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Using Computational Linguistics to Understand Near-Death Experiences: Concurrent Validity for the Near Death Experience Scale

Rense Lange
Lusofona University of Humanities and Technologies and Integrated Knowledge Systems, Chatham, Illinois

Bruce Greyson
University of Virginia Health System

James Houran
Lusofona University of Humanities and Technologies and Integrated Knowledge Systems, Grapevine, Texas

Latent semantic analysis—a technique to quantify qualitative data—was used on a large dataset of near death experience (NDE) accounts for which a sizable portion also had scores on Greyson's NDE Scale. Given previous research with the NDE Scale showing there is a "core NDE" comprised of a probabilistic hierarchy of cognitive, affective, transcendental, and paranormal components, we hypothesized that there would be a similar hierarchy of experiential components reflected in NDErs' verbal accounts as evidenced by a significant relation between NDE intensity and NDE content. Predictions were largely confirmed. The verbal accounts associated with True NDEs, defined by above median scores on the NDE Scale, stood out as highly structured episodes with a clear framework comprised of seven major linguistic clusters of descriptors. Four of the linguistic factors included transcendent or paranormal themes, whereas the remaining three factors tended to focus on both vague and specific references to physiological or environmental elements. The results are argued to support concurrent validity issues with Greyson's NDE Scale and illustrate how latent semantic analysis (LSA) and related approaches can be used to study qualitative information across topics relevant to the many facets of theory-building in consciousness studies.

Keywords: near-death experiences (NDEs), latent semantic analysis (LSA), transpersonal psychology, qualitative data, verbal accounts

Medical and social scientists have long known that some adults and children suddenly faced with death experience a distinctive state of consciousness in which their existence was seemingly unbounded by the physical body or earthly environs (Blackmore, 1996, 2012; Locke & Shontz, 1983; Ring, 1980). Termed a *near-death experience* (NDE), this state is defined as a transcendental experience precipitated by a confrontation with death and which does not seem to be adequately understood as the mere phenomenology of a dying or medi-

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Rense Lange, Laboratory of Statistics and Computation, Lusofona University of Humanities and Technologies and Integrated Knowledge Systems, Chatham, Illinois; Bruce Greyson, Division of Perceptual Studies, Department of Psychiatry & Neurobehavioral Sciences, University of Virginia Health System; James Houran, Laboratory of Statistics and Computation, Lusofona University of Humanities and Technologies and Integrated Knowledge Systems, Grapevine, Texas.

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Correspondence concerning this article should be addressed to James Houran, Laboratory of Statistics and Computation, Lusofona University of Humanities and Technologies, Campo Grande, 376, 1749-024 Lisbon, Portugal. E-mail: Jim_houran@yahoo.com; jhouran@aethoscg.com

cally compromised body (for reviews, see Greyson, 2001; Greyson, Kelly, & Kelly, 2009; Holden, Greyson, & James, 2009; Irwin & Watts, 2007; Perera, Jagadheesan, & Peake, 2001). NDEs are among the most dramatic of exceptional human experiences (Holden et al., 2009) with many percipients interpreting them partly or wholly as "mystical, spiritual, or paranormal" occurrences. In fact, the *Diagnostic Manual of Statistical and Mental Disorders* added the V-Code category "Religious or Spiritual Problem," in part to acknowledge and guide clinicians in addressing the psychological impact and aftereffects of NDEs and related experiences (Brown, 2011; Lukoff, Lu, & Turner, 1998; Turner, Lukoff, Barnhouse, & Lu, 1995).

To advance clinical and empirical work in understanding this phenomenon, Bruce Greyson designed the NDE Scale (Greyson, 1983, 1985, 1990) to quantify the *intensity* of NDEs according to their cognitive, affective, transcendental, and paranormal components. The scale was specifically developed through an iterative process from an initial list of 80 phenomenological features reported to be characteristic of NDEs. Analysis of item-total score correlations yielded a 16-item scale, which had face validity and which was highly correlated with other measures of NDEs. Moreover, this scale differentiated unequivocal NDEs from ambiguous or questionable experiences. Each of the 16 experiences is rated in terms of three ordered categories that generically represent "not present," "mildly or ambiguously present," or "definitively present," but whose exact wording varies depending on the nature of questions. When such categories are scored 0, 1, and 2 a sum-score of 32 can be achieved. In earlier research (Greyson, 1983, 1990) a sum of 7 was chosen as the criterion for identifying someone with a "True-NDE," because that value was one standard deviation below the mean among a criterion group of NDErs. This approach was later validated in a comparison between NDErs and people who had come close to death without an NDE (Greyson, 1990). The instrument has proved useful in several applications (see, e.g., Holden et al., 2009), especially for identifying such "True NDEs" from other respondent types. That said, we acknowledge that the term may invoke unavoidable semantic associations in some readers; that is, truth and reality, a state of affairs that is as it appears or is claimed to be. This may imply to some that other experiences are untrue or less true or meaningful. Therefore, "True-NDE" should be understood as being equated with a "classic NDE" in an authentic or consensual sense. Given this understanding, we retain use of the "True NDE" term here for consistency with previous studies using the NDE Scale.

Lange, Greyson, and Houran (2004) showed that NDE intensity, as defined by Greyson's NDE Scale, satisfactorily fit a Rasch (1960/1980) model, thus yielding a unidimensional measure with interval-level scaling properties. With increasing intensity, NDEs were found to reflect peace, joy, and harmony, followed by insight and mystical or religious experiences, while the most intense NDEs involved an awareness of things occurring in a different place or time. By the very nature of Rasch scaling, components mentioned later in this NDE sequence become salient only after those early in the sequence have already been reported with considerable likelihood (cf., Bond & Fox, 2007)—that is, the NDE components identified by Greyson form an actual cumulative hierarchy. The NDE Scale appears to capture a "NDE core experience" as it is invariant across True-NDErs' gender, current age, age at time of NDE, as well as years elapsed since the NDE and intensity of the NDE. Under the assumption that a similar hierarchy is reflected in NDErs' verbal accounts of their experiences, there should exist a relation between the quantitative NDE intensity and the qualitative NDE content. We note that the analytic technique to be used, latent semantic analysis (LSA), is not limited to linguistic information and other variables can simply be included as additional "features." In the present research we have access to some NDErs' age and gender information. Since people's vocabulary likely varies with their age and gender, thereby affecting the prediction rules, we also conducted runs using age and gender as independent variables (i.e., by adding them as predictors), as well as runs where age and gender were treated as dependent variables.

The present research therefore aims to explore the applicability of the NDE Scale in providing concurrent validity for NDE reports (or alternatively, concurrent validity for the scale itself) by providing a direct link between

NDErs' verbal accounts, which are available in written form, and the intensity of their experiences as expressed on Greyson's (1983, 1985, 1990) NDE Scale. As an aside, we note that our validation efforts by establishing a correlation are best seen as addressing concurrent validity, rather than predictive validity, because the reporting of the experiences and the administration of Greyson's NDE intensity measure tended to occur in close temporal proximity. As will be explained in the following section, we use LSA to express verbal accounts in a form suitable for quantitative analysis (see, e.g., Deerwester et al., 1990; Landauer, Foltz, & Laham, 1998). Once such narratives are represented in quantitative form, standard statistical techniques can be used to establish concurrent validity. Under the assumption that a similar hierarchy of experiential components is reflected in NDErs' verbal accounts of their experiences, we specifically hypothesize that a significant relation should exist between NDE intensity and NDE content. No exact match between the items and NDErs' accounts is required since LSA will recognize terms that are (nearly) synonymous. Operationally, this implies that scores on the NDE Scale associated with a particular NDE account can be predicted from the meaning of their (free-format) written accounts thereof. If so, in addition to supporting concurrent validity, we will have obtained a system that is capable of capturing at least some aspects of NDEs.

Using the terminology of Schwartz et al. (2014), LSA provides an "open-vocabulary" approach that does not require a predefined set of keywords. Rather, given a collection of NDE accounts, relevant words and word sequences are identified using unsupervised learning. While this study research focuses on establishing the concurrent validity of the NDE Scale, it is also serves as a general case study of LSA as a new tool for establishing concurrent validity based on the use of qualitative verbal information, as well as an effective method for understanding subjective, narrative-based data from other aspects of psychiatry and social science (see, e.g., Osborne, 1994).

Latent Semantic Analysis

LSA provides an effective method for knowledge induction and representation by automating the process for determining the similarity of meaning of words and passages of written text (for an overview, see Deerwester et al., 1990). Based on word and context co-occurrences, LSA represents the words, sentences, and paragraphs used in it as points in a very high dimensional "semantic space" (for an overview, see, e.g., Landauer et al., 1998). Singular value decomposition (SVD), a mathematical matrix decomposition technique closely akin to factor analysis, is then used to simplify this space. While SVD itself has long been known, its application became technically feasible only after the development of efficient computer algorithms capable of dealing with large data sets. LSA revolves around the concepts of *corpus*, *tokens*, *vector space*, and *model*. A *corpus* is a collection of text units (e.g., typed answers, word processer files, or web pages), called documents. The words in these documents define of a series of *tokens* that represent useful aspects of the answers' semantics. Tokens deemed useful in a particular application are gathered in a dictionary, and words not in that dictionary are simply ignored. For instance, the word "the" is probably useless in most contexts and will not appear in the dictionary. The *vector space* approach represents documents' tokens as sparsely coded vector features combined with their frequencies. For instance, the sentence "The soldier saw another soldier approaching" might be represented as the token vector [("soldier,"2), ("approaching,"1), ("saw,"1)], while the word "the" is ignored. Word order plays no role here, and the preceding is referred to as the "bag of word" approach.

The vector space model assumes that similar documents have similar vectors and that vector similarity reflects similarity in meaning. Experience indicates that first transforming tokens' raw frequencies using a log entropy weighting function supports these assumptions (see, e.g., Manning & Schütze, 1999). In this approach, if tf_{ij} represents the number of times token i occurs in document j, then each token i receives a global weight g_i, defined as:

$$g_i = 1 + \left(\sum p_{ij}\log_2(p_{ij})\right)/\log_2 n, \qquad (1)$$

where n is the number of documents in the entire corpus, and p_{ij} is the probability of the term i appearing in the document j. The local

weight of this term inside a particular document j is then defined as:

$$l_i = \log_2(1 + tf_{ij})g_i \quad (2)$$

The net effect of this approach is to reduce the relative importance of high frequency tokens, while assigning higher weights to tokens that distinguish between different documents.

LSA proceeds to decompose the weighted *document-by-token* data matrix A into the product of three matrices: an orthonormal *document-by-k* matrix T, a $k \times k$ diagonal matrix of singular-values s_{ij} whose diagonal values are in decreasing order (i.e., $s_{ii} <= s_{(i-1)(i-1)}$), and an orthonormal *document-by-k* matrix D. The value of k represents the number of singular values in truncated versions of T, S, and D that allows A to be reconstructed with acceptable loss of information, while reducing noise and variability (Berry, Dumais, & O'Brien, 1995).

$$A \approx T_k S_k D'_k. \quad (3)$$

Although the optimal number of factors will vary between applications, values of k in the range 100–300 are typical (Landauer, 2007). LSA essentially reduces the size of the document vectors by placing (near) synonyms at similar locations in the k-dimensional vector space.

In this paper we take these reduced vectors as our basic units of observation, to be used as input for further analysis. While LSA works well in practice, even for relatively small samples, the factors it produces are typically difficult to interpret. Other vector-based methods, like latent Dirichlet analysis (LDA), tend to be superior in this respect (e.g., Blei, Ng, & Jordan, 2003). However, LDA also requires a larger corpus of cases than is available here.

Method

Data

The second author maintains an ongoing database of NDE accounts provided personally by those reporting NDEs. Available for analysis were a total of 863 such accounts, some of which constitute only a couple of paragraphs, whereas others span 10–20 typewritten pages. On average, the accounts contain 224.90 tokens (SD = 146.98). Scores on Greyson's (1983, 1985, 1990) NDE Scale were also available for 588 of these NDE accounts. As was noted earlier, this scale is defined by 16 experiential items derived from hundreds of NDE accounts. Respondents rated each component in terms of three ordered categories that generically represent "not present," "mildly or ambiguously present," or "definitively present," but whose exact wording varies with the nature of questions. Using the parameters listed in Lange et al. (2004), maximum likelihood estimates of respondents' Rasch NDE intensity were computed for each respondent ($M = -0.17$, SD = 1.34 logits) using the UCON method described in Wright and Masters (1982). For 369 respondents (48 men and 321 women) both age and gender were known. This subsample was used for ancillary analyses.

Data Preparation

As recommended by Berry and Browne (2005), the narratives were first "purified" to eliminate tokens providing little useful information. First, to minimize the occurrence of spurious tokens, all accounts were spell-checked using Norvig's (2007) software, and all proposed changes were verified manually before being accepted. Also, words were normalized to their essential roots by a process known as stemming (Berry & Browne, 2005). For example, and depending on the stemming method being used, the words "fishing," "fished," and "fisher" would reduce to the root "fish." Such stems need not be part of the (natural) language, but stemming assumes that words with a common stem usually have strongly related meanings. For instance, the words "argue," "argued," and "argues" reduced to the stem "argu." All stemming operations are based on the widely used Porter algorithm, as is included in the Gensim (Řehůřek & Sojka, 2010) software.

The resulting tokens were all written in lower case letters, with end-of-sentence markers (i.e., "!," "?," or ".") denoted by "#." Some concepts are defined by a sequence of two words rather than a single word (e.g., New York, well-defined). To capture such cases, all possible pairs of adjacent elements in a sentence, or *bigrams*, were added as well. The present corpus was deemed too small to also use sequences

of more than two words. Finally, tokens that either occurred very frequently (in more than 2/3 of all accounts) as well as tokens occurring very infrequently (in fewer than five cases) were omitted since these provide very little or very unreliable information. This last condition removed all but the most frequently occurring bigrams.

SVD Software

All LSA analyses reported here are based on Řehůřek and Sojka's (2010) versatile Gensim system that can be downloaded (http://radimrehurek.com/gensim/install.html). This Python-based software contains libraries for topic modeling, document indexing, and similarity retrieval for large corpora of texts.

Results

A file was created with the 588 respondents' scores on Greyson's NDE Scale (when available), together with the coordinates of their accounts projected in a 400 dimensional space (see Method section). These dimensions were ordered according to their corresponding eigenvalues. Using the *glm* procedure provided by the R language, the first 50 coordinates, first 100 coordinates, and so on, incrementing by 50, up to 400 were used to predict respondents' Rasch scaled NDE measures in Logits. The second and third columns of Table 1 show the squared multiple correlations for sets of coordinates of varying sizes, as well as the adjusted R^2, which takes into account the number of predictor variables and the sample size.

By definition, using increasingly complex semantic spaces adds predictive power, as is indicated by the fact that R^2 increases continuously when more predictors are added. However, the adjusted R^2 values, which take into account the number of predictors and the sample size, reach a maximum value (i.e., 0.33) for about 250 predictor variables, and this value is perhaps a more appropriate estimate of the quality of prediction. Yet, the finding that at least one-third of the variation in respondents' quantitative Rasch NDE measures can be predicted from their qualitative NDE accounts strongly supports our hypotheses.

Factor Interpretations

With 250 predictors in the multiple regression model, only the contributions of the seven factors shown in Table 2 reach statistical significance at $p < .001$. This stringent Type I error level was used given the large number of predictors. Table 2's columns list these factors in extraction order, that is, lower numbered factors explain more of the variance in the semantic space than do those with higher ordinals. Note that the significant factors cover a wide extraction range (i.e., 4–247), indicating that some of the "later" factors, that is, factors that explain less of the variance in the semantic space, nevertheless contribute significantly to prediction. This interpretation is supported by the finding that the correlation between variance explained by the first 250 factors and their weights in the multiple regression equation is essentially zero ($r = -0.06$).

Table 1
Linguistic Dimensions Used for Prediction

Number of dimensions	Semantics only[a] R^2	Adjusted R^2	Semantics with gender and age[b] R^2	Adjusted R^2
1–400	0.81	0.23	[c]	
1–350	0.75	0.28	0.96	0.10
1–300	0.70	0.31	0.87	0.29
1–250	**0.64**	**0.33**	**0.86**	**0.39**
1–200	0.56	0.29	0.68	0.29
1–150	0.49	0.29	0.57	0.26
1–100	0.42	0.29	0.43	0.27
1–50	0.36	0.29	0.37	0.27

[a] $N = 588$. [b] $N = 369$, gender and age were added as predictors. [c] No meaningful solution exists due to number of predictors and sample size.

Table 2
Themes Across the Seven Major NDE Linguistic Clusters of Components

	Factor[a]						
	4	7	26	38	49	235	247
Extreme[b]	water	tunnel	warm	door	accident	didn	light
	operate	surgery	brother	sensation	angel	path	above
	surgery	light	demon	pain	watch	nde	yes
	recall	beautiful	breath	open	doctor_nurse	play	nose
	car	heaven	god	music	must	quite	following
	body	god	breathe	recall	room	hot	each
	occurred	bright	oxygen	lights	ill	work	cry
	event	angel	christ	coma	window	complete	began
	blood	warm	pulse	remember	heart	else	phone
	which	white	accident	love	minute	area	process
Sign change	vs.	vs.	vs.	vs.	vs.	vs.	vs.
	here	these	husband_wife	major	soft	dad	front
	angel	minute	head	voice	husband_wife	forget	form
	couldn	drive	tunnel	nurses	black	shoulder	nearly
	baby	phone	stay	everything	four	appear	familiar
	church	some	recall	hands	float	tremendous	between
	want	labor	energy	bed	god	wonder	breathe
	beautiful	event	aware	quite	home	pleasant	also
	earth	dream	sister	ceiling	recall	ask	darkness
	god	operate	coma	ago	darkness	comfortable	feelings
Extreme	love	baby	voice	lord	music	night	wake

[a] Factors are listed in order of decreasing eigenvalue. [b] Tokens are listed in order of decreasing loadings.

As a guide to the factors' interpretation, each column in Table 3 lists the 20 tokens with the highest absolute loadings among the 1,500 entries in the dictionary. For simplicity, the exact loadings are not shown. Rather, since the sign of tokens' loadings (i.e., either positive or negative) is arbitrary, only the juxtaposition of the top versus bottom parts of each column matters for a factor's interpretation. It can be seen that some of the factors broadly agree with findings reported in earlier qualitative research. For example, the "core NDE" Rasch hierarchy described by Lange et al. (2004), by its inherent definition, focuses on many of the transcendental and seemingly paranormal components to many NDE accounts. Four of the seven major linguistic factors (4, 7, 26, 49) included such themes, whereas the remaining three major linguistic factors (38, 235, 247) tended to include both vague and specific references to physiological or environmental elements. It is interesting that the esoteric and dramatic components to NDEs neither fully defined nor dominated NDEs in these linguistic dimensions. However, any further or detailed interpretation or deemed relevance of the linguistic factors is hindered by several issues. First, the linguistic structures outlined in Table 2 do not always immediately or obviously relate to the experiential factors previously mentioned in NDE literature. Second, LSA strips all temporal relational information from the data and, consequently, any interpretation of the descriptors or components in terms of their potential progressive relationships is not possible. Stated simply, the elements in Table 2 defy a coherent conceptualization, and little theoretical meaning

Table 3
Predicting Percipient Age Across the Linguistic Dimensions

Number of dimensions	R^2	Adjusted R^2	With gender R^2	Adjusted R^2
1–350	**0.98**	**0.51**	**0.98**	**0.48**
1–325	0.92	0.35	0.93	0.34
1–300	0.86	0.26	0.87	0.26
1–250	**0.76**	**0.25**	**0.77**	**0.27**
1–200	0.63	0.19	0.64	0.21
1–150	0.56	0.25	0.57	0.27
1–100	0.41	0.18	0.43	0.21
1–50	0.28	0.17	0.32	0.20

can be inferred from the empirical patterns at this time.

Age and Gender as Predictors

For 369 respondents (321 women and 48 men) both age and gender were known as well. The fourth and fifth columns in Table 1 show the multiple correlations when the preceding analyses are repeated, but with these two variables included. As before, R^2 increases as more factors are included, rising to 0.96 when the first 350 factors, plus gender and age, are used. Note, however, that the number of predictors almost equals the sample size and hence the adjusted value drops precipitously. The adjusted R^2 again reaches a maximum for 250 factors, plus gender and age. For that case, the explained variance increases by 6% (i.e., 33 vs. 39%). However, due to the smaller sample size, and perhaps selection factors, all other adjusted R^2 values are lower than before. We conclude that gender and age improves prediction, but only in combination with an optimal selection of the number of semantic factors.

Predicting Gender and Age

It can conversely be asked whether the gender and age for the 369 individuals' complete cases (321 women and 48 men) can be predicted from their verbal NDE accounts—that is, treating age and gender as dependent variables. First, using a variety of approaches, including linear regression, logistic regression, and discriminant analysis, no reliable method could be identified to predict gender from the semantic factors, regardless of the number of factors being used. For instance, linear and quadratic discriminant analysis both only allowed the correct classification of 323 cases, or 88%, which hardly improves the baseline value of 87% correct classification (i.e., the percentage of women).

Age, by contrast, could be predicted with considerable accuracy. Table 3 shows the R^2 obtained from multiple regression, together with their adjusted values, across a varying numbers of predictor factors being used. The analyses were repeated with and without using gender as a predictor and the results are shown in columns 4 and 5, and 2 and 3, respectively. By definition, R^2 increases with the number of predictors, but unlike the results in Table 1, so does the adjusted R^2. Settling this issue probably requires larger samples of observations, but if (as in the prediction of NDE intensity) we use the first 250 factors, then about a quarter of the age variation can be explained by the semantic factors. We note that including gender as a predictor consistently has only minimal effects on the adjusted R^2 and this variable can thus be ignored.

True NDEs

We noted earlier that a raw sum of 7 or higher on the NDE items is used as a criterion for labeling respondents' experiences as a "True NDE" versus other experiences. Based on this rule, 523 of the 588 (87%) respondents with NDE scale data were classified as True NDErs. This classification was difficult to predict. For instance, logistic regression in the *R* programming language using the first 250 factors as predictors, did not converge. Also, standard linear regression to predict NDE categorization failed to reach statistical significance ($R^2 = 0.41$, $F(250, 282) < 1.0$), and the results are nonsensical when adjusted for the number of variables and sample size ($R^2 = -0.11$).

Not surprising in light of the overall predictability of NDE intensity, when the NDErs are divided into two (nearly) equal groups based on their median NDE scores, classification is successful. In particular, the support vector machine method, as embodied in R package e1071 (Karatzoglou, Meyer, & Hornik, 2006), can identify low versus high scoring individuals with 64% accuracy using 10-fold validation (i.e., against a baseline of 50%).

Discussion

The findings strongly support the concurrent validity of Greyson's (1983, 1985, 1990) NDE Scale by confirming our basic hypothesis that the intensity of NDErs' experiences can be predicted from their written subjective accounts, as captured quantitatively using LSA. This statement summarizes a complex chain of events that starts from the assumption that co-occurring words share a similar meaning. The complexity of this approach is reduced through SVD, which assigns to arbitrary collections of words a location in a semantic space. These spatial coordinates were then successfully used

as predictor variables for statistical correlation and prediction. While we phrased the findings as contributing to the concurrent validity of Greyson's NDE measure, it could be argued that one might also conclude that the findings support the validity of the LSA approach, or offer concurrent validity for certain NDE accounts, based on their correlation with the NDE measure. The issue constitutes a "chicken and egg" problem since Greyson derived his questionnaire items from accounts and interviews with people who reported NDE-like experiences. Thus, verbal data are the primary source of information, and the NDE Scale can be seen as a secondary encapsulation thereof. We suggest that either interpretation is valid.

It is important to note that our results are open-vocabulary, that is, they do not require a predefined set of NDE keywords with a known correspondence to NDE intensity or other variables. Rather, except for some basic rules concerning word occurrence, unsupervised learning proved successful in creating a useful semantic space of NDE's cognitive, affective, transcendental, and paranormal components. Currently, once computed for a collection of accounts, this space is static since its structure remains fixed even though new accounts become available. However, if updating the semantic space as more accounts become available proves useful, the Gensim software (Řehůřek & Sojka, 2010) can also do this.

Although we have achieved a useful encoding of NDE accounts that predicts NDE intensity and percipient age, it is legitimate to ask what exactly has been learned. First, the semantic space contained factors that summarize some of the basic themes of NDErs' phenomenology, including physical and environmental factors, as well as more esoteric and dramatic perceptions of interest to transpersonal and humanistic-oriented psychologies. Thus, our findings validate earlier research on the robustness of a core NDE (for a review, see Holden et al., 2009; cf., Lange et al., 2004). Nevertheless, follow-up research is needed to meticulously scrutinize our present results in terms of several competing models (for reviews, see Greyson, 2001; Greyson et al., 2009; Holden et al., 2009; Perera et al., 2001):

- Sabom (1981) categorized NDEs as autoscopic, transcendental, combined (having both autoscopic and transcendental features), or non-NDEs (having features of neither autoscopic nor transcendental features and therefore not qualifying as NDEs);
- Emotionally pleasant, neutral, or unpleasant NDEs;
- NDEs precipitated by cardiac arrest, or by accident, or by anesthesia/drugs, or by no known precipitant. It has been suggested that there are five phenomenological clusters of NDEs, linked to low stress, emotional stress, intoxicants, anesthetics, and cardiac arrest;
- Proximity to death (e.g., loss of vital signs; seriously ill or injured but without loss of vital signs; or not seriously ill or injured).

Additional insights for theory-building might be obtained in this way, as well as new hypotheses amenable to LSA approaches. We plan to pursue this avenue in future research. Second, LSA knowledge is declarative rather than procedural, and it is best seen as "semantic," that is, the SVD generated space resembles a generalized record of facts and meanings concerning reality. In a different context, Landauer et al. (1998) argued that LSA offers an approximation to human knowledge in a specified cognitive domain and they observed that:

> One might consider LSA's maximal knowledge of the world to be analogous to a well-read nun's knowledge of sex, a level of knowledge often deemed a sufficient basis for advising the young (p. 262).

Not unlike the clinical impact NDEs can have on percipients' every day attitudes and experiences observed by Lukoff and colleagues (Lukoff et al., 1998; Turner et al., 1995), we showed earlier (Lange et al., 2004) that NDEs have the power to restructure people's cognitions by reprioritizing the items they deem relevant. This fact is also reflected in our semantic space, since it proved possible to distinguish reliably between individuals with low versus high scores on Greyson's NDE Scale. Our findings indicate that NDEs appear to have an inherent predictable structure that represents a distinct state of consciousness worthy of continued study. Academia merely has NDE reports to analyze rather than the direct physical experiences themselves. Therefore, new perspectives and research avenues like LSA hold promise for the development of more highly

integrated multidisciplinary research on the NDE question. The authors, therefore, seek cross-cultural collaborations to advance research in this area using more and varied datasets to properly test the generalizability of these results.

We believe that the present research is only the beginning of many other research efforts across various phenomena in consciousness studies. For instance, while LSA is certainly the most widely used for computerized linguistic analysis, it certainly seems worthwhile to try other computational approaches as well. As noted earlier, this will probably require the availability of larger datasets than the present one. We caution, however, that different cultures express similar phenomena in qualitatively different and idiosyncratic ways, thereby complicating prediction and analysis in general (for examples, see Belanti, Perera, & Jagadheesan, 2008; Lange, Thalbourne, Houran, & Lester, 2002). In extreme cases, cultural differences entail the use of different languages (with their own grammar and vocabularies) as well. However, analogous to our use of age and gender, in all cases where the same language is used across subgroups, we suggest that cultural factors are included together with linguistic data in order to define an optimal semantic space.

Most importantly, this paper demonstrated how a novel methodology can enhance our understanding of human experiences where data typically consists of verbal accounts. We strongly expect that the approach will prove fruitful in applications besides NDE. For example, it seems possible that LSA or related approaches could be used to assess the veracity of verbal accounts—a topic that could perhaps be studied by contrasting reliable accounts with "fabricated" ones produced by knowledgeable collaborators. Once authentic or consensual accounts are identified, further LSA analyses on these screened accounts might reveal patterns relevant to theory-building for the phenomena in question. The range of potential topics is vast, including dreaming and lucid dreaming, meditation, and other internal attention states, out-of-body experiences, dissociative, transliminal, hallucinatory, and delusionary episodes, as well as spontaneous case material (historic and contemporary) across the disciplines of abnormal and transpersonal psychologies. Alternatively, researchers might gather written (or other free-response) information in applications where this is typically not done. For example, the study of interpretations of ambiguous stimuli, including putative parapsychological experiences, might benefit greatly from augmenting quantitative measures of paranormal belief and experience (Lange, Irwin, & Houran, 2000; Irwin & Marks, 2013) with qualitative verbal accounts. Another obvious and rich area for potential application is accounts of syncretic cognitions, involving a dedifferentiation (or fusion) of perceptual qualities in subjective experience such as: *physiognomic perception* (fusion of perception and feeling), *synesthesia* (fusion of sensory modalities), and *eidetic imagery* (fusion of imagery and perception, i.e., structural eidetic imagery).

We propose that LSA and related approaches provide a flexible and powerful operationalization of an interactionist framework that encompasses a mixture of self-attribution and stimulus-attribution variables when individuals perceive, remember, and later articulate anomalous experiences. This could be done, for instance, by analyzing different phenomena using a common semantic space. As such, the approach outline here promises to provide a powerful unifying quantitative framework for the integration of what currently appear to be disjoint and qualitatively different phenomena.

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