standardized estimates. Asterisks indicate significant paths (*p = .01, ***p < .001).

and Fig. 2b). When the four-factor symptom-based morality factor was replaced with the 15-factor trait-based morality factor used in the other structural equation models, the same findings emerged (see Table S3 in the Supplemental Material). Including personality as a predictor revealed no impact of personality change on perceived identity and, furthermore, reduced model fit (Table S3).

AD model

Our aim in the analysis targeted at AD participants (n = 114) was to determine whether specific memory deficits affect perceived identity. This analysis also allowed us to see whether moral change continues to exert an influence on identity even in patients for whom moral deterioration is not the primary or characteristic symptom of the disease.

Participants in the AD group responded to items characteristic of that disease. These included difficulty planning, disorientation and confusion, paranoia, difficulty paying attention, agitation, aphasia, depression, and blunted affect. Different forms of memory deficit were also probed (Table 1).

The AD structural model contained three latent factors—morality, amnesia, and identity. The morality and personality factors were composed of the same two sets of 15 traits used in the main model. Factor analysis on six memory-related items revealed that five items formed a coherent factor: deterioration of episodic memory, semantic memory, memory for personally meaningful

Table 5. Standardized Estimates for the Measurement Model of Frontotemporal Dementia Patients Only

Latent variable and observed variable	β
Identity	
Still know patient	0.648
Depth of change	0.696
Same person underneath	0.633
Seems like a stranger	0.659
Morality	
Antisocial behavior	0.701
Apathy	0.646
Reduced empathy	0.811
Reduced social inhibitions	0.618

Note: The p value for all coefficients was .000.

Table 6. Standardized Estimates (With Significance Levels) for Variables Predicting Personal Identity in the Structural Model of Frontotemporal Dementia Patients Only

Variable	β	p
Morality	0.796	.002
Motivation	0.008	.951
Paranoia	–0.062	.632
Hygiene	–0.041	.791
Hyperorality	–0.091	.507
Compulsivity	–0.058	.662
Sex drive	0.157	.190
Amnesia	–0.103	.409
Aphasia	–0.077	.601
Apraxia	–0.046	.727

Note: The structural model is displayed graphically in Figure 2b.

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Table 7. Standardized Estimates for the Measurement Model of Alzheimer's Disease Patients Only

Latent variable and observed variable	β
Identity	
Still know patient	0.708
Depth of change	0.575
Same person underneath	0.794
Seems like a stranger	0.769
Morality	
Honesty	0.662
Integrity	0.701
Altruism	0.548
Justice	0.672
Mercy	0.613
Trustworthiness	0.398
Generosity	0.649
Loyalty	0.783
Purity	0.717
Obedience	0.664
Decency	0.486
Duty	0.579
Gratitude	0.550
Compassion	0.536
Humility	0.635
Memory	
Episodic	0.605
Semantic	0.623
Personally meaningful information	0.917
Generic information	0.883
Old information	0.628

Note: The *p* value for all coefficients was .000.

information, memory for generic information, and memory for old information (α = .85).[3] A measurement model of the three latent factors demonstrated good fit, $\chi^2(249) = 316$, CMIN/DF = 1.27, $p = .003$; CFI = .939, RMSEA = .049.

Table 8. Standardized Estimates (With Significance Levels) for Variables Predicting Personal Identity in the Structural Model of Alzheimer's Disease Patients Only

Variable	β	*p*
Morality	0.517	.000
Amnesia	0.281	.097
Depression	0.108	.219
Blunted affect	0.023	.799
Agitation	0.059	.590
Paranoia	–0.141	.176
Difficulty paying attention	0.044	.669
Difficulty planning	0.073	.518
Disorientation	–0.064	.657
Aphasia	–0.011	.917

Note: The structural model is displayed graphically in Figure 2c.

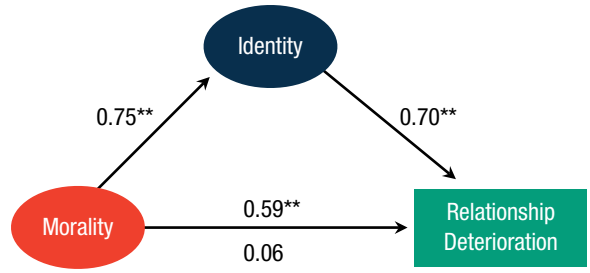

Fig. 3. Mediation model showing the effect of moral change on relationship deterioration, as mediated by perceived identity. Along the bottom path, the value above the arrow shows the total effect, and the value below the arrow shows the direct effect after controlling for the mediator. Values shown are standardized estimates. Asterisks indicate significant paths (**$p < .005$).

The observed exogenous variables in the structural model were blunted affect, depression, agitation, paranoia, difficulty paying attention, difficulty planning, disorientation, and aphasia (Table 7). Two items—agnosia and apraxia—that produced Heywood cases were removed to avoid collinearity (Heywood, 1931). Structural analysis supported model fit, $\chi^2(417) = 554$, CMIN/DF = 1.33, $p < .001$; CFI = .905, RMSEA = .054. This model showed that moral-trait change is the sole predictor of identity change in Alzheimer's patients, β = 0.56, $p < .001$ (see Table 8 and Fig. 2c). No other symptoms reached significance, including the amnesia factor and the emotional-trait items (blunted affect, depression, and agitation). In an alternative model, the amnesia items were treated as exogenous variables instead, and none of them influenced perceived identity (all *p*s > .2). As with the FTD condition, a model including the personality factor reduced fit and revealed no significant effect of personality on perceived identity (see Table S4 in the Supplemental Material).

Relationship-deterioration model

We next tested whether identity change has a reliable downstream effect on social bonds. To determine whether perceived identity explains the effect of psychological change on relationship deterioration, we ran a multiple mediation bootstrap analysis (Preacher & Hayes, 2008). This model resembles the main structural equation model but with relationship deterioration as the dependent variable and perceived identity as the potential mediator between the independent variables (morality, personality, amnesia, aphasia, apraxia, depression, duration) and relationship deterioration (Fig. 3).

As with perceived identity, moral change had the greatest impact on relationship deterioration, β = 0.59, $p = .002$, 95% confidence interval (CI) = [0.40, 0.76], and aphasia a smaller effect, β = 0.15, $p = .015$, 95% CI = [0.03, 0.27]. None of the other predictor variables, including disease duration, had an influence on relationship deterioration. When identity was

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added to this model as a mediator, identity demonstrated complete mediation. That is, the relationship from morality to identity, β = 0.75, p = .002, 95% CI = [0.58, 0.92], and identity to relationship deterioration, β = 0.70, p = .005, 95% CI = [0.46, 0.95], fully explained the relationship between moral change and relationship deterioration, which was reduced to nonsignificance, β = 0.06, n.s. Likewise, the effect from aphasia to identity, β = 0.15, p = .03, 95% CI = [0.01, 0.26], fully mediated the relationship between aphasia and relationship deterioration, β = 0.04, n.s.

An alternative hypothesis is that relationship deterioration leads to perceived identity change, rather than vice versa. To test this possibility, we ran an alternative model in which relationship deterioration was the mediating variable and identity the dependent variable. The standardized estimates in this model were weaker than in the original model. The effect of relationship deterioration on identity was β = 0.42, whereas the effect of identity on relationship deterioration was β = 0.70; the total effect of morality on identity was β = 0.50, whereas the indirect effect of morality on identity was β = 0.75. These results suggest that the best available account of the data is the causal path laid out in the original model (Fig. 3).

Discussion

These findings support the view that identity is at risk for deteriorating during neurodegeneration primarily when the moral system is impaired. Aphasia also exerts an influence, though this effect is weaker and does not reliably show up in all models (e.g., in the AD model). The primacy of morality in determining identity holds up even for dementia types in which moral impairment is not the characteristic or dominant feature. This effect is observed whether moral change is measured as a function of changes in moral traits or symptomatology related to moral behavior.

These results speak to significant and longstanding questions about the nature of identity, questions that have occupied social scientists, neurologists, philosophers, and novelists alike. Identity has variously been located in memories (Locke, 1690/2009), distinctiveness (Vignoles, Chryssochoou, & Breakwell, 2000), and dispositional emotion (S. Klein, 2013). The current results support the essential-moral-self hypothesis: As long as core moral capacities are preserved, perceived identity will remain largely intact (Strohminger & Nichols, 2014).

This investigation dovetails nicely with existing social-cognition work demonstrating that moral character is at the heart of person perception (N. H. Anderson, 1968; Goodwin et al., 2014; Wojciszke et al., 1998). Our results show that the primacy of morality extends beyond impression formation to individual-identity recognition more generally. We suspect this commonality may reflect a shared mechanism or mechanisms between forming impressions and recognizing individuals.

The role of the language system in identity continuity has received little attention (Shadden, 2005), though the present results with aphasia highlight it as a promising area for future research. Self-expression and communication may be an important component of perceived identity.

Social psychologists have often focused on identity from the first-person perspective (Baumeister, 1998; Erikson, 1968), but there has been relatively little empirical work directed at third-person recognition of individual identities (cf. Blok et al., 2001; Strohminger & Nichols, 2014). This is a notable omission from the literature, as determining individual identities and tracking them over time is surely of central importance to people's lives as social animals.

A key question for future research is whether the privileging of moral traits we observed in recognition of other people extends to recognition of the self. Systematic biases in self-estimation, especially in the moral dimension, suggest that competence may be especially important to self-directed identity judgments (Abele & Wojciszke, 2007; Epley & Dunning, 2000). While there is evidence that moral values are of central importance in self-directed judgments of personal identity, this effect may be less pronounced (Heiphetz, Strohminger, & Young, 2015). The identity crises that underlie cases of moral injury, such as posttraumatic stress disorder (Maguen & Litz, 2012), suggest that our findings may well extend to real-world self-directed experiences of identity disruption.

Neurodegeneration is just one instance of psychological change that can arise from multiple causes—some organic and some psychiatric, some clinical and some healthy. For this reason, the findings reported here may apply more broadly to psychological change across the human life span.

An estimated 36 million people are living with neurodegenerative disease worldwide (World Health Organization & Alzheimer's Disease International, 2012). While loss of identity may be feared as an undesirable clinical outcome unto itself, the present research highlights that identity deterioration has significant downstream consequences for healthy relationships. The devastation of these diseases extends beyond functional impairments and indeed extends beyond the patients themselves. Future therapies ought to be aimed at—and take into account—preserving moral function, a previously unappreciated factor in the well-being of patients and their families.

Author Contributions

N. Strohminger conceived and designed the study, analyzed the data, and wrote the manuscript. S. Nichols provided critical feedback on the study design, results, and manuscript.

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The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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Notes

1. In a separate study, 113 participants were recruited online. Participants used a Likert-type scale to rate each trait's desirability (1–7), positivity (1–7), and relation to morality (1–5). All participants rated all traits on all dimensions. Trait order was randomized between participants, and question order was fixed. The scale is designed such that traits can be desirable or positive without being related to morality. For instance, intelligence and sense of humor are rated as being highly desirable but having a low association with morality. (See Table S1 in the Supplemental Material available online for the full scale and results of the norming study.)
2. Although participants in the ALS condition also filled out symptom-specific survey questions, we did not create a separate model for ALS. There were fewer participants in this condition, so it is unlikely we could draw any reliable conclusions from a structural equation model. Creating a model of ALS patients is also unlikely to advance active theoretical debates, as no one in the literature has argued that identity primarily resides in motor control.
3. Difficulty remembering new information did not fit well onto the amnesia factor, corrected item-total correlation = .391. It was therefore excluded from the final analysis. However, including this item in the structural equation model, either as part of the amnesia factor or as a separate observed exogenous variable, did not change the statistical significance of the results.

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