Pathways to Late-Life Suicidal Behavior:
Cluster Analysis and Predictive Validation of Suicidal Behavior in a Sample of Older Adults With Major Depression

Katalin Szanto, MD[a],*; Hanga Galfalvy, PhD[b]; Polina M. Vanyukov, PhD[a];
John G. Keilp, PhD[b]; and Alexandre Y. Dombrovski, MD[a]

ABSTRACT

Objective: Clinical heterogeneity is a key challenge to understanding suicidal risk, as different pathways to suicidal behavior are likely to exist. We aimed to identify such pathways by uncovering latent classes of late-life depression cases and relating them to prior and future suicidal behavior.

Methods: Data were collected from June 2010 to September 2015. In this longitudinal study we examined distinct associations of clinical and cognitive/decision-making factors with suicidal behavior in 194 older (50+ years) nondemented, depressed patients; 57 nonpsychiatric healthy controls provided benchmark data. The *DSM-IV* was used to establish diagnostic criteria. We identified multivariate patterns of risk factors, defining clusters based on personality traits, perceived social support, cognitive performance, and decision-making in an analysis blinded to participants' history of suicidal behavior. We validated these clusters using past and prospective suicidal ideation and behavior.

Results: Of 5 clusters identified, 3 were associated with high risk for suicidal behavior: (1) cognitive deficits, dysfunctional personality, low social support, high willingness to delay future rewards, and overrepresentation of high-lethality attempters; (2) high-personality pathology (ie, low self-esteem), minimal or no cognitive deficits, and overrepresentation of low-lethality attempters and ideators; (3) cognitive deficits, inability to delay future rewards, and similar distribution of high- and low-lethality attempters. There were significant between-cluster differences in number (*P* < .001) and lethality (*P* = .002) of past suicide attempts and in the likelihood of future suicide attempts (*P* = .010, 30 attempts by 22 patients, 2 fatal) and emergency psychiatric hospitalizations to prevent suicide (*P* = .005, 31 participants).

Conclusions: Three pathways to suicidal behavior in older patients were found, marked by (1) very high levels of cognitive and dispositional risk factors suggesting a dementia prodrome, (2) dysfunctional personality traits, and (3) impulsive decision-making and cognitive deficits.

J Clin Psychiatry 2018;79(2):17m11611

[a]Department of Psychiatry, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania
[b]Department of Psychiatry, Columbia University, New York, New York
*Corresponding author: Katalin Szanto, MD, Western Psychiatric Institute and Clinic, 3811 O'Hara St, Pittsburgh, PA 15213 (szantok@upmc.edu).

Suicidal behavior emerges from a confluence of multiple risk factors, eg, depression, personality characteristics, cognitive and decision-making deficits, and lack of social support. However, when examined individually, these factors have low specificity. Most older adults who attempt suicide or die by suicide suffer from depression,[1,2] but only a minority of depressed individuals contemplate suicide, and even fewer transition to suicidal behavior. Among the subset of depressed individuals who do attempt suicide, there is also considerable heterogeneity. For example, studies have uncovered temperamental heterogeneity, suggesting that there may exist various "suicidal-risk personalities."[3] In the present study, we aimed to identify clusters of characteristics that confer suicidal behavior risk and may form the bases for distinct pathways to suicidal behavior.

While earlier accounts of the stress-diathesis model[4] emphasized the role of impulsivity, accumulating evidence suggests that only a subgroup of people who engage in suicidal behavior is impulsive[5,6] and this proportion is lower in old age.[7] What might characterize suicidal individuals with low levels of impulsivity? A large body of evidence indicates that cognitive deficits are associated with suicidal thoughts and behavior.[8,9] One pathway to suicide may thus be characterized by late-onset suicidal behavior where age-related cognitive decline or prodromal dementia[10–13] interact with dispositional and environmental factors. Another pathway may be marked by decision-making deficits[14–16] accompanied by different levels of cognitive impairment[12,15–21] and impulsivity, as seen in a subgroup of suicide attempters in real life as well as in the laboratory.

In contrast to the predominantly early-onset, low-lethality suicide attempts often seen in borderline personality disorder, medically serious suicide attempts are most consistently associated with cognitive impairments,[17,21,22] most closely approximate death by suicide, and are more prevalent in older patients.[23] Personality pathology, if present in this subgroup, may be characterized by lifelong patterns of limited social interactions.[24]

Our longitudinal study of attempted suicide in late-life enables us to examine the validity of these pathways. We selected potential risk variables suggested by the Mann stress-diathesis model[4] and dispositional measures including interpersonal functioning.[25] We included measures of cognitive performance,[17,26] decision competence,[14] different facets of impulsivity,[27–29] and social support.[30] We examined the multivariate patterns of risk factors to identify clusters of individuals on the basis of their personality/

Clinical Points

- As suicidal behavior in older adulthood is heterogeneous, pathways differentiating risk profiles need to be identified.
- This study was able to identify 3 pathways: one is characterized by late-onset depression and cognitive deficits resembling a dementia prodrome, another is characterized by early-onset depression and prominent personality pathology, and a third is defined by short-sighted decision-making and moderate cognitive deficits.

social support and cognitive/decision-making profiles, without including psychiatric diagnoses or suicidality. Then, we provided predictive validation of this categorization based on the individuals' suicidal ideation and behavior both prior to baseline assessment and during the follow-up period.

METHODS

Sample and Procedures

Sample. Two hundred fifty-one older adults (age range, 50–87, mean = 66.7, SD = 8.0), 194 of whom were depressed, were recruited to participate in a case-control longitudinal study (R01 MH085651) of late-life suicidal behavior from June 2010 to September 2015 and provided written informed consent as required by the University of Pittsburgh Institutional Review Board. Our recruitment strategy was to oversample those who have risk factors for suicidal behavior, such as past history of suicide attempt and suicidal ideation. Our primary recruitment source for attempters and ideators was geriatric psychiatric units. Given that a high proportion of our sample came from an inpatient psychiatric facility, the participants were more likely to be acute, have more comorbidities, and be more similar to participants who die by suicide than participants in other studies recruited primarily from the community or outpatient facilities. Of the 194 depressed patients, 50 had had no lifetime history of suicidal behavior or ideation, 46 had contemplated suicide, and 98 had made a suicide attempt. Suicide attempters had made a self-injurious act with the intent to die; 49 had made high-lethality attempts, and 49 had made low-lethality attempts. Medical seriousness was assessed using the Beck Lethality Scale (BLS).[31] For participants with multiple attempts, data for the highest lethality attempt are presented. High-lethality attempters scored ≥ 4 on the BLS for an attempt needing treatment in medical or surgical units or emergency departments, whereas low-lethality attempters incurred no significant medical damage. Suicide ideators endorsed suicidal ideation with a plan, as assessed using the Beck Scale for Suicidal Ideation,[32] but had no history of suicide attempt. Nonsuicidal depressed controls had no history of suicide attempt or suicidal ideation. Participants were diagnosed with unipolar nonpsychotic major depression using the Structured Clinical Interview for *DSM-IV* Axis I disorders.[33] Current depression severity was measured by the 17-item Hamilton Depression Rating Scale (HDRS).[34]

We also assessed 57 demographically matched, nondepressed controls (ie, healthy controls with no lifetime history of mental health treatment and no lifetime diagnosis of *DSM-IV* Axis I disorder), as a benchmark group and to calculate standardized cognitive scores, but they were not included in any analyses.

We excluded individuals with clinical dementia (score < 24 on the Mini-Mental State Examination[35]) and those with a history of neurologic disorder, delirium, or sensory disorder that would preclude neuropsychological testing.

Characterization

Global cognitive ability was assessed with the Mattis Dementia Rating Scale (DRS),[36] cognitive control with the Executive Interview (EXIT),[37] and premorbid IQ with the Wechsler Adult Reading Test.[38]

Decision-making. Decision competence was assessed using 2 subscales of the Adult Decision-Making Competence task[39]: Resistance to Framing and Resistance to Sunk Cost. Delay discounting was assessed with the Monetary Choice Questionnaire (MCQ).[40]

Dispositional factors. We measured negative urgency (UPPS Negative Urgency subscale[41]) and impulsive/careless social problem-solving style (Social Problem Solving Inventory [SPSI] Impulsivity/Carelessness subscale[42]). We assessed personality functions and different aspects of social support with the Interpersonal Needs Questionnaire Perceived Burdensomeness subscale[43] and the Interpersonal Support Evaluation List (ISEL) Self-esteem and Belongingness subscales.[44]

Social support. Perceived availability of practical support was assessed with the ISEL Tangible Support subscale. Items assess different aspects of tangible support, eg, if needed, do you have somebody to take you to the hospital, lend you a car for a few hours, lend you $100, stay with you in an emergency?

A more detailed characterization of the assessments can be found in the supplementary materials online.

Data Analysis

Variables with inherently non-Gaussian distributions, namely, the MCQ score, were log-transformed. Analysis of variance was used to compare the 4 depressed groups on the cognitive and personality/social support measures, as well as some psychiatric scales and demographic variables. Post hoc pairwise comparisons were performed using the Tukey honest significant difference method for adjustment. Summary statistics for the healthy control group are also reported for comparison but were not included in statistical tests.

Prior to the cluster analysis, all the scales were recoded, so that higher values on a scale corresponded to higher risk. The z scores were calculated for all measures using the mean and standard deviation of the healthy controls.

To identify distinct risk profiles among the patients, we performed a cluster analysis on the 11 measures identified in the Characterization section, and also included the HDRS.

Table 1. Demographic and Clinical Characteristics by Clusters[a]

Characteristic	Healthy Control[b] (n = 57)	Cluster 1 (n₁ = 13)	Cluster 2 (n₂ = 71)	Cluster 3 (n₃ = 30)	Cluster 4 (n₄ = 49)	Cluster 5 (n₅ = 26)	F or χ²	P[c]	Post hoc[d]
Age (years)	67.0 (6.8)	69.2 (11.4)	66.9 (7.2)	72.2 (8.3)	62.9 (5.9)	66.1 (7.6)	7.5	**.0**	3–2,4,5 2–4
Male	49%	39%	55%	53%	45%	54%	2.1	.7	
White	88%	92%	90%	87%	88%	65%		.1	
Education (years)	15.2 (2.8)	12.0 (3.1)	15.3 (2.9)	12.9 (2.8)	14.0 (2.2)	13.0 (2.3)	8.1	**.0**	2–1,3,5
SES per capita[e]	29.6 (15.4)	21.3 (19.9)	25.7 (21.5)	15.2 (17.6)	16.3 (12.8)	22.8 (20.5)	12.2	**.0**	2–3,4
Hamilton Depression Rating Scale (without suicide item)[f]	2.4 (1.9)	24.1 (6.2)	16.3 (3.9)	18.5 (5.9)	21.4 (3.9)	17.9 (5.0)	13.8	**.0**	1–2,3,5 2–4 3–5
IQ	108.6 (12.2)	95.2 (12.5)	110.0 (14.8)	97.4 (18.9)	105 (14.1)	97.5 (18.2)	6.1	**.0**	2–1,3,5
Age at onset of first depressive episode	N/A N/A	55.6 (20.5)	50.5 (19.9)	47.4 (22.4)	37.7 (19.1)	39.5 (22.0)	4.3	**.0**	4–1,2
Physical illness burden[f]	6.6 (3.9)	9.5 (3.5)	8.7 (4.4)	10.7 (3.6)	8.2 (3.6)	8.1 (3.1)	2.4	.1	
Ideation									
Current[f]	0.2 (0.1)	20.2 (6.3)	9.4 (11.4)	17.5 (10.5)	15.6 (10.9)	11.7 (9.9)	5.6	**.0**	2–1,3,4
Lifetime[f]	0.2 (0.1)	21.9 (7.2)	11.9 (12.0)	21.1 (10.3)	22.5 (9.0)	17.1 (12.3)	8.8	**.0**	2–1,3,4
Anxiety disorder									
Current	0%	62%	44%	13%	55%	39%		**.0**	3–1,2,4
Lifetime	0%	69%	47%	23%	55%	42%		**.0**	1–3,4
Substance abuse									
Current	0%	23%	6%	13%	14%	19%		.1	
Lifetime	0%	39%	31%	40%	37%	46%		.7	
History of attempt at baseline	N/A	76%	32%	60%	51%	50%	13.2	**.0**	1–2

[a]All values are mean (SD) unless otherwise noted. For rows in which Fisher exact test was used, no statistic is provided.
[b]Please note that analysis of variance was performed only in the depressed participants; healthy control group is included only as a benchmark.
[c]Boldface type indicates statistical significance.
[d]Post hoc comparisons were done to communicate significant between-cluster differences.
[e]SES data are reported in thousands.
[f]Higher scores indicate more pathology.
Abbreviations: N/A = not applicable, SES = socioeconomic status.

Healthy controls were excluded to avoid assumptions about the homology of subgroups among psychiatrically healthy versus depressed individuals, as were 5 subjects with missing MCQ scores. Using the remaining 189 subjects, we performed k-means cluster analysis (using the "kmeans" function in R[45]), with default parameter choices and numerical method,[46] with k = 2 to 7 clusters. We selected k = 5 because it was the smallest number of clusters for which the between-cluster variability, expressed as a proportion of the total variability, exceeded our preset criterion of 30%. We omitted attempter status, suicidal ideation, and lethality in the derivation of the clusters to avoid circularity in the identification of clusters.

We provided qualitative and quantitative summaries of each cluster based on the cluster means for each measure used to derive them. Association between suicide attempt history and cluster membership was tested using Fisher exact test, and post hoc comparisons compared cluster membership of each suicidal group to that of the depressed control group using the Holm method of adjustment for multiple comparisons. We compared mean scores of past suicide attempt lethality, baseline suicidal ideation, and the planning subscale of the suicide intent scale. We prospectively assessed suicide attempts or emergency psychiatric hospitalizations during the follow-up period and used these data to test the predictive validity of our clusters by comparing the probability of suicide attempt between clusters using survival analysis, specifically the log rank test, and post hoc cluster comparisons, adjusted using the Bonferroni method. The (possibly censored)

number of emergency psychiatric hospitalizations between clusters during the follow-up period was compared using the Kruskal-Wallis test, followed by pairwise comparisons using Wilcoxon tests, adjusted using the Bonferroni method for multiple comparisons.

RESULTS

Demographic, clinical, cognitive and personality measures across groups and mean differences therein are reported in Supplementary eTables 1 and 2.

Cluster Analysis

Tables 1 and 2 report demographic, clinical, cognitive, and personality measures by clusters. In the selected cluster model (k = 5), the smallest cluster size was n₁ = 13 and the largest n₂ = 71. There were significant differences across the clusters on every measure (all P values < 0.001, after adjustment for multiple testing).

Inspection of the profile plot (see Figure 1) and univariate comparisons (Tables 1 and 2) revealed unique profiles for each of the 5 clusters that also corresponded to clinical presentations (see supplementary material for case examples).

Cluster 1 (C-1). *Marked cognitive deficits with serious psychopathology* (n₁ = 13, 7% of the depressed sample [n = 189]), is characterized by severe cognitive deficits as indicated by poorer cognitive control (EXIT) than all the other

Table 2. Cognitive, Decision-Making, and Personality Characteristics and Social Support by Clusters[a]

Characteristic	Healthy Control[b] (n = 57)	Cluster 1 (n_1 = 13)	Cluster 2 (n_2 = 71)	Cluster 3 (n_3 = 30)	Cluster 4 (n_4 = 49)	Cluster 5 (n_5 = 26)	F	P[c]	Post hoc[d]
Global cognition	138.3 (2.8)	124.7 (8.1)	136.0 (3.9)	126.6 (6.6)	136.1 (3.9)	133.2 (4.5)	34.3	**.0**	1–2,4,5 3–2,4,5
Cognitive control[e]	5.7 (3.1)	14.7 (5.3)	5.7 (3.1)	11.5 (3.1)	6.6 (2.7)	8.5 (3.5)	33.6	**.0**	1–2,3,4,5 3–2 5–2,3
Resistance to framing	4.3 (0.5)	3.5 (0.7)	4.4 (0.4)	4.1 (0.6)	4.1 (0.6)	2.9 (0.8)	37.4	**.0**	1–2,3,4,5 2–4 5–2,3,4
Resistance to sunk cost	4.8 (0.6)	4.5 (0.6)	4.8 (0.6)	4.0 (0.9)	4.3 (0.7)	4.5 (0.7)	8.8	**.0**	2–3,4
UPPS negative urgency[e]	18.9 (4.3)	38.4 (7.5)	23.5 (6.0)	26.3 (8.2)	31.7 (6.5)	28.2 (6.4)	20.1	**.0**	1–2,3,4,5 2–4,5 3–4
Delay discounting[f]	−5.4 (1.2)	−6.0 (1.8)	−5.0 (1.4)	−3.6 (1.1)	−4.3 (1.1)	−4.8 (1.2)	10.2	**.0**	3–1,2,5 4–1
Impulsive carelessness[e]	86.0 (9.3)	123.2 (13.0)	92.7 (12.6)	86.9 (7.0)	107.4 (16.7)	108.8 (15.2)	28.1	**.0**	1–2,3,4,5 2–4,5 5–3,4
Perceived burdensomeness[e]	0.2 (0.5)	5.2 (3.4)	1.1 (1.6)	3.1 (3.4)	4.7 (3.3)	1.1 (1.3)	20.0	**.0**	2–1,3,4 5–1,3,4
Self-esteem	9.4 (1.4)	2.4 (1.9)	6.6 (2.5)	6.3 (2.4)	3.1 (2.0)	6.4 (2.3)	25.4	**.0**	1–2,3,5 4–2,3,5
Belonging	10.5 (1.5)	6.8 (2.2)	8.3 (2.5)	7.5 (3.1)	4.8 (2.8)	8.6 (2.5)	14.9	**.0**	4–2,3,5
Practical support	11.0 (1.5)	5.6 (3.5)	9.9 (1.9)	7.4 (2.6)	5.4 (3.0)	8.7 (2.4)	27.0	**.0**	2–1,3,4 4–3,5 5–1

[a]All values are mean (SD) unless otherwise noted.
[b]Please note that analysis of variance was performed only in the depressed participants; healthy control group is included only as a benchmark.
[c]Boldface type indicates statistical significance.
[d]Post hoc comparisons were done to communicate significant between-cluster differences.
[e]Higher scores indicate more pathology.
[f]For this assessment, both extremely high and extremely low scores are indicative of maladaptive decision making.
Abbreviation: UPPS = UPPS (Urgency, Premeditation, Perseverance, Sensation Seeking) Impulsive Behavior Scale, Negative Urgency subscale.

clusters and poorer global cognition (DRS) than clusters 2, 4 and 5, combined with severe depression and higher levels of dispositional risk factors. These individuals displayed certain facets of impulsivity, as indicated by very high scores on the SPSI Impulsivity/Carelessness subscale and the UPPS (Urgency, Premeditation, Perseverance, Sensation Seeking) Impulsive Behavior Scale, Negative Urgency subscale. However, they were willing to wait for delayed rewards, displaying extremely low levels of discounting compared with the healthy control group (n = 57). They reported low self-esteem, perceived themselves as a burden, and reported limited tangible social support.

Cluster 2 (C-2). *Intact* (n_2 = 71, 38% of the depressed sample) is characterized by the lowest depression scores and almost uniformly low risk scores on both cognitive and dispositional risk factors.

Cluster 3 (C-3). *Poor decision-making and moderate cognitive deficits* (n_3 = 30, 16% of the depressed sample) is characterized by pronounced deficits in global cognition (less severe than C-1, but worse than all the other clusters) and cognitive control. They also demonstrated the highest levels of delay discounting and susceptibility to sunk cost bias.

Cluster 4 (C-4). *Dysfunctional personality* (n_4 = 49, 26% of the depressed sample), unlike C-1, displays no cognitive deficits, but is characterized by the lowest levels of belonging and tangible social support and high levels of perceived burdensomeness and impulsivity.

Cluster 5 (C-5). *Framing deficits* (n_5 = 26, 14% of the depressed sample) is characterized by susceptibility to framing effects and impulsive/careless social problem-solving style. These individuals were otherwise intact as indicated by relatively high self-esteem, lack of perceived burdensomeness, low depression scores, and good social support.

To test whether age or education differences among clusters explained cluster differences in global cognition (DRS scores), we fit 2 analysis of covariance models adjusted by age and education, respectively. Cluster differences remained significant after adjustment ($P < .0001$), while age also had a significant adjusted effect ($F_{1, 183} = 17.18$, $P < .0001$), but education did not ($F_{1, 183} = 0.07$, $P = .7989$). We conclude that cluster differences in cognition are not all due to age or education differences.

The identified clusters reflect the suicide risk profiles, including both the states and the traits, of the subjects at baseline. To avoid assuming every cluster ages the same way, we did not adjust for age before creating clusters. Our data indicate the possibility that accelerated or pathological aging that affects cognition and decision-making is part of the suicidal diathesis in old age.

Retrospective Validation: A Breakdown by Cluster of History of Suicide Attempts and Suicidal Ideation

Although variables capturing suicidal behavior and ideation were omitted when deriving the clusters, cluster

Figure 1. Cognitive and Personality Characteristics and Social Support by Cluster[a]
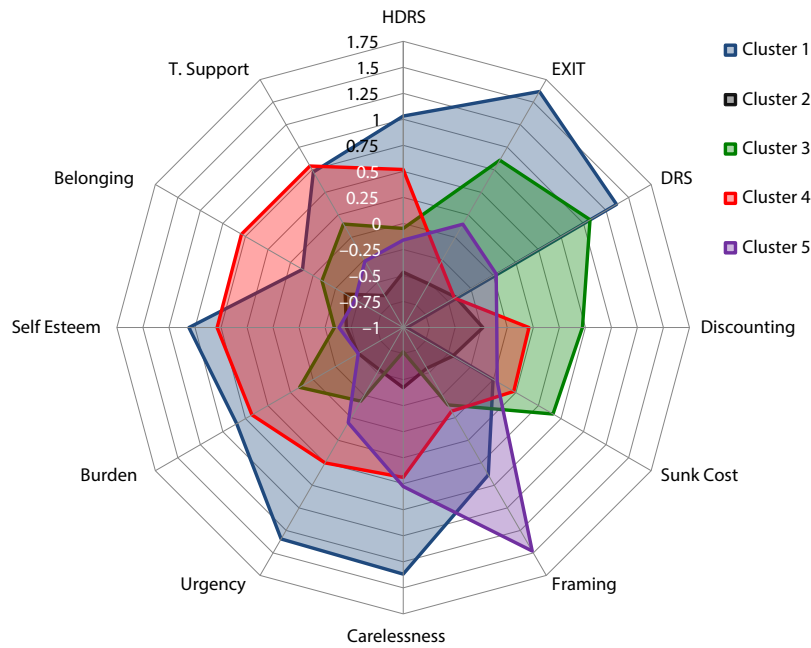
[a]Please note that all the scales were aligned in the risk direction, so that higher values on a scale were associated with higher risk of psychopathology, eg, high levels of depression, cognitive deficits, low tangible social support.

Abbreviations: Burden = Interpersonal Needs Questionnaire, Perceived Burdensomeness subscale; Carelessness = Social Problem Solving Inventory, Impulsivity/Carelessness Style subscale; DRS = Mattis Dementia Rating Scale; Discounting = Monetary Choice Questionnaire; EXIT = Executive Interview; Framing = Adult Decision Competence Scale, Resistance to Framing subscale; HDRS = Hamilton Depression Rating Scale; Sunk Cost = Adult Decision Competence Scale, Resistance to Sunk Cost subscale; Self-Esteem = Interpersonal Support Evaluation List, Self-Esteem subscale; Belonging = Interpersonal Support Evaluation List, Belongingness subscale; T. Support = Interpersonal Support Evaluation List, Lack of Tangible Social Support subscale; Urgency = UPPS (Urgency, Premeditation, Perseverance, Sensation Seeking) Impulsive Behavior Scale, Negative Urgency subscale.

composition nonetheless differed based on study group (Fisher exact test $P < .001$). When the combined attempter group was contrasted with non-attempters (Fisher exact test $P < .001$), post hoc pairwise comparisons showed that differences were limited to clusters 1–2 and clusters 2–3. Distributions of high-lethality and low-lethality attempters also differed across groups ($P = .021$ and $P < .001$, respectively.)

C-1 did not contain any depressed controls. High-lethality attempters compared to depressed controls were only overrepresented in C-1 compared with the composition of C-2 (C-2 vs C-1: odds ratio (OR) = 0, 95% CI, 0.00–0.38, adjusted $P = .003$). The proportion of low-lethality attempters, when compared to depressed controls, was higher in C-3 and C-4, but not in C-1 (C-3 vs C-2: OR = 11.40, 95% CI, 2.46–65.75, adjusted $P = .002$; C-4 vs C-2: OR = 19.13, 95% CI, 4.99–89.89, adjusted $P < .001$; C-2 vs C-1 OR = 0.00, 95% CI, 0.00–0.40, adjusted $P = .007$). In C-4, compared to C-3, ideators were overrepresented compared to depressed controls (OR = 797, 95% CI, 2.27–33.33, adjusted $P = .002$). Results were similar when continuous lethality scores were compared between clusters. For a depiction of the retrospective validation, see Supplementary eFigure 1, where it shows significant between-cluster differences ($F_{4,89} = 4.53$, $P = .002$) in lethality of past suicide attempts.

Clusters differed in the number of past suicide attempts (Kruskal-Wallis test $\chi^2_4 = 25.9$, $P < .001$): C-2 contained the lowest proportion of subjects with multiple past attempts. Severity of ideation differed between clusters ($F_{4, 184} = 8.76$, $P < .001$), such that C-2 ideation scores were significantly lower than those of C-1, C-3, and C-4.

Predictive Validation: A Breakdown by Cluster of Suicide Attempt and Emergency Hospitalizations to Prevent Suicide

We recorded a total of 30 suicide attempts (2 fatal) in 22 participants during the follow-up period (mean duration of follow-up 30 ± 18 months). Two participants had 2 attempts and 3 had 3 attempts. The majority of these incident attempts were made by participants with a prior history of suicide attempt. There were 4 participants classified as ideators at baseline who made an attempt during the follow-up period (ie, had their "first ever" suicide attempt). There were significant between-cluster differences in the incidence of suicide attempts during the follow-up period using the log rank test ($P = .010$), with post hoc pairwise differences showing fewer follow-up attempters in C-2 (3%) than in C-1 (31%, adjusted $P = .002$), C-3 (20%, adjusted $P = .012$), and C-4 (14%, adjusted $P = .044$); in C-1 and C-3, 1 fatal

suicide occurred in each cluster. The number of emergency psychiatric admissions during follow-up also differed by cluster ($P = .005$), with significantly fewer readmissions in C-2 than in C-1 (post hoc Wilcoxon test adjusted $P = .029$) or C-3 (adjusted $P = .013$). We also assessed the presence and severity of suicidal ideation during the follow-up with in-person or phone assessments for up to 4 years. Worst ideation scores at any time during the follow-up differed significantly ($P < .001$) between clusters, with C-2 having lower scores than C-4 (post hoc adjusted $P < .001$) and C-5 (adjusted $P = .024$), but not C-1 and C-3, showing a different pattern than for suicide attempts and hospitalizations.

DISCUSSION

To identify distinct pathways toward suicidal behavior, we used a data-driven approach that relied on self-report, clinician-administered diagnostic assessments, cognitive performance tests, and complex decision competence tasks to classify a large sample of depressed individuals into homogeneous clusters.

Our findings are consistent with the hypothesis that distinct pathways toward suicidal behavior (clusters C-1, C-3, and C-4) exist in the second half of life. Providing external validation, our analyses showed there were between-cluster differences in the number and lethality of suicide attempts prior to baseline and during the average 30-month follow-up period. Outcome prediction is the best test of classifications in psychiatry.[47] Clusters C-1 and C-3 had the highest proportions of subjects with 1 incident suicide attempt or more (31% and 20%, respectively, with 1 fatal attempt in each) contrasted with only 3% of participants in C-2.

Perhaps of greatest clinical interest is cluster C-1, which contained the highest proportion of high-lethality attempters and strongly predicted reattempt. Its members displayed severe cognitive deficits, even though the study excluded participants diagnosed with dementia. What underlying factors may account for this putative pathway? We speculate that the cognitive profile of C-1 participants corresponds most closely to early dementia. Behavioral prodromes characterized by mood, personality change, and poor decision-making are common in frontotemporal dementia and the frontal variant of Alzheimer's disease. Consistent with this notion, individuals in C-1 had a later age of depression onset approximately 18 years later than C-4). Supporting this theory of prodrome, a nationwide Taiwanese study[10] reported that attempted suicide in late-life predicted subsequent dementia. Given that our analysis is based on a single cognitive assessment, we cannot rule out the possibility that these cognitive deficits are lifelong[48]; however, many C-1 members performed in the early dementia range.

Less clear is the status of individuals in C-3, who were equally likely to have a history of low- and high-lethality suicide attempts and a high reattempt rate. Some of the C-3 patients may also fall into the prodromal dementia category, as their global cognitive performance was not much better than that of C-1 patients, but the mean age at depression onset was earlier in C-3 than in C-1. They were most susceptible to sunk cost bias, which has been linked to facets of emotional dyscontrol such as anger, rumination, and impulsivity.[49] They also displayed an exaggerated preference for immediate versus delayed rewards. This combination of short-sightedness, lack of perspective, and limited cognitive resources would be consistent with a failure to anticipate that suffering during a suicidal crisis is likely to be time-limited and that consequences of a completed suicide are final.

Individuals in C-4 had the earliest age at onset of depression and high levels of dispositional risk factors (especially poor interpersonal functioning) in the setting of intact cognition. This constellation of chronic interpersonal dysfunction, perceived abandonment, and suicidal behavior suggests borderline personality traits. This conclusion is supported by the overrepresentation of low-lethality suicide attempters in C-4.

In accordance with our previous findings in a smaller sample,[27] individuals in C-3 and C-4 display an exaggerated preference for immediate rewards, whereas those in C-1 are unusually willing to wait for larger rewards. High delay discounting is broadly associated with impulsivity and seen in disorders characterized by poor impulse control and short-sighted choices (addiction, gambling, bulimia, and borderline and antisocial personality).[50] In contrast, an extreme ability to delay gratification was observed in obsessive-compulsive personality disorders (OCPD) and aneroxia nervosa.[50] We speculate that what may be in common between OCPD, anorexia, and serious suicidal behavior is the neglect of the opportunity cost,[51,52] or the rewards that could be obtained with an alternative course of action. This neglect could manifest in a single-minded dedication to the pathological behavior at the expense of better alternatives.

We are cautious in interpreting C-5. Susceptibility to framing (responding to superficial features of how a problem is presented) was its defining characteristic, perhaps highlighting a distinct contribution of this factor.[14]

Most of the research to date has focused on identification of risk factors for suicide contemplation.[53,54] A number of recent reviews[55,56] concluded that risk factors for contemplation of suicide differ from risk factors for the transition from ideation to attempt. Thus, it is not unanticipated that C-4 participants who had the highest level of personality-based risk factors, such as low self-esteem, subjective lack of belonging, and feeling like a burden, but who had no cognitive deficits, showed high levels of ideation during the follow-up while their reattempt rate was relatively low. These participants seem to fit the profile of borderline personality disorder, and many of them had a chronic, high level of suicidal ideation.

Research that has investigated risk factors for suicide attempt has mainly based the classification of attempters on attempt characteristics.[57–60] For example, Lopez-Castroman and colleagues[58] classified suicide attempters into 3 groups ("impulsive-ambivalent," "well-planned," and "frequent"). However, as one-third to one-half of older adults who die by suicide do not have a previous attempt, prediction based on

features other than attempt characteristics has high clinical value.[2] Strengths of this current study include sampling across the spectrum of suicide risk (from depressed patients with no lifetime history of suicidal ideation to high-lethality attempters), prospective ascertainment of suicidal behavior, and a detailed characterization of risk factors and suicidal behavior itself.

Limitations

Subgroups identified here require out-of-sample validation. Our findings may not be generalizable to other age groups. In addition, as dementia is more prevalent with increasing age, there were fewer older participants who were potentially eligible for participation given that clinical dementia precluded participation.

In summary, we have found that 3 putative subgroups of depression patients are at the highest risk for subsequent suicidal behavior: one characterized by concurrent high levels of cognitive impairment and personality pathology, one defined by short-sighted decision-making and moderate cognitive deficits, and a third characterized by interpersonal dysfunction.

REFERENCES

1. Conwell Y, Brent D. Suicide and aging, I: patterns of psychiatric diagnosis. *Int Psychogeriatr*. 1995;7(2):149–164.
2. Waern M, Runeson BS, Allebeck P, et al. Mental disorder in elderly suicides: a case-control study. *Am J Psychiatry*. 2002;159(3):450–455.
3. Engström G, Alsén M, Gustavsson P, et al. Classification of suicide attempters by cluster analysis: a study of the temperamental heterogeneity in suicidal patients. *Pers Individ Dif*. 1996;21(5):687–695.
4. Mann JJ, Waternaux C, Haas GL, et al. Toward a clinical model of suicidal behavior in psychiatric patients. *Am J Psychiatry*. 1999;156(2):181–189.
5. Keilp JG, Gorlyn M, Oquendo MA, et al. Aggressiveness, not impulsiveness or hostility, distinguishes suicide attempters with major depression. *Psychol Med*. 2006;36(12):1779–1788.
6. Keilp JG, Beers SR, Burke AK, et al. Neuropsychological deficits in past suicide attempters with varying levels of depression severity. *Psychol Med*. 2014;44(14):2965–2974.
7. McGirr A, Renaud J, Bureau A, et al. Impulsive-aggressive behaviours and completed suicide across the life cycle: a predisposition for younger age of suicide. *Psychol Med*. 2008;38(3):407–417.
8. Keilp JG, Gorlyn M, Russell M, et al. Neuropsychological function and suicidal behavior: attention control, memory and executive dysfunction in suicide attempt. *Psychol Med*. 2013;43(3):539–551.
9. Lara E, Olaya B, Garin N, et al. Is cognitive impairment associated with suicidality? a population-based study. *Eur Neuropsychopharmacol*. 2015;25(2):203–213.
10. Tu Y-A, Chen M-H, Tsai C-F, et al. Geriatric suicide attempt and risk of subsequent dementia: a nationwide longitudinal follow-up study in Taiwan. *Am J Geriatr Psychiatry*. 2016;24(12):1211–1218.
11. Haw C, Harwood D, Hawton K. Dementia and suicidal behavior: a review of the literature. *Int Psychogeriatr*. 2009;21(3):440–453.
12. Gujral S, Ogbagaber S, Dombrovski AY, et al. Course of cognitive impairment following attempted suicide in older adults. *Int J Geriatr Psychiatry*. 2016;31(6):592–600.
13. Erlangsen A, Zarit SH, Conwell Y. Hospital-diagnosed dementia and suicide: a longitudinal study using prospective, nationwide register data. *Am J Geriatr Psychiatry*. 2008;16(3):220–228.
14. Szanto K, Bruine de Bruin W, Parker AM, et al. Decision-making competence and attempted suicide. *J Clin Psychiatry*. 2015;76(12):e1590–e1597.
15. Jollant F, Bellivier F, Leboyer M, et al. Impaired decision making in suicide attempters. *Am J Psychiatry*. 2005;162(2):304–310.
16. Clark L, Dombrovski AY, Siegle GJ, et al. Impairment in risk-sensitive decision-making in older suicide attempters with depression. *Psychol Aging*. 2011;26(2):321–330.
17. Keilp JG, Sackeim HA, Brodsky BS, et al. Neuropsychological dysfunction in depressed suicide attempters. *Am J Psychiatry*. 2001;158(5):735–741.
18. Richard-Devantoy S, Jollant F, Kefi Z, et al. Deficit of cognitive inhibition in depressed elderly: a neurocognitive marker of suicidal risk. *J Affect Disord*. 2012;140(2):193–199.
19. Richard-Devantoy S, Berlim MT, Jollant F. A meta-analysis of neuropsychological markers of vulnerability to suicidal behavior in mood disorders. *Psychol Med*. 2014;44(8):1663–1673.
20. Dombrovski AY, Butters MA, Reynolds CF 3rd, et al. Cognitive performance in suicidal depressed elderly: preliminary report. *Am J Geriatr Psychiatry*. 2008;16(2):109–115.
21. Richard-Devantoy S, Szanto K, Butters MA, et al. Cognitive inhibition in older high-lethality suicide attempters. *Int J Geriatr Psychiatry*. 2015;30(3):274–283.
22. McGirr A, Dombrovski AY, Butters MA, et al. Deterministic learning and attempted suicide among older depressed individuals: cognitive assessment using the Wisconsin Card Sorting Task. *J Psychiatr Res*. 2012;46(2):226–232.
23. De Leo D, Padoani W, Scocco P, et al. Attempted and completed suicide in older subjects: results from the WHO/EURO Multicentre Study of Suicidal Behaviour. *Int J Geriatr Psychiatry*. 2001;16(3):300–310.
24. Szanto K, Dombrovski AY, Sahakian BJ, et al. Social emotion recognition, social functioning, and attempted suicide in late-life depression. *Am J Geriatr Psychiatry*. 2012;20(3):257–265.
25. Joiner TE Jr, Van Orden KA, Witte TK, et al. *The Interpersonal Theory of Suicide: Guidance for Working with Suicidal Clients*. Washington, DC: American Psychological Association; 2009.
26. Gujral S, Dombrovski AY, Butters M, et al. Impaired executive function in contemplated and attempted suicide in late life. *Am J Geriatr Psychiatry*. 2013;S1064-7481(13)00030-4.
27. Dombrovski AY, Szanto K, Siegle GJ, et al. Lethal forethought: delayed reward discounting differentiates high- and low-lethality suicide attempts in old age. *Biol Psychiatry*. 2011;70(2):138–144.
28. Klonsky ED, May A. Rethinking impulsivity in suicide. *Suicide Life Threat Behav*. 2010;40(6):612–619.
29. Gibbs LM, Dombrovski AY, Morse J, et al. When the solution is part of the problem: problem solving in elderly suicide attempters. *Int J Geriatr Psychiatry*. 2009;24(12):1396–1404.
30. Duberstein PR, Conwell Y, Conner KR, et al. Poor social integration and suicide: fact or artifact? a case-control study. *Psychol Med*. 2004;34(7):1331–1337.
31. Beck AT, Beck R, Kovacs M. Classification of suicidal behaviors, I: quantifying intent and medical lethality. *Am J Psychiatry*. 1975;132(3):285–287.
32. Beck AT, Kovacs M, Weissman A. Assessment of suicidal intention: the Scale for Suicide Ideation. *J Consult Clin Psychol*. 1979;47(2):343–352.
33. First MB, Spitzer RL, Gibbon M, et al. *Structured Clinical Interview for DSM-IV Axis I Disorders, Patient Edition (SCID-I/P). 2nd edition*. New York, NY: New York State Psychiatric Institute; 1995.
34. Hamilton M. A rating scale for depression. *J Neurol Neurosurg Psychiatry*. 1960;23:56–62.
35. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". a practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res*. 1975;12(3):189–198.
36. Mattis S. *Dementia Rating Scale Professional Manual*. Odessa, FL: Psychological Assessment Resources; 1988.
37. Royall DR, Mahurin RK, Gray KF. Bedside assessment of executive cognitive impairment: the executive interview. *J Am Geriatr Soc*. 1992;40(12):1221–1226.
38. Wechsler D. *Wechsler Test of Adult Reading*. San

Antonio, TX: The Psychological Corporation; 2001.

39. Bruine de Bruin W, Parker AM, Fischhoff B. Individual differences in adult decision-making competence. *J Pers Soc Psychol*. 2007;92(5):938–956.

40. Kirby KN, Petry NM, Bickel WK. Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls. *J Exp Psychol Gen*. 1999;128(1):78–87.

41. Whiteside S, Lynam D. The Five Factor Model and impulsivity: using a structural model of personality to understand impulsivity. *Pers Individ Dif*. 2001;30(4):669–689.

42. D'Zurilla TJ, Nezu AM. Development and preliminary evaluation of the Social Problem-Solving Inventory. *Psychol Assess*. 1990;2(2):156–163.

43. Van Orden KA, Witte TK, Gordon KH, et al. Suicidal desire and the capability for suicide: tests of the interpersonal-psychological theory of suicidal behavior among adults. *J Consult Clin Psychol*. 2008;76(1):72–83.

44. Brookings JB, Bolton B. Confirmatory factor analysis of the Interpersonal Support Evaluation List. *Am J Community Psychol*. 1988;16(1):137–147.

45. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing; 2012.

46. Hartigan JA, Wong MA. Algorithm AS 136: A k-means clustering algorithm. *J R Stat Soc Ser C Appl Stat*. 1979;28(1):100–108.

47. Marquand AF, Wolfers T, Mennes M, et al. Beyond lumping and splitting: a review of computational approaches for stratifying psychiatric disorders. *Biol Psychiatry Cogn Neurosci Neuroimaging*. 2016;1(5):433–447.

48. Andersson L, Allebeck P, Gustafsson JE, et al. Association of IQ scores and school achievement with suicide in a 40-year follow-up of a Swedish cohort. *Acta Psychiatr Scand*. 2008;118(2):99–105.

49. Coleman MD. Sunk cost, emotion, and commitment to education. *Curr Psychol*. 2010;29(4):346–356.

50. Bickel WK, Jarmolowicz DP, Mueller ET, et al. Excessive discounting of delayed reinforcers as a trans-disease process contributing to addiction and other disease-related vulnerabilities: emerging evidence. *Pharmacol Ther*. 2012;134(3):287–297.

51. Niv Y, Daw ND, Joel D, et al. Tonic dopamine: opportunity costs and the control of response vigor. *Psychopharmacology (Berl)*. 2007;191(3):507–520.

52. Green Dl. Pain-cost and opportunity-cost. *Q J Econ*. 1894;8(2):218–229.

53. May AM, Klonsky ED. What distinguishes suicide attempters from suicide ideators? a meta-analysis of potential factors. *Clin Psychol Sci Pract*. 2016;23(1):5–20.

54. Nock MK, Hwang I, Sampson NA, et al. Mental disorders, comorbidity and suicidal behavior: results from the National Comorbidity Survey Replication. *Mol Psychiatry*. 2010;15(8):868–876.

55. Franklin JC, Ribeiro JD, Fox KR, et al. Risk factors for suicidal thoughts and behaviors: a meta-analysis of 50 years of research. *Psychol Bull*. 2017;143(2):187–232.

56. Klonsky ED, Qiu T, Saffer BY. Recent advances in differentiating suicide attempters from suicide ideators. *Curr Opin Psychiatry*. 2017;30(1):15–20.

57. Arensman E, Kerkhof JF. Classification of attempted suicide: a review of empirical studies, 1963–1993. *Suicide Life Threat Behav*. 1996;26(1):46–67.

58. Lopez-Castroman J, Nogue E, Guillaume S, et al. Clustering suicide attempters: impulsive-ambivalent, well-planned, or frequent. *J Clin Psychiatry*. 2016;77(6):e711–e718.

59. Rapeli CB, Botega NJ. Clinical profiles of serious suicide attempters consecutively admitted to a university-based hospital: a cluster analysis study. *Rev Bras Psiquiatr*. 2005;27(4):285–289.

60. Paykel ES, Rassaby E. Classification of suicide attempters by cluster analysis. *Br J Psychiatry*. 1978;133(1):45–52.

Supplementary material follows this article.

Supplementary Material

Article Title: Pathways to Late-Life Suicidal Behavior: Cluster Analysis and Predictive Validation of Suicidal Behavior in a Sample of Older Adults With Major Depression

Author(s): Katalin Szanto, MD; Hanga Galfalvy, PhD; Polina M. Vanyukov, PhD; John G. Keilp, PhD; and Alexandre Y. Dombrovski, MD

DOI Number: https://doi.org/10.4088/JCP.17m11611

List of Supplementary Material for the article

Disclaimer

This Supplementary Material has been provided by the author(s) as an enhancement to the published article. It has been approved by peer review; however, it has undergone neither editing nor formatting by in-house editorial staff. The material is presented in the manner supplied by the author.

SUPPLEMENTAL MATERIAL

Case examples:

<u>Cluster 1: Cognitive deficits with psychopathology</u>

Participant is a 72-year old white male, never married, who shot himself in the chest with a 16-gauge shotgun in a forest, where he was found accidently by a policeman. He dropped out of school after 8th grade and worked blue collar jobs, eventually obtaining work in a steel mill. He reported being a loner all of his life, a description confirmed by his nephew, who noted that he was "socially backward" and avoided social interactions with people unless he knew them well. He was uncomfortable in new surroundings, lived by routines, and did not cope well when they were disturbed. He reported being comfortable with this life until the onset of his current (first) depressive episode at age 72. At this time he felt sad and useless, he was concerned about his health and burdening others, ruminated about actions from 30 years prior, had trouble thinking and concentrating, and had intermittent thoughts of taking his own life. He had severe deficits in cognitive control (EXIT: 19) and some deficits in other cognitive domains (total cognition DRS: 129). He responded well to antidepressant and at his one year follow-up he was living in a personal care home. He said "he gets angry with himself when he thinks of the suicide attempt last year", but states "I tried to tell people how bad the pain was getting."

<u>Cluster 2: Intact</u>

Participant is a 73-year old retired, married, male living with his wife with no history of suicide attempt or ideation. He went into the service after high school and upon returning home began working for a vending machine company, married and had three children. Though he retired from a stable career, had a good relationship with his wife, and successful children and grandchildren, patient reported feeling down, having little interest or pleasure, trouble sleeping, psychomotor retardation, loss of energy, and feeling like he has let his family down. He stated

that he just has absolutely no interest in doing anything as he ages, and started to see that as a problem. "I just feel like maybe there is something else, it seems like a waste to not have a purpose." He was no longer engaged in activities he formerly enjoyed, such as hunting, fishing, gardening, checking out cars, and home remodeling.

<u>Cluster 3: Poor decision-making and moderate cognitive deficits</u>

Participant is an 82-year old widowed male with suicidal ideation following the loss of his "lady friend." He completed high school and joined the Navy upon graduation. When he returned home he got married and had four children. He worked as a school counselor for 30 years. Participant and his wife were married 55 years until her death in 2007, after which he entered into a relationship with another woman who died of leukemia. He notes these losses as the trigger for his depression, as he doesn't expect to find companionship again "at his age." Impulsively, patient "acquired" a book about poisons with a plan to end his life but he did not take steps to further this plan. At baseline he had moderately severe cognitive impairments (DRS= 127; EXIT=11). Two years after entering the study, patient failed his driving test three times and his license was revoked. He found this loss of independence extremely upsetting. He felt increasingly lonely, as his children had moved out of the area. He made a suicide attempt by overdose of Ambien and Vicodin, stating that he "just became very discouraged, hit a low point in [his] life" and that his "world was collapsing around him." He described the attempt as impulsive, which he immediately regretted and reached out for help.

<u> Cluster 4: Dysfunctional personality</u>

Participant is a 72-year old widowed female who lives alone. She attempted suicide via overdose on 7-15 Ambien pills. She concedes that she knew lethality would be unlikely, but recalls "just wanting to escape…to end it all," and longing to join her late husband in heaven. She endured physical abuse at the hands of her alcoholic father from a young age and

was physically and sexually abused by an older brother. Her mother was depressed and attempted suicide at least twice. Patient reported losing her identity after she retired 6 years ago, and seems to struggle now with finding "where she fits." Long-term patterns of conflict with her family and financial difficulties were her primary stressors. Her son-in-law recently commented that "[patient] needs to let her daughters know what's going on [financially] so that they can decide what to do" with her, and her daughter cut up her credit card in front of her grandchildren, leaving her only an allowance. Patient felt hurt, humiliated, and betrayed by these events, and maintains that she refuses to burden her daughters by living with them as her mother did with her. When asked her reaction to the suicide attempt, she stated "There's a part of me that feels I'm lucky to be here and I should be thankful for what I have, but it's hard not to be paranoid and negative."

Cluster 5: Framing effects but good social support and self-esteem

Participant is a 72-year old married male who resides with his wife of 42 years. He completed high school and worked at US Steel as a shipper until his retirement. Since then he kept busy by volunteering at his church and spending time with his 3 children and 15 grandchildren. He runs a cancer support group and mentors young men with a group called MAD DADS. He had a period of alcohol abuse between ages 30 and 40, at which time he would miss work, get into drunken altercations, and received several DUI charges. His first depressive episode began at age 28 after the death of his father, and his current depressive episode began when he was diagnosed with prostate cancer. Although the cancer is now in remission, his worsening arthritis has led to multiple knee replacement surgeries and mobility limitations, which he cites as triggers of his depression. He denied suicidal ideation and had moderately severe depression (Hamilton score 16).

Measurements:

Global cognitive ability was assessed with the Mattis Dementia Rating Scale (DRS) total score, ranging from 0-144, with lower scores indicating more impairment. The DRS subscales assess Initiation/Perseveration, Attention, Construction, Conceptualization, and Memory. Cognitive control was assessed using the Executive Interview (EXIT; range 0-50 with higher scores indicating more impairment). The 25 items comprising this screening test are administered in rapid succession with minimal instructions to elicit automatic behaviors and disinhibition and also include modifications of well-known "frontal lobe" tests (number/letter sequencing, Stroop, fluency tests, go/no-go tests, and Luria's hand sequences).

Decision competence was assessed using two subscales of the Adult Decision Competence task: Resistance to Framing and Resistance to Sunk Cost (ADMC). These two constructs measure cognitive biases in decision-making. Framing effects occur when value assessments are affected by irrelevant variations in problem descriptions. Sunk cost is the inability to stop an action even after realizing its futility. Sunk cost occurs when one cannot ignore prior investments when making decisions. Optimally, past expenditures should be ignored so that decisions reflect only possible future outcomes. Resistance to framing is cognitively demanding, while susceptibility to sunk cost has been associated with impulsivity. Lower scores indicate suboptimal decision making. Delay discounting was assessed with the Monetary Choice Questionnaire (MCQ).

Dispositional factors: We measured negative urgency (UPPS Negative Urgency subscale, and impulsive/careless social problem solving style (Social Problem Solving Inventory Impulsive/Carelessness subscale. UPPS higher scores, and SPSI lower scores indicate more pathology. We assessed personality functions and different aspects of social support with the perceived burdensomeness scale (higher scores indicate feeling more of a burden), and the

Interpersonal Support Evaluation List (ISEL) Self-esteem subscale (lower scores less self-esteem) and Belongingness subscales.

Supplementary eTable 1. Clinical Characteristics by Suicide Group Status

	Healthy Control[c] (n=57)		All subjects (n=251)		Depressed Controls (n=50)		Ideators (n=46)		Low Lethality Attempters (n=49)		High Lethality Attempters (n=49)		F / Chi-Squared	P	Post-hoc
	Mean | SD(Percentage)														
Age	67.0	6.8	66.7	7.8	67.6	5.8	66.4	9.0	65.5	8.1	67.1	9.0	0.6	0.59	
Gender	28	49%	127	50.6%	25	50%	25	54%	23	47%	26	53%	0.6	0.89	
Caucasian	50	88%	216	86.1%	42	84%	39	85%	40	82%	45	92%	2.3	0.51	
Education (Years)	15.2	2.8	14.3	2.9	14.4	2.4	14.6	2.8	13.8	2.6	13.3	3.4	2.1	0.14	
SES per-capita	29,600	15,400	22,900	19,200	21,600	17,100	22,700	21,800	16,800	17,800	23,800	21,500	0.9	0.46	
Hamilton depression scale (without suicide item)[a]	2.4	1.9	15.0	8.3	16.9	3.4	19.5	5.0	19.6	6.0	19.2	5.6	3.0	**0.03**	D<I,LL
IQ	108.6	12.2	105	15.1	107.4	14.8	106.5	15.4	102.1	15.5	98.5	19.0	3.2	**0.03**	D>HL
Age of Onset of First Depressive Episode	N/A	N/A	45.7	20.9	50.5	18.4	46.4	22.1	39.5	19.3	46.7	22.3	2.3	0.08	
Physical Illness Burden[a]	6.6	3.9	8.3	4.0	10.2	3.4	7.6	4.0	9.2	3.6	8.2	4.4	4.5	**0.00**	D>I,HL
Ideation (Current)[a]	0.2	0.1	10.4	11.3	0.02	0.1	12.3	8.1	18.7	8.9	22.7	7.1	99.0	**0.00**	D<I,LL,HL I<LL, HL LL<HL
Ideation (Lifetime)[a]	0.2	0.1	13.6	12.6	0.7	1.7	18.4	7.2	25.3	6.1	26.2	4.6	245.5	**0.01**	D<I,LL,HL I<LL,HL
Anxiety Disorder (Current)	0%		34%		50%		48%		43%		35%		2.8	0.43	
Anxiety Disorder (Lifetime)	1.8%		37%		49%		51%		51%		39%		0.67	0.57	
Substance Abuse (Current)	0%		9.6%		0%		15%		18%		16%		9.7	**0.02**	D<I,LL,HL
Substance Abuse (Lifetime)	0%		27.9%		26%		37%		47%		35%		4.8	0.19	

[a]Higher scores indicative of more pathology

[c]Please note that ANOVA was only performed in the 4 depressed groups.

Supplementary eTable 2. Cognitive and Personality Characteristics and Social Support by Suicide Group Status

|	Healthy Control[c] (n=57)		All subjects (n=251)		Depressed Controls (n=50)		Ideators (n=46)		Low Lethality Attempters (n=49)		High Lethality Attempters (n=49)		F / Chi-Squared	P	Post-hoc
	Mean|SD(Percentage)														
Global Cognition	138.3	2.8	134.4	6.3	135.2	4.0	132.9	7.8	132.2	7.5	132.7	5.9	2.1	0.10	
Cognitive Control[a]	5.7	3.1	7.2	4.1	6.3	3.5	8.5	4.8	8.2	4.3	8.3	3.9	3.0	**0.03**	D<I
Resistance to Framing	4.3	0.5	4.1	0.7	4.2	0.7	4.0	0.7	4.0	0.8	3.8	0.8	2.7	**0.05**	D>LL
Resistance to Sunk Cost	4.8	0.6	4.7	0.7	4.6	0.6	4.7	0.6	4.1	0.8	4.7	0.8	6.7	**0.00**	D,I>LL LL<HL
UPPS Negative Urgency[a]	18.9	4.3	26.0	7.9	25.1	5.9	28.3	7.7	30.2	7.3	27.2	9.7	3.7	**0.01**	D<LL
Delay Discounting[b]	-5.4	1.2	-2.2	0.7	-4.7	1.2	-4.4	1.2	-4.3	1.4	-5.1	1.7	3.1	**0.03**	LL>HL
Impulsive Carelessness[a]	86.0	9.3	96.7	16.6	98.0	15.8	98.9	15.8	102.6	18.8	99.8	17.1	0.7	0.57	
Perceived Burden- someness[a]	0.2	0.5	2.2	2.8	0.6	0.8	3.5	3.3	4.1	3.3	2.4	2.8	16	**0.00**	D<I,LL,HL LL>HL
Self-Esteem	9.4	1.4	6.2	3.1	6.7	2.7	4.8	2.7	4.4	2.7	5.3	2.6	7.4	**0.00**	D>I,LL,HL
Belonging	10.5	1.5	7.9	3.1	8.2	2.5	6.6	3.6	5.9	2.3	7.8	3.2	6.5	**0.00**	D>I,LL LL<HL
Practical Support	11.0	1.5	8.6	3.2	9.2	2.2	7.5	3.6	6.9	3.1	7.8	3.2	5.2	**0.00**	D<I,LL

[a]Higher scores indicative of more pathology

[b]For this assessment, both extremely high and extremely low scores are indicative of maladaptive decision making

[c]Please note that ANOVA was only performed in the 4 depressed groups.

The 194 depressed patients were compared on demographic, clinical, cognitive and personality measures by suicide subgroups. High-lethality attempters had lower IQ than the other depressed groups. The three suicidal groups were more likely to have current substance use than non-suicidal depressed participants, but did not differ among themselves on this measure.

Although depression level was significantly different across groups, none of the pairwise comparisons passed the significance cutoff. Differences across groups on most cognitive and personality/social support measures were driven predominantly by the non-suicidal depressed group. Suicide attempters had higher ideation severity than the ideators. The low-lethality attempter group had more severe deficiencies on Resistance to Sunk Cost than all other groups, including ideators and high-lethality attempters. There were also significant differences between attempters: low-lethality attempters were worse in delaying future rewards, had higher perceived burdensomeness, and reported less belonging than high-lethality attempters.

Supplementary eFigure 1. Proportion of Low- and High- lethality Suicide Attempters, Ideators, and Depressed Controls in each Cluster
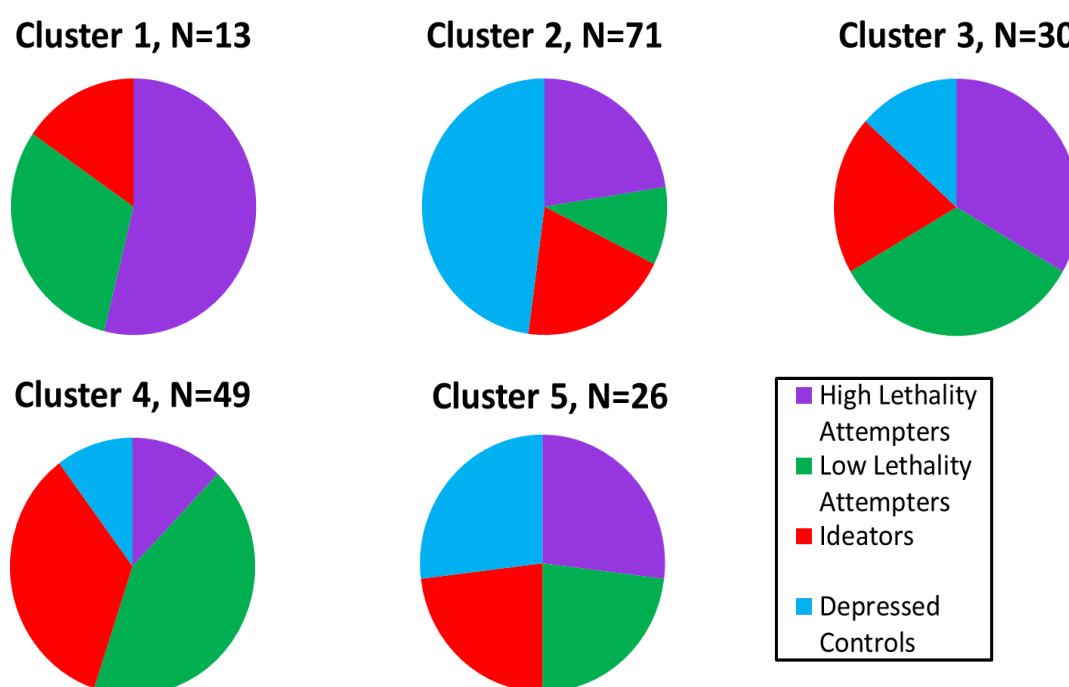
aThe figure illustrates that there were large differences in the compositions of clusters with greater and lesser degrees of suicidal ideation/behavior. The number of participants in the four groups were similar (High lethality attempters N= 49, Low lethality attempters N=49, Ideators N=46, Depressed controls N=50), as high suicide risk groups were oversampled.   Thus, we can interpret between-cluster differences but not the absolute proportions.

"Attempt lethality by clusters" appears on the next page.

Attempt lethality by clusters

We reported that there were significant differences among the clusters when binary lethality data were used (see Manuscript). Results were similar when continuous lethality scores of past attempts were used between clusters (F=4.53, df=4,89; p=0.002). Post-hoc comparisons indicated that C-1 and C-2 included individuals with higher lethality of attempts than C-4 (the high personality risk cluster).