



Original Research

Intermittent degradation and schizotypy

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ABSTRACT

Intermittent degradation refers to transient detrimental disruptions in task performance. This phenomenon has been repeatedly observed in the performance data of patients with schizophrenia. Whether intermittent degradation is a feature of the liability for schizophrenia (i.e., schizotypy) is an open question. Further, the specificity of intermittent degradation to schizotypy has yet to be investigated. To address these questions, 92 undergraduate participants completed a battery of self-report questionnaires assessing schizotypy and psychological state variables (e.g., anxiety, depression), and their reaction times were recorded as they did so. Intermittent degradation was defined as the number of times a subject's reaction time for questionnaire items met or exceeded three standard deviations from his or her mean reaction time after controlling for each item's information processing load. Intermittent degradation scores were correlated with questionnaire scores. Our results indicate that intermittent degradation is associated with total scores on measures of positive and disorganized schizotypy, but *unrelated* to total scores on measures of negative schizotypy and psychological state variables. Intermittent degradation is interpreted as potentially derivative of schizotypy and a candidate endophenotypic marker worthy of continued research.

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1. Introduction

From trial-to-trial within an experimental task, there is often marked fluctuation in the quality of a patient with schizophrenia's performance or what has been referred to as intermittent degradation (ID; Matthyse et al., 1999). For example, Belin and Rubin (1995) and Rubin and Wu (1997) demonstrated that distributions of eye-tracking performance scores for some schizophrenic subjects were best explained by two component distributions: one distribution that approximated that of normal subjects and another that was unique to patients with schizophrenia. This latter distribution was characterized by a lower mean and increased variance.

Informed by these reports, Matthyse et al. (1999) thoroughly explicated the ID process and outlined a strategy for its study. The main points of Matthyse et al.'s model can be summarized as follows:

- 1) Only some patients with schizophrenia are susceptible to ID.
- 2) In susceptible individuals, ID only occurs on some trials.
- 3) There are two types of ID indicators, inferential and direct. Inferential indicators include the presence of outliers in data sets, abnormalities in distributional shape, and evidence of transient abnormal performance from time series data. Direct indicators include

measures of cortical activity that have high temporal resolution and the results of advanced statistical analysis, i.e. mixture modeling.

- 4) Finally, the authors suggest researchers follow a two-step strategy. First, robust inferential indicators of ID should be identified. Second, formal mixture modeling or direct measures should be used.

The importance of investigations of ID is threefold. First, such investigations move away from asking *if* patients with schizophrenia perform more poorly than controls on experimental tasks, to asking *why* their performance is inferior. That is, they can address whether impaired task performance results from a task deficit, ID, or a task deficit and ID. Second, given ID only affects *some* patients with schizophrenia, it may serve to identify a unique subgroup of patients. The reduction of the heterogeneity inherent to schizophrenia has been a vexing problem for over a century and identifying subgroups of patients who perform deviantly on laboratory tasks represents one means of gaining leverage on this problem (Lenzenweger, 2010). Finally, ID might serve as an endophenotype (Gottesman and Gould, 2003; Lenzenweger, 2013) for schizophrenia. Over the last two decades, endophenotypes have become a major focus of scientific inquiry as it is hoped they will serve to bridge the gap between the behavioral and genetic levels of analysis. A major challenge in identifying endophenotypes in people diagnosed with schizophrenia is that what appear to be endophenotypes in these populations may result from third variable confounds (e.g. symptom severity) associated with, but not necessarily inherent to the

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schizophrenia diathesis (Lenzenweger, 1998). One research strategy that allows for the circumvention of such issues is the study of schizotypy (Lenzenweger, 2010; Meehl, 1962, 1990); that is, studying persons at higher risk for schizophrenia.

In this study, we sought to determine the relationships between schizotypy and a novel inferential indicator of ID. This novel indicator, which captures exceedingly abnormal task performance by identifying outliers in time series data, conforms to Matthyse et al. (1999) general definition of ID (“the temporary substitution of a less efficient process of task performance”, pg. 131) and their specific definition of an inferential indicator of ID. We hypothesized ID would be positively related to schizotypy and schizotypal features, and unrelated to psychological state variables (e.g., depression, anxiety).

2. Method

2.1. Subjects

110 State University of New York at Binghamton undergraduate students were recruited for participation. Enrollment in the study was open and as compensation, students received experimental credit in the psychology course of their choice. To purge the dataset of random and reckless responders, all subjects scoring 2 or greater on the Jackson Inventory (Jackson, 1984) were removed. After this was done, psychometric data for 92 subjects were available for analysis. Mean participant age was 19.52 ($SD = 1.54$), and the sample was predominantly female (68.5%) and Caucasian (64%). The study’s experimental procedure was reviewed and approved by Binghamton’s Institutional Review Board, and informed consent was obtained from all participants prior to their participation.

2.2. Measures

2.2.1. Psychometric schizotypy

Four measures of schizotypy were administered: the Perceptual Aberration (PAS; Chapman et al., 1978), Magical Ideation (MIS; Eckblad and Chapman, 1983), Revised Social Anhedonia (RSAS; Chapman et al., 1995), and Physical Anhedonia (PA; Chapman et al., 1995) scales. The PAS is a 35-item true-false measure of body image and perceptual aberrations. The MIS is a 30-item true-false measure of belief in forms of causation that by conventional standards are invalid. The RSAS is a 40-item true-false scale measure of schizoid indifference, withdrawal, and asociality. The PA scale is a 61-item true-false measure of one’s ability to derive pleasure from sensory experience. The reliability and validity of these scales as measures of schizotypy is strongly supported (Chapman et al., 1982; Chapman et al., 1995; Lenzenweger, 2010).

2.2.2. Schizotypal Personality Questionnaire

The SPQ (Raine, 1991) is a 74-item true-false questionnaire that assesses features of DSM-III-R’s schizotypal personality disorder (SPD) (American Psychiatric Association [DSM-IV-TR], 1983). The internal consistency and test-retest reliability of the SPQ are excellent and deviance on the SPQ has been shown to identify people with SPD (Raine, 1991).

2.2.3. Psychological state measures

Participants completed the State-Trait Anxiety Inventory (STAI; Form Y, Spielberger, 1983), Positive and Negative Affect Schedule (PANAS; Watson et al., 1988), and Beck Depression Inventory-II (Beck et al., 1996). The STAI is a 40-item true-false self-report inventory that assesses state and trait anxiety. The PANAS, is 20-item self-report measure utilizing a five-point Likert-type scale to measure the intensity of positive and negative affect. The BDI-II is a 21-item self-report measure utilizing a four-point Likert-type scale that measures depressive symptoms over the past two

weeks. Each of these scales is used widely and a large body of literature exists to support their reliability and validity (Beck et al., 1996; Crawford and Henry, 2004; Spielberger, 1983; Sprinkle et al., 2002; Storch et al., 2004; Watson et al., 1988).

2.2.4. Jackson Inventory

The Jackson Inventory (JI; Jackson, 1984) is a 14-item True-False measure that assesses random, reckless, or invalid responding. This measure includes items like “At times when I was ill or tired, I have felt like going to bed early” and “Driving from New York to San Francisco is generally faster than flying between these cities” which, when a participant is responding validly to questionnaire items, should all be answered in one direction. Scores above 2 on the JI are considered an indication of an invalid response style and grounds for participant removal from further analyses.

2.2.5. Demographic and participant health history

Demographic data, and information about participant health history and use of nicotine, alcohol, and psychiatric medication were collected using two author-generated forms.

2.3. Procedure

Questionnaires were completed at computer workstations. Questionnaire items were combined, randomized, and presented in a unique order for each participant in *Superlab 4.0* (Abboud et al., 2006). Along with the subject’s answers, participant reaction times were also recorded. Reaction time precision for keyboard responses on a Macintosh CPU running *Superlab 4.0* is 8–12 milliseconds. Participants answered 435 questions and this took, on average, 30 minutes. Subjects completed the study in a well lighted, climate-controlled, and quiet room. No subjects were interrupted during their participation and no extraneous, intermittent, or loud noises occurred while subjects were participating. Additionally, subjects were monitored through a one-way mirror to ensure compliance with the demands of the protocol.

2.4. Intermittent degradation

Given that our study focused on individual differences, we had to develop a novel quantitative measure of ID that was in accord with Matthyse et al. (1999) definition (“the temporary substitution of a less efficient process of task performance”, pg. 131). When this definition is dissected, it becomes clear that ID is an intra-individual transient deviation from normal task performance and thus, to accurately represent ID one must differentiate normal performance from deviant performance for each individual in isolation. To do this, we converted participant’s raw reaction times to normal scores using their mean and standard deviation and then counted the number of standard scores greater than or equal to three. To remove item-level characteristics that may have influenced participant reaction times, we took two steps. First, prior to converting raw reaction times to normal scores, reaction time was regressed on Flesch-Kinkaid Grade-Level and Reading Ease scores (Kincaid et al., 1975) and the residuals from this regression were then used to create the z-scores described above. This regression removed the effect of item reading difficulty on reaction times. Second, the number of instances of ID was determined for each item, the mean and standard deviation for ID across items was calculated, and items with abnormally high instances of ID were removed. This resulted in seven items being eliminated from analysis. The elimination of these items removed the effect of item-specific features other than reading difficulty on total ID scores. Thus, our measure of ID was a *count variable* of the number of times a person had a reaction time three standard deviations or more away from their mean after correcting for various item-level characteristics that may have led to prolonged reaction times.

2.5. Statistical methods

The relationships between our psychometric measures and ID were assessed using correlational analyses. To determine the amount of overlap between and unique variance attributable to measures that significantly correlated with ID, partial correlational analyses were performed. To facilitate interpretation of our findings we calculated one measure of effect size, Cohen's *d*, for all statistically significant results.

2.5.1. Post hoc analyses

To determine whether ID scores were influenced by the content or personal relevance of the questions on the scales it correlated with, we removed the items from the PAS and SPQ's Unusual Perceptual Experiences, Odd or Eccentric Behavior, and Odd Speech subscales, recalculated ID scores based on the remaining 361 items, and correlated these scores with the schizotypy scale scores that correlated significantly with ID in our *a priori* analyses. To provide context for the interpretation of these correlations, we created 10,000 random samples of 361 questions and recalculated ID scores as above. These scores were then correlated with the schizotypy scales that significantly correlated with ID in our *a priori* analyses and the average correlation across all 10,000 samples, as well as its 95% confidence interval, were derived. Comparing these two sets of correlations allowed us to determine whether the reductions in the correlations observed when items from scales that correlated significantly with ID were removed exceed what would be expected owing to the removal of 67 items from the calculation of ID scores.

Additionally, to determine the variance in ID that was explained by our psychometric measures, two regressions were performed. First, ID was regressed on all study measures. Second, ID was regressed on the measures that significantly correlated with it. The first regression allowed us to determine the amount of variance in ID that was explained by all of our measures and the second allowed us to determine the amount of variance in ID that was explained by the measures our analyses identified as significantly related to ID. We report the adjusted R^2 values.

Table 1
Descriptive statistics and correlations between psychometrics and intermittent degradation.

Measure	Mean	SD	Min	Max	<i>r</i>
<i>Positive schizotypy</i>					
PAS	4.58	4.84	0	27	.216*
MIS	6.24	4.58	0	21	.191
<i>Negative schizotypy</i>					
RSAS	7.77	5.25	0	25	.099
PA	12.78	7.06	2	38	-.007
<i>Psychological state</i>					
STAI I	33.47	8.18	21	65	.163
STAI II	36.55	8.67	22	64	.121
PANAS I	31.79	7.86	14	49	-.009
PANAS II	19.88	6.89	10	43	.152
BDI-II	10.29	9.34	0	45	.093
<i>SPQ dimensions</i>					
Ideas	3.28	2.53	0	9	.006
Social anxiety	3.97	2.45	0	8	.103
Beliefs	1.20	1.61	0	7	.076
Perception	2.39	1.95	0	8	.247*
Behavior	2.86	2.25	0	7	.238*
Friends	1.88	1.99	0	8	.020
Speech	3.98	2.24	0	9	.207*
Affect	1.73	1.64	0	6	-.053
Paranoid	2.90	2.21	0	8	-.063
<i>Intermittent degradation</i>					
ID	5.70	2.19	1	13	-

* $p < .05$; STAI I = state anxiety; STAI II = trait anxiety; PANAS I = positive affect; PANAS II = negative affect.

3. Results

Means, standard deviations, ranges, and correlations between all study variables and ID, are presented in Table 1. Participant age ($r = .063, p = .550$), sex ($t(90) = 1.834, p = .070$), and self-identified racial group ($F(4,86) = .767, p = .549$), as well as time of day for experimental participation ($r = -.019, p = .860$), consumption of caffeine ($t(90) = .660, p = .511$) or cigarettes ($t(90) = .584, p = .561$) on the day of experimental participation, and psychiatric medication use ($t(90) = 1.14, p = .259$) were found to have negligible relationships with ID. No participant reported consuming alcohol on the day experimental participation and alcohol consumption within one week of experimental participation ($t(90) = .923, p = .258$) did not significantly influence ID scores. Finally, psychiatric medication use did not correlate significantly with scores on any psychometric measure (all p 's $> .08$). Thus, no measured third variable confound significantly impacted participants' intermittent degradation scores.

3.1. Correlations between measures of psychometric schizotypy and ID

Scores on the PAS ($r = .216, p = .038, d = .44$), and SPQ's Unusual Perceptual Experiences ($r = .247, p = .018, d = .51$), Odd Speech ($r = .207, p = .048, d = .42$), and Odd or Eccentric Behavior ($r = .238, p = .023, d = .49$) dimensions correlated significantly with ID; whereas, scores on measures of negative schizotypy, paranoia, and all psychological state variables were found to have small, statistically non-significant relationships with ID. Together, these correlations suggest that intermittent degradation may be a feature of positive and disorganized schizotypy, but is unrelated to negative schizotypy and psychological state variables.

3.2. Partial correlations between psychometric measures and ID

Given that the PAS and SPQ Perceptual dimension both measure perceptual aberrations, and that the SPQ Speech and Behavior dimensions both measure disorganized schizotypy, we also examined the relationships between scales measuring perceptual aberrations and ID while partialling measures of disorganized schizotypy, and examined the relationships between scales measuring disorganized schizotypy and ID while partialling measures of positive schizotypy. As can be seen in Table 2, neither positive nor disorganized schizotypy scores retained statistically significant relationships with ID when scores on the other dimension were controlled for. These results suggest that some shared underlying factor connects positive and disorganized schizotypy to intermittent degradation.

3.3. Correlations between ID and schizotypy scale scores following the removal of schizotypy and random subsets of questionnaire items

The results from these analyses are presented in Table 3. In both versions of these analyses, the correlations between ID, PAS, and SPQ subscales were similarly reduced and all of the correlations for ID scores calculated without the schizotypy items fell within the 95% confidence interval for ID scores calculated based on the removal of a random subset of 67 items. This suggests that the reductions in the correlations between ID, PAS, and the SPQ subscales when items from these scales

Table 2
Partial correlations between perceptual aberrations, disorganized schizotypy, and intermittent degradation.

Scale	$r_{\text{disorganization}}$	$r_{\text{perceptual aberrations}}$
PAS	0.118	-
SPQ Percept	0.136	-
SPQ Behavior	-	0.146
SPQ Speech	-	0.097

Table 3

Correlations between select psychometric scales and ID calculated with all items, ID calculated without items from the PAS and select SPQ subscales, and the average correlation across 10,000 samples where ID was calculated based on removal of 67 items.

Scale	All items	Schizotypy items removed	Bootstrapped correlations	95% CI (percentile-based)
PAS	.216	.162	.173	.081–.265
PERCEPT	.247	.175	.158	.061–.256
BEH	.238	.197	.148	.056–.240
SPCH	.207	.137	.132	.039–.225

were removed from the calculation of ID are no greater than the average correlation when an equivalent subset of randomly chosen items were removed; meaning, the content or personal relevance of the items from the schizotypy scales is inconsequential in the determination of ID.

3.4. Regression analyses

When all study measures were regressed on ID, the amount of variance explained was 7.2%. When ID was regressed on only the PAS and SPQ subscales that significantly correlated with it, the amount of variance explained was 4.8%. Thus, while much variance remains to be explained, approximately 66% of the total variance explained by the psychometric measures included in our study, was related to odd perceptual experiences and disorganized phenomena.

4. Discussion

The purpose of our study was to determine if individual differences in schizotypy, assessed using psychometric methods, were related to periods of ID. Our results were consistent with our *a priori* hypothesis that individual differences in schizotypy would be positively related to individual differences in ID. The PAS and SPQ Perceptual, Odd Speech, and Odd or Eccentric Behavior dimensions all correlated significantly with our measure of ID, while measures of negative schizotypy, current mood, depression, and state and trait anxiety did not. Partial correlational analyses indicated that the variance that positive and disorganized schizotypy share with ID overlapped significantly, possibly suggesting a shared underlying process. Furthermore, our results suggest that schizotypy item characteristics and the personal relevance of schizotypy item content do not meaningfully impact ID. Taken together, our results are consistent with the notion that ID, an anomaly in neurocognitive processing, is reflective of neurocognitive processing deficits in persons deemed schizotypic (Meehl, 1962, 1990).

That ID correlated significantly with aspects of positive and disorganized schizotypy, and that these symptom dimensions overlapped in the variance they share with ID is not surprising. On a theoretical level, hypotheses about the connection between these two symptoms date back to Bleuler (1950) and their relationship was given a sophisticated framework by Meehl (1962, 1990). On a data-analytic level, recent research has demonstrated that perceptual abnormalities and disorganized schizotypy interact in ways that are important for schizotypic symptom maintenance (Debbané et al., 2013) and psychotic conversion (Raballo et al., 2011). Our study extends this research by identifying a possible endophenotype (Gottesman and Gould, 2003; Lenzenweger, 2013) that underlies both of these dimensions.

Several caveats must be kept in mind when evaluating our results. First, our sample was derived exclusively of young adult university students. One could argue that the subgroup of subjects scoring highly on our measures of schizotypy would represent cases of high-functioning schizotypy. However, if this is true, it should serve to minimize any potential effects to be found and, that an effect was found, speaks to the robustness of the phenomenon we studied. Second, because Axis I psychopathology was not screened for, it cannot be ruled out as an explanatory confound. That said, this concern is tempered against by the fact that individual differences in current psychological state and

psychotropic medication status were found to be unrelated to ID. Third, the use of a three standard deviation cut to define ID was somewhat arbitrary. That said, we chose this rigorous cut off to ensure what was being labeled as ID represented marked deviation from typical performance for each person and in using a strenuous cut-off for the definition of ID we sought to minimize false positives, even at the expense of false negatives. Fourth, it may be the case that what we are labeling as intermittent degradation could result from factors other than ID. While this may be true, we would maintain that though imperfect, our operationalization of ID captures enough true score variance (as evidenced by the significant relationships with schizotypy) to be considered a valid inferential indicator of ID. Fifth, participants were not given instructions regarding the ideal pace of their performance. While we believe our approach has high ecological validity, whether the occurrence of ID would have been different if participants were given some performance demand related to pacing is an open question. Future ID research should carefully consider this methodological issue. Sixth, while ID correlated significantly with measures of positive and disorganized schizotypy, the regression analyses revealed much of ID's variance remains to be explained. Seventh, some may argue that the probability of our results given the number of statistical tests we ran or the size of our correlations are not of sufficient size to warrant confidence in our results. We would argue against this for two reasons. First, the correlations between perceptual abnormalities and ID and disorganized schizotypy and ID were *consistent* across two distinct measures of each construct. Furthermore, the relationships between ID and other constructs assessed with multiple measures (e.g. negative schizotypy) were also consistent across measures. While the validity of one significant correlation within a moderately sized correlation matrix may be questioned, the consistency of all of these correlations bolsters confidence in our findings. Second, when our correlations were converted to Cohen's *d* values the observed effects become all the more impressive (*d* range: .42–.51).

Although in this paper, we have focused on reaction times to questionnaire items, we believe, following Matthyse et al. (1999), that in ID vulnerable individuals, ID will evidence itself and impact performance scores on any experimental task. Yet, given its putatively random nature, the occurrence of ID will only be apparent when experimental tasks involve a large number of trials and/or performance is recorded with great precision (e.g., eye movements). As a result, this phenomenon has great potential and relevance for the study of visual perception, where experimental tasks (e.g., contour integration, contrast sensitivity, surround suppression, and backward masking tasks) involve a large numbers of trials, stimuli are regularly presented, and each trial requires a response from the participant.

One visual perception task that would lend itself particularly well to the study of ID is the 240-trial Jittered Oriented Visual Integration task (JOVI; Silverstein et al., 2012; Feigenson et al., 2014). Of note, part of the standard curve fitting analyses for this task involves the calculation of a variable that quantifies what are classically thought of as lapses in attention, λ (Wichmann and Hill, 2001). In essence, λ reflects asymptotic level of performance, or, inversely, missed responses to trials in the easiest task conditions where the stimulus target is easy to identify (cognitive demands are low) and participant performance is expected to be near perfect. While people diagnosed with schizophrenia have been demonstrated to have lower λ levels than control participants (Silverstein et al., 2012), no one has yet attempted to characterize the time course of these lapses, their clinical correlates, or their impact on overall task performance. As such, as outlined in the introduction, it is therefore unclear the degree to which the observed deficits in contour integration in patients with schizophrenia may result from a true inability to do the task versus increased expression of ID. Understanding this may help the field to develop a greater understanding of why people diagnosed with schizophrenia or schizophrenia-spectrum pathology evidence deficits on contour integration tasks and further, potentially reconcile discrepant findings across studies (i.e., some studies may

enroll more ID vulnerable individuals than others). As noted above, this same scenario applies to performance on many often-used tests of perception, as well as other cognitive tasks often used in schizophrenia research to assess functions such as attention, working memory and cognitive control (e.g., N-back, CPT, etc.). Incorporation of the concept of ID into studies using measures such as these would have the additional benefit of parsing contributions from failures of the processes purportedly being measured from a more general ID process.

This study represents the first explicit investigation of ID in psychometric schizotypy and provides preliminary evidence that ID is a feature of the schizotypy construct and not simply the result of the schizophrenic disease process or third variable confounds. As such, they suggest that ID may be a useful endophenotype (Gottesman and Gould, 2003; Lenzenweger, 2013) for schizotypy. This, together with the fact that ID was found to be related to schizotypic dimensions that have recently been found to be meaningfully connected to schizotypic symptom maintenance and psychotic conversion, suggest it is a construct worthy of continued study. Replication of our results using similar experimental methods with other populations at-risk for the development of schizophrenia (i.e. first-degree biological relatives) would bolster its status as an endophenotype.

Conflicts of Interest

The authors have no conflicts of interests to report.

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