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## A Longitudinal Follow-up Of Discrete Mass At Zero With Gap

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The first part of this paper discusses a five-year systematic review of the *Journal of Consulting and Clinical Psychology* following the landmark power study conducted by Sawilowsky and Hillman (1992). The second part discusses a five-year longitudinal follow-up of a radically nonnormal population distribution: discrete mass at zero with gap. This distribution was based upon a real dataset.

Key words: Discrete mass at zero with gap, longitudinal data, nonnormality, onset variables, power.

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### Introduction

There has been a historical concern among researchers and statisticians regarding the prevalence of normally distributed data in real-world populations (Pearson 1895; Geary 1947; Pearson & Please, 1975; Micceri, 1989). For example, Micceri (1989) conducted a study involving population characteristics by examining 440 large-sampled achievement and psychometric data sets in the fields of education and psychology. All of the distributions failed tests of normality, and only 3% remotely resembled a Gaussian distribution (e.g., symmetric with light tails). The concern about nonnormality in real-world data sets has fostered inquiry into the power and robustness of commonly employed parametric statistics under nonnormal conditions (Blair & Higgins, 1980;

Sawilowsky & Hillman, 1992; Sawilowsky & Blair, 1992; Bridge & Sawilowsky, 1999).

An implication of normality is that the probabilities associated with hypothesis tests become inaccurate, and power tables become inexact. Sawilowsky and Hillman (1992) conducted a study that examined the utility of Cohen's (1988) power tables with radically nonnormal distributions. Specifically, the Type I and Type II error properties of the discrete mass at zero distribution were analyzed.

This distribution occurs when portions of the scores fall on zero, and the remaining scores begin to form the shape of the group's distribution. It is common in the fields of public health, as well as education and psychology, and is most prevalent with first use or onset variables, including the age of first cigarette use, age of first alcoholic drink, or the age of first suicide attempt. Sawilowsky and Hillman made two major findings. First, the independent samples  $t$  test was robust as it pertained to Type I error. Second, and thusly, researchers were not discouraged from using Cohen's power tables when analyzing radically nonnormal distributions.

In addition to the findings by Sawilowsky and Hillman (1992), a question was raised regarding the comparative power of radically nonnormal distributions, such as discrete mass at zero with gap. For example, Bridge and Sawilowsky (1999) found the Wilcoxon Rank-Sum test to be more powerful than the independent

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samples  $t$  test when analyzing distributions with heavy tails or extreme skew, including the discrete mass at zero with gap distribution. Therefore researchers should consider the comparative power of nonparametric statistics when choosing procedures.

An important question stemming from Sawilowsky and Hillman (1992) is what happens to the shape of radically nonnormal distributions over time? Equally important is to assess how researchers approached statistical analysis, as well as the comparative power of nonparametric statistics when faced with extreme nonnormal distributions. For example, were the zero scores re-coded, removed, or treated as outliers? The main point is, however, if the data become normal over time, these issues vanish.

#### Purpose of the Study

The seminal power study conducted by Sawilowsky and Hillman (1992), and Bridge and Sawilowsky (1999) should have raised concerns among researchers and statisticians who encounter radically nonnormal distributions, such as discrete mass at zero with gap. The first purpose of this study was to conduct a five-year systematic review of the *Journal of Consulting and Clinical Psychology*, following Sawilowsky and Hillman (1992), to determine the extent to which researchers who encounter discrete mass at zero with gap address the comparative power issues within their studies. The second purpose is to report on a five-year longitudinal analysis of an academic data set meeting discrete mass at zero with gap. The distributions were assessed in order to determine if there was a shift towards normality or to determine if the distributions remained radically nonnormal overtime.

#### Methodology – Part 1

The *Journal of Consulting and Clinical Psychology* was systematically reviewed over a five-year period following the Sawilowsky and Hillman (1992) publication, involving a power study of the independent samples  $t$  test under a radically nonnormal psychometric distribution. Each article was examined in order to identify any study, which had considered discrete mass at zero with gap or without gap within the context of the population distributions and inclusion variables. Any article that had included onset variables or

distributions that appeared to follow discrete mass at zero with and without gap were flagged.

#### Results

The five-year systematic review identified  $n= 44$  studies that met the criteria for discrete mass at zero with gap (see Appendix). There appeared to be no evidence of the term “discrete mass at zero with gap” used by the authors when either plotting or discussing their distributions. Several studies utilized multiple statistical approaches with scores that fell on zero. For example, Farrell and Danish (1993) re-coded scores with zero, Darkes and Goldman (1993) excluded  $n= 148$  participants due to either non-use (zero) and or extreme scores, and Curran, Stice and Chassin (1997) dropped  $n= 74$  families because a child had reported no (zero) individual and or no (zero) peer alcohol use.

Several studies, however, raised concerns about measurement issues and statistical assumptions. For example, Willett and Singer (1993) introduced discrete-time survival analysis, Loeber and Farrington (1994) discussed violations of population normality, and Gardner, Lidz, Mulvey, and Shaw (1996) noted extreme skew and nonnormality with their discrete mass at zero without gap distribution.

#### Methodology – Part 2

The second phase of this study included identifying a real-live, academic data set which consisted of  $N= 357$  undergraduates who had enrolled in a developmental math course during the Fall of 1995. This cohort was selected because 69 of the students (19%) received a zero in the remedial math course. Each of the students' grade point average (G.P.A.) during the Fall semester was then tracked over a five-year period (1996-2000) in order to describe and analyze the distributions. The academic data were obtained by permission from a mid-western junior college. The appropriate Institutional Review Board approved the study design. All student identifiers were removed from the database and were replaced by a unique identifier.

The cohort was obtained from the colleges' database, with assistance from the school's Institutional Research Office using Microsoft Access 2000 (Microsoft, 2000). The abstracted variables included the developmental math grade for the Fall of 1995, the Fall semester

G.P.A. (1996-2000), as well as the unique identifier. The data were then imported into a database using SPSS for Windows, version 11.00 (SPSS Inc, 1999). Descriptive statistics were then generated and included the mean, median, standard deviation, proportions, frequency counts, kurtosis and skew.

Results

Table 1 includes descriptive data derived from the academic distributions. There were a total of n= 69 (19.3%) cases that fell on zero at baseline. This number decreased to n= 4 (1.1%) cases by year 2000. All of the distributions had negative skew and negative kurtosis. Further, all of the distributions remained radically nonnormal over time (see Figure 1 to the right, and continuing on next page). Each distribution could be described as discrete mass at zero with gap except for year 1999, which had no gap. A total of 21 (5.88%) zero scoring performers at baseline had shifted to a positive score at least one time. Additionally, 26 (7.28%) of positive grades at baseline had shifted back to zero at least one time.

Table 1: Descriptive Data

	Base-					
	Line	1996	1997	1998	1999	2000
N	357	178	106	57	44	47
Mean	2.51	2.61	2.62	2.71	2.53	2.76
SD	1.46	1.23	1.24	1.22	1.43	1.20
Skew	-.685	-.991	-.962	-.962	-.650	-1.058
Kurtosis	-.924	-.090	-.080	-.031	-1.001	.277
Scores of Zero						
n	69	20	12	5	6	4
%	19.3	5.6	3.4	1.4	1.7	1.1

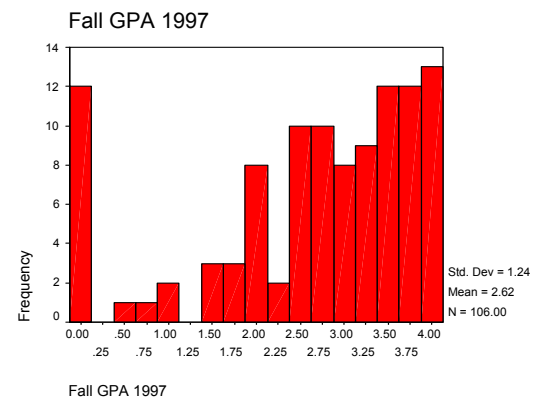
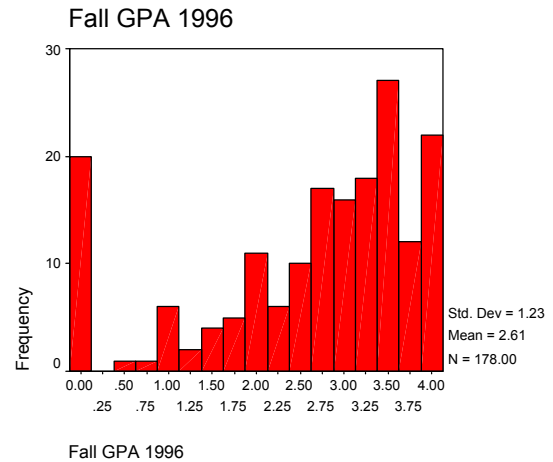
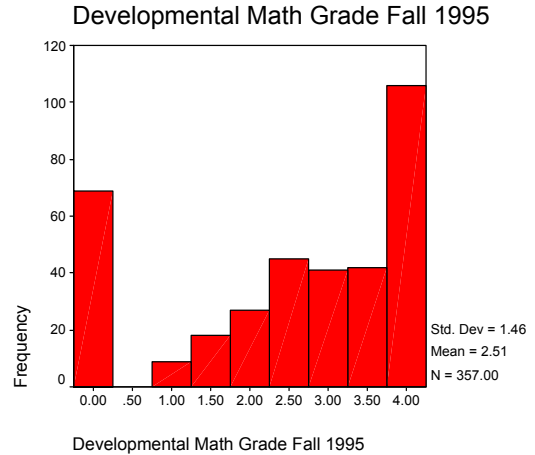




Figure 1 (continued). Distributions.

Conclusion

A systematic five-year review of the *Journal of Consulting and Clinical Psychology* following the

Sawilowsky and Hillman (1992) power publication involving prevalent psychometric distributions with the independent samples *t* test was performed. The results found that none of the authors had considered the outcomes and recommendations reported by Sawilowsky and Hillman despite employing onset variables, which may include radically nonnormal distributions such as discrete mass at zero with gap. This may lead to the inappropriate application of a statistical test, thus, raising concerns about validity.

The compendium clearly diagrams the various approaches that the authors adopted in order to evaluate the variables including recoding zero to a positive number, excluding non-users (those responses who fell on zero), as well as beginning age of onset at age ten. Several authors, however, raised concerns about nonnormality, extreme skew, and the general lack of longitudinal data beyond one year.

The five-year follow-up of discrete mass at zero with gap data set, which was based upon real, radically nonnormal academic data, found that the shape of the distribution remained unchanged over time. Despite a decrease in population size from baseline of  $N= 357$  to  $N= 47$  by year five, the radically nonnormal distribution did not shift towards normality. Four of the five distributions met the criteria for discrete mass at zero with gap, and one distribution, the Fall of 1999, could be described as discrete mass at zero without gap.

An interesting finding among the student G.P.A. scores included the shift from a positive G.P.A. to a zero G.P.A.  $n= 26$  (7.28%) and, vice versa, a shift from a zero G.P.A. to a positive G.P.A.  $n= 21$  (5.88%). This phenomenon may occur with other onset variables, perhaps within a 30-day, 6-month, and 12-month alcoholic relapse log that a family maintains following a loved one's discharge from an inpatient treatment program. However, onset variables such as age at first abortion and or age at first sexual experience do not permit the responder to migrate from a positive value back to a zero response.

Besides understanding onset variables, applied researchers should consider the following three points when analyzing radically nonnormal distributions: 1) Type I error rates are fine and do not make much difference as it relates to power; 2) Researchers are encouraged to use Cohen's (1988)

power tables with no adverse effect; and, 3) A study is likely to have more power if a nonparametric statistic is employed rather than a parametric statistic.

This study represents the first longitudinal report of discrete mass at zero with gap. Future research should investigate other constructs and onset variables in order to determine if the population distributions behave in a similar or dissimilar fashion. It would also be important to gain an understanding of academic data sets in which student scores consistently remain at zero over time as well as to understand the factors associated with migration towards zero.

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## Appendix. Five-year Systematic Review

Information provided from least current to most recent: Author/Year, Population, Inclusion Variable, DMZ (Discrete Mass at Zero) Consideration.

Simons & Thase (1992), 53 patients with major depression, Age of onset of first depression, No

Barkley et al.(1992), 61 adolescents with ADHD, Age of ADHD onset, No

Mulhern et al.(1992), 49 long-term survivors of childhood leukemia, Age at diagnosis, Age at testing, No

Wieczorek & Miller (1992), 156 convicted-while-intoxicated offenders, Age at first drink, No

Killen et al. (1992), 618 smoking cessation participants, Age began smoking, No

Mueser et al. (1992), Review article, Age at first Hospitalization, No

Burman et al. (1993), Married couples: 17 physically aggressive 15 verbally aggressive 18 withdrawing 15 non-distressed, low-conflict Physical aggression scores, No

St. Lawrence (1993), 195 African-American adolescents, Sexual behavior: Number sexual partners & frequency of un-protected sex in past 6 months; Condom use during first intercourse & frequency of protected & unprotected sex in past 6 months, No

Ludwick-Rosenthal & Neufeld (1993), 72 first-time cardiac catheterization patients, Age at first catheterization, No

Farrell & Danish (1993), 1,256 middle school Students, Frequency of drug use past 30 days & frequency of peers offering alcohol & drugs past 30 days, Zero was removed from the scale and replaced with a "1" = never

Darkes & Goldman (1993), 218 male undergraduates screened for a sample of 70 who drank  $\geq 6$  &  $\leq 40$  servings of alcohol/week, 4-week retrospective consumption record, 148 non-users & extreme drinkers were excluded

Leaf et al. (1993), 820 records from 466 female & 361 male, Retrospective analysis included the General Health Questionnaire used to detect acute case onset of distress, Zero treated as the *best possible mental health*. Scattergram provided

Thackwray et al. (1993), 65 bulimic females in different types of treatment for bulimia nervosa, Six-month follow-up of binge eating & purging frequency, 15-69% of participants were abstinent from binge eating & purging

Domencio & Windle (1992), 616 female adult children of alcoholics and non-alcoholics, Number years married Alcohol use past 30 days Cigarette/marijuana use, No

Fairburn et al. (1993), 75 bulimic patients, Degree of attitudinal disturbance: 0-7, 8-10, & 11-12, No

Hughes (1993), Review of pharmacotherapy of smoking cessation, Abstinence rates, DMZ distribution included

Kalichman et al. (1993), 468 males, HIV-related risk factors, Two risk behaviors moved to zero following disclosure at 17 days

Willett & Singer (1993), Review of discrete-time survival analysis as it pertains to event occurrence, Onset of : Suicide ideation Depression Cocaine relapse, Authors introduce discrete-time survival analysis with real clinical data. DMZ distributions included

Stephens et al. (1994), 161 males & 51 females seeking treatment for marijuana use, Age first marijuana use or age first daily use. Alcohol & drug use past 90 days. Marijuana relapse over 12 months., Included DMZ line graph that plots abstinence post-treatment

Harris et al. (1994), 653 serious criminal Offenders, Year of index offense Teen alcohol abuse 0(none) Elementary school maladjustment 0 (never drank), DMZ distributions generated using PCL-R scores

Delucchi (1994), Review of binary outcome results, 2-group  $p$  values, DMZ distributions generated using  $p$  values

Miller-Johnson (1994), 88 children with Type II diabetes, Age at Diagnosis, No

Hiss et al. (1994), 18 participants with obsessive-compulsive disorder, Mean age of onset of symptoms, No

Drummond & Glautier (1994), 35 alcoholic men, Age of first drink. Age first problem drinking. Age first morning drinking. Age first morning withdrawal. Alcohol consumption post follow-up period., No

Loeber & Farrington (1994), Review, Age of onset. Age at termination. Age at committing behavior for the last time., Discussed violations of normality. Notes that it is rare to follow subjects > 1 year.

Epstein & McCrady (1994), Review & Commentary, Age of onset. Degree of sociopathy., Authors suggest comparing subjects along a continua such as age of onset.

Ball et al. (1995), 399 cocaine abusers, Age at onset of drug abuse. Frequency cocaine use past 30 days., No

St. Lawrence et al. (1995), 246 African American adolescents, Age at first intercourse. Number of sex partners past 12 months. Alcohol & marijuana use past 2 months. Perception of personal HIV risk: 0 (no) to 10 (high-risk) scale., No

Talcot et al. (1995), 332 military recruits, Number months smoking. Percent smoking per day: 0-10, 11-20 & 21+., No

Simons et al. (1995), 53 outpatients prior to cognitive therapy treatment, Age at onset of first depression, No

Curry et al. (1995), 1,137 smokers, Age at smoking onset. Longest previous period of abstinence., No

McMillen et al. (1995), 154 low-income women who were sexually abused as children, Age at first abuse, No

O'Connor et al. (1996), 516 smoking cessation participants, Age of onset of smoking. Number of lifetime quit attempts., No

Pianta et al. (1996), 110 women in second trimester of pregnancy, Number of T  $\geq$  65 elevations range: 0 (44%) to 7 (5%), No

Newman et al. (1996), 961, 21-year-olds from New Zealand's Health & Development Study(DMHDS), Age of onset of mental disorders, Authors did not assess disorders before age 10

Bartlett et al. (1996), 130 obese women, Age of onset of obesity. Age first overweight by 6.8 kg. Number diets lasting < 3 days past year., No

Gardner et al. (1996), 357 pairs of psychiatric Emergency Room Patients, Level of seriousness of violence, DMZ distribution included. Authors note extreme skew & non-normality.

Basen-Engquist et al. (1996), 5,537 high school students, 25 health risk behaviors beginning with zero, No

Ichiyama et al. (1996), 274 men in MSU-UM Longitudinal Study, Onset of alcohol-related difficulties over the life-span, No

Dobkin et al. (1997), 82 mother-son dyads subsampled from 1,037 French-speaking Canadian boys. All Fathers were alcoholic, Early-onset of substance abuse, No

Webster-Stratton & Hammond (1997), 97 children with early-onset conduct problems. Parents: 95 mothers & 71 fathers., Age of onset of conduct problems., No

Curran et al. (1997), 363 Hispanic & Caucasian adolescents, Individual & peer alcohol use, 74 families dropped from study because child reported no individual or peer alcohol use

Grilo et al. (1997), 114 adolescent Psychiatric inpatients, Age at first psychiatric contact & psychiatric hospitalization; number of prior psychiatric hospitalizations, No

Agras et al. (1997), 93 obese women, Age of onset of being overweight and age of onset of binge eating, No