RELIABLE CHANGE
&
THE RELIABLE CHANGE INDEX IN THE CONTEXT OF EVIDENCE-BASED PRACTICE:
A TUTORIAL REVIEW

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NZPsS Conference

Wellington

2 – 4 September, 2016

Abstract

Background: The concept of Reliable Change in the context of psychological treatment was introduced by Jacobson and colleagues in 1984. Their Reliable Change Index (RCI) specifies the amount of change a client must show on a specific psychometric instrument between measurement occasions for that change to be reliable, i.e., larger than that reasonably expected due to measurement error alone. Only if change is reliable is it then meaningful to consider if it is practically or clinically significant. Evidence of reliable change is, therefore, at the heart of evidence-based practice. Despite this, reliable change and the RCI is rarely considered either in applied/clinical research or practice.

Aims: This talk will review the psychometric foundations of the RCI and relate this to clinical/applied/practical significance.

Main contributions: In addition to showing how the RCI is calculated for any particular psychological measure I will also demonstrate a graphical procedure that practitioners can use to systematically track, client by client, if they are producing reliable change. I will also show how this can be extended to show if the change is clinically significant. Modifications of the RCI for neuropsychological testing to take account of practice effects will also be discussed.

Conclusions: The paper will review the concept of Reliable Change and provide a tutorial in its use and interpretation for researchers and practitioners.

The Challenge of Change

Change central to all applied & clinical psychology

Detect
Induce
Measure
Analyse
Theorise
Explain
Predict & Control
CHANGE

Methodological challenges researching change (1)

Focus

- within-participant change
- Not between participant difference
  - Rutherford “stamp collecting”
  - Skinner “botanizing”
  - Lakens (2013)
    “designism”

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for *t*-tests and ANOVAs. *Frontiers in Psychology, 4*, article 863

[Typical] studies involve two groups, one of which is subjected to some manipulation and the other of which is not. The mean scores of the groups are compared, and if they differ, it is concluded that the manipulation caused the individuals to shift their opinions, attributions, or whatever…At least two things should be noted about this dreadful literature. First, between-persons data are being used to make an inference of a within-individual effect. Second, a group effect (summed over persons) is being used to infer a causal effect whose nexus is located within the individual. Neither inference is warranted .

[Rorer, L.G., & Widger, T.A. (1983). Personality structure and assessment. *Annual Review of Psychology, 34*, 431-463.]

Methodological challenges researching change (2)

Focus

- On Individuals, not
- Group means

So we need

idiographic

as well as

nomothetic

science

The application of knowledge is always to the individual case (Allport, 1942, p 58)

Causality operates on single instances, not on populations. (Cohen, 1994, p 1001).

… it is the individual organism that is the principle unit of analysis in the science of psychology. (Barlow & Nock, 2009, p19).

Nomothetic vs idiographic research

nomothetic

- Concerned with general laws
- Concerned with the universal
- Abstract
- Timeless
- Objective/impersonal
- Inter-individual research
- Legacy of Quetelet/Fisher

idiographic

- Concerned with the individual case in context
- Concerned with the particular
- Concrete
- Historically situated
- Subjective/personal
- Intra-individual research
- Legacy of Bernard/Pavlov/ Skinner

This is not a trivial issue

Addictive Behaviors 36 (2011) 1228–1232

Contents lists available at ScienceDirect

Addictive Behaviors

Utilizing reliable and clinically significant change criteria to assess for the development of depression during smoking cessation treatment: The importance of tracking idiographic change ☆

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ARTICLE INFO

Keywords:
Smoking
Depression
Reliable change
Clinically significant change

ABSTRACT

Studies typically measure mood changes during smoking cessation treatment in two ways: (a) by tracking mean change in depression scores or (b) by tracking the incidence of major depression development using diagnostic assessments. However, tracking mean change does not capture variability in individual mood trajectories, and diagnosing participants at multiple time points is time and labor intensive. The current study proposes a method of assessing meaningful increases in depression without the use of diagnostic assessments by utilizing reliable and clinically significant change criteria. This method was applied to 212 participants in a smoking cessation trial to explore the relationship between smoking status and depressed mood, assessed at baseline, end-of-treatment, and 2-, 6-, and 12-month follow-ups. High rates of reliable (24–28%) and both reliable and clinically significant increases (23–24%) in depressed mood were observed across all participants, regardless of whether or not they achieved abstinence. However, when we calculated group mean change in depression during the trial, only decreases in depressed mood where observed across several intervals. Findings indicate that utilizing reliable and clinically significant change criteria to track symptoms of depression during smoking cessation treatment leads to different conclusions than simply tracking mean changes. We propose that a combination of reliable and clinically significant change criteria may serve as a useful proxy measure for the development of major depressive disorder during smoking cessation.

The concept of *Reliable Change*

Why do we need this concept?

Because

- What we study is intrinsically variable

(a natural phenomenon)

- We make errors of measurement in measuring things

(an inevitable part of measurement)

- Change affects observed variability
- Challenge: to separate the variability due to change from the variability due to measurement error

Also

In applied/clinical contexts we need change to be large enough to make a difference

Clinical significance

When a client ends up [with a score] in the range of a normative peer group after therapy she/he has met one of two necessary conditions for being classified as "improved". The other criterion is that there must have been change during the course of therapy. It is nonsensical to speak of clinically significant treatment effects when no change has occurred … Jacobson, et al.(1984, p 343)

Yes, but

How much change should there have been for a client who ends up in the normative range to be considered "improved"? ….

More generally, in order for change to be considered clinically significant it must also be statistically reliable; We must be able to determine that the change is "real".

[Jacobson, et al., (1984, p 344)]

So

"reliability" of change is prerequisite for

"clinical significance" of change

How to determine if change is statistically reliable/ “real” – Reliable Change

Reliable change

&

The Reliable Change Index

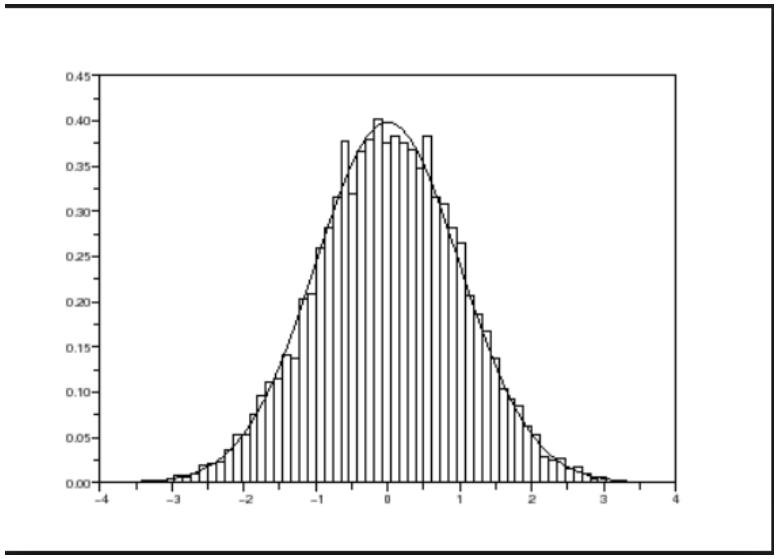
Key reference

Jacobson, N.S., & Truax, P. (1991). Clinical significance: A statistical approach to defining meaningful change in psychotherapy research. *Journal of Consulting & Clinical Psychology, 59*, 12 – 19.

NB: has the correct formulas (Jacobson, et al., 1984 was wrong)

Reliable Change & Measurement Error

Frequency of error



- 17 - 18th C astronomy
- One astronomer
- One telescope
- Observing one object

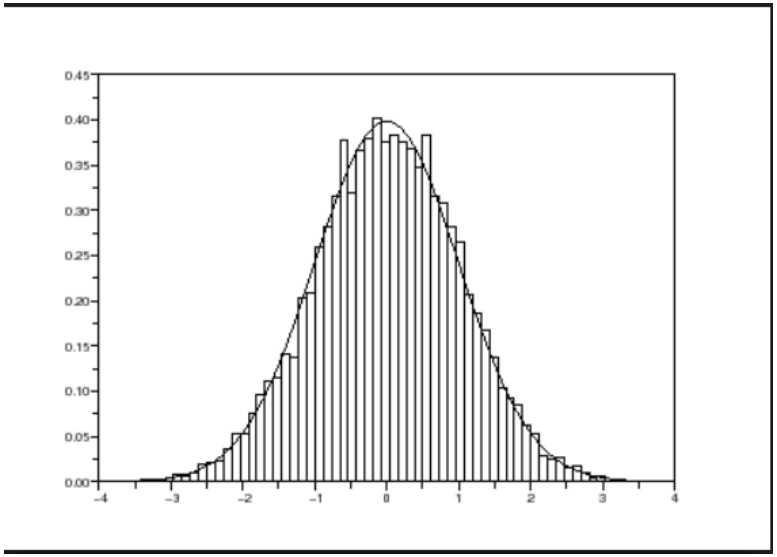
Errors of observation:

- Many small +/-
- Moderate # intermediate values +/-
- Few large errors +/-

Reliable Change & Measurement Error

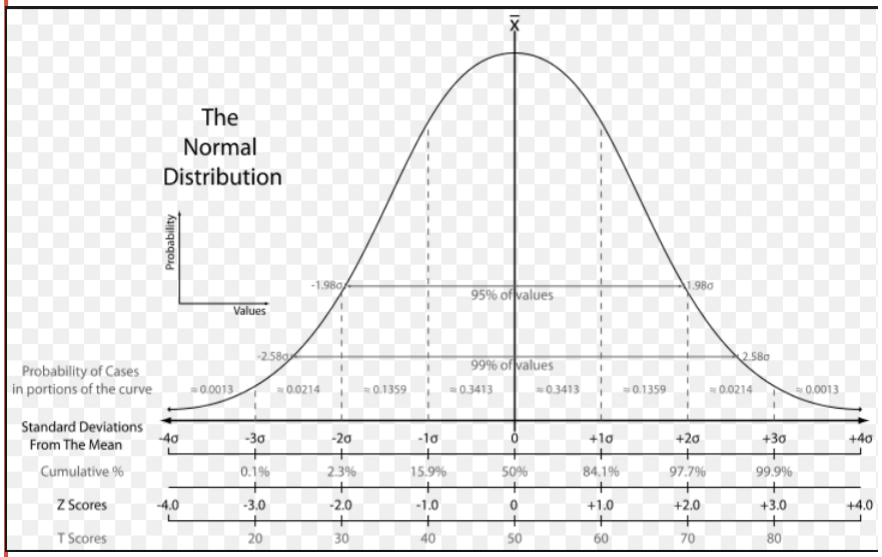
Frequency of error

The normal law of error



Measurement error is distributed systematically as -

The Gaussian distribution



Measurement error

- Unless measurement procedure is faulty, or
- Unless measurement instrument is biased

- ERRORS are NORMALLY DISTRIBUTED

- So, all properties of the Normal Curve apply to error distributions

- Mean = 0
- SD – is called ‘The standard error’ [SEM]of the distribution
- 95% if errors will lie +=/- 1.96 Standard Errors

Logic of RCI

Is the same as for the *t*-test

Observation = true score +/- error

Ho for any Difference Score ($X_{time1} - X_{time\ 2}$)

= no difference (true score 1 = true score 2)

(i.e., no treatment effect)

Therefore, if Difference Score ≠ 0, must be due to error

BUT, if Standardized Difference Score ≤ +/-1.96 this is improbable ($p < .05$) under Ho

Therefore we reject Ho and accept that there is a treatment effect (true score 1 ≠ true score 2) – in combination with error

Reliable Change

Steps & formulae

1. Compute Standard Error of Measurement

$$SE_M = s\sqrt{1-r_{xx}}$$

This is the SD of the errors of measurement of any measurement instrument/process

Function of

- Intrinsic variability of things being measured - *s*
- Reliability of the measure – r_{xx}

- Psychometrically, *s* is SD of some reference group
- r_{xx} is reliability of instrument – test-retest or Chronbach's alpha

Reliable Change

1. Compute Standard Error of Measurement

$$SE_M = s\sqrt{1-rxx}$$

2. Compute S_{DIFF}

$$S_{DIFF} = \sqrt{2(SE_M^2)}$$

A difference score will compound error from both measurements so

$S_{DIFF} > S_{EM}$

S_{DIFF} is SD of the errors of measurement of the **Difference Scores**

Reliable Change

Steps & formulae

1. Compute Standard Error of Measurement

$$SE_M = s\sqrt{1-rxx}$$

2. Compute S_{DIFF}

$$S_{DIFF} = \sqrt{2(SE_M^2)}$$

3. Compute the difference score for each individual

$$Diff = x_{t_1} - x_{t_2}$$

4. Compute $RC = x_{t_1} - x_{t_2} / S_{DIFF}$

This is the same as computing a *z-score*

It standardizes the difference – Called Reliable Change – in SD units

RC computation

Steps & formulae

1. Compute Standard Error of Measurement

$$SE_M = s\sqrt{1-rxx}$$

2. Compute S_{DIFF}

$$S_{DIFF} = \sqrt{2(SE_M^2)}$$

3. Compute the difference score for each individual

$$Diff = x_1 - x_2$$

4. Compute $RC = x_1 - x_2 / S_{DIFF}$

5. If RC≥1.96 a difference that large is in 5% tail of error distribution

- not likely due to measurement error alone – **Change not likely due to measurement error p < .05**

Example

1. If variability s = 7.5

Chronbach's α = .80

$SE_M = 7.5\sqrt{1- .8} = 3.35$

2. $S_{DIFF} = \sqrt{2(3.35*3.35)} =$ 4.74

3. So if

xt1 = 47.75

xt2 = 32.5 Diff = -15

4. -15/4.74 = -3.16

-3.16 > 1.96 – **Change is reliable**

RC – what you need to know to compute

Info about the measure

- S = SD of reference data-set
- r_{xx} = Test-retest reliability of measure (Chronbach's alpha)

Used to compute

1. SE_M
2. S_{DIFF}

NB:

RC = individual's standardized score

RCI is index – absolute value determines if score is in =/- 5% area of error distribution

Source

Generally get these from published sources reporting the development and norms of the measure

Use local norms if possible

OR – calculate from you own data (if sample is large enough)

Reliable Change (RC) & Reliable Change Index (RCI) -

RCI = the absolute value of the difference score required for RC to be reliable (i.e., unlikely, $p<.05$, due to measurement error alone)

From the example RCI = S_{DIFF} * 1.96 = 9.3

So: 15 > 9.3 - **Change is reliable**

Eqn 1: $RC = Diff/S_{DIFF}$

Eqn 2: $Diff = RCI = RC*S_{DIFF}$

NB: Literature is ambiguous about what “RC” & “RCI” refer to

Jacobson & Truax (1991) call RC an ‘index’.

But it is a standardized difference score

RCI is the absolute difference required for a change score to be regarded as reliably > measurement error

Calculating RC/RCI

Example

Specifically for the Depression scale of the DASS-42:

Step 1 Locate an appropriate source of test norms:

Lovibond and Lovibond (1995b) report the SD of their Australian normative sample as 6.54 and Chronbach's alpha as .91.

Step 2: by the formulae given in Jacobson & Truax, (1991) Calculate:

$SE_M = 1.64$

$S_{Diff} = 2.31$

RCI = 2.31 x 1.96 = 4.53.

Interpreting RC/RCI

RC & RCI may be + & -

Interpretation of RC/RCI depends on what increases or decreases in the measured score mean

Adjust Diff calculation so:

RC+ = Reliable Improvement

& RC- = Reliable Deterioration

RCo = Indeterminate change

DASS-42: S_{Diff} = 2.31, and RCI = 4.53.

Classifying			USING Standardized Score			
S#	Pre	Post	Difference	RC	?>/-1.96	
9	22	2	20	8.66	Yes	RC+
7	18	0	18	7.79	Yes	RC+
2	17	1	16	6.93	Yes	RC+
1	15	2	13	5.63	Yes	RC+
5	31	19	12	5.19	Yes	RC+
8	23	11	12	5.19	Yes	RC+
4	13	2	11	4.76	Yes	RC+
3	11	1	10	4.33	Yes	RC+
6	18	13	5	2.16	Yes	RC+
11	4	4	0	0.00	No	RC0
12	13	15	-2	-0.87	No	RC0
13	3	5	-2	-0.87	No	RC0
14	1	3	-2	-0.87	No	RC0
10	19	22	-3	-1.30	No	RC0
16	33	40	-7	-3.03	Yes	RC-
17	8	16	-8	-3.46	Yes	RC-
15	12	26	-14	-6.06	Yes	RC-

Classifyng				USING RCI		
S#	Pre	Post	Difference		?>+/-4.53	
9	22	2	20		Yes	RC+
7	18	0	18		Yes	RC+
2	17	1	16		Yes	RC+
1	15	2	13		Yes	RC+
5	31	19	12		Yes	RC+
8	23	11	12		Yes	RC+
4	13	2	11		Yes	RC+
3	11	1	10		Yes	RC+
6	18	13	5		Yes	RC+
11	4	4	0		No	RC0
12	13	15	-2		No	RC0
13	3	5	-2		No	RC0
14	1	3	-2		No	RC0
10	19	22	-3		No	RC0
16	33	40	-7		Yes	RC-
17	8	16	-8		Yes	RC-
15	12	26	-14		Yes	RC-

Conclusion

RC+ 9/17 = 53%

RC0 5/17 = 29%

RC- 3/17 = 18%

NB: RC+% is an Effect Size

RCI and Ceiling & Floor Effects

The RCo category will be affected by ceiling and floor effects.

May not matter as any individuals affected will likely not be in the clinical range @ baseline

Ceiling effect

Max score – RCI

Floor effect

Min score + RCI

If in this zone at baseline cannot show reliable + change

Methodological lessons

- ALWAYS think about Measurement Error
- Measurement error has 2 components
  - 1. Random error — No Control
  - 2. Systematic error — Can reduce

How?

- Systematic measurement **procedures**
- **Train** persons doing measurement
- **Calibrate** your measurement instrument

  Includes
  - Select valid measure
  - Match measure to cognitive abilities
  - Age appropriate language etc
  - Culturally appropriate measurement

Lessons ….

- Select measures with small SEM

  Makes it easier to detect reliable change

- Interpret statistical significance in light of RC/RCI
  - NHST is concerned with sampling error not measurement error
  - Error variance in ANOVA blends within-subject variance & measurement error
  - RC/RCI is concerned only with measurement error
  - A mean difference can be statistically significant yet be smaller than the margin of measurement error

Lessons …

- Use RC/RCI to group participants &/or select participants for research (Zarah & Hedge, 2010).
  - E.g., You do a mood manipulation as an independent variable in a therapy outcome study
  - By calculating the RC/RCI for the test of mood you can either
    - Classify participants as RC+/RCo/RC- (and see how that affects results), or
    - Use only those participants who have shown reliable change in mood in expt (manipulation check).

Calculating RC/RCI

Use a simple calculator following the Jacobson & Truax (1991) formulas

Or: There are Excel calculators on-line: e.g.,

https://www.google.co.nz/#q=reliable+change+index+excel

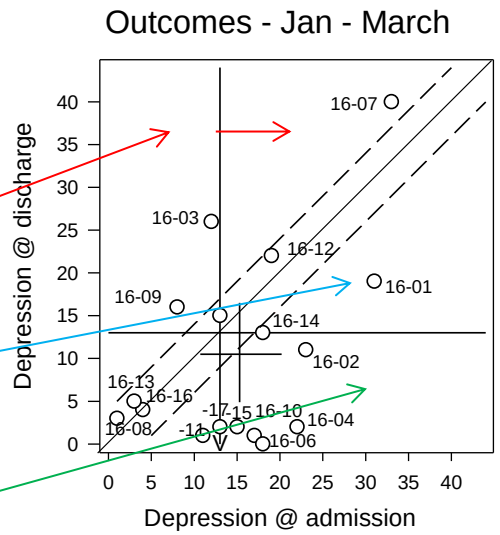
Warning, this spreadsheet confuses RCI and RC (labels).

Remember RCI is absolute value of difference score

RC is standardized score to compare with 1.96

Use to monitor practice/service

Template can be used to track outcomes achieved



Deterioration

Recovering

Clinically significant change

Fitzgerald, J., & Blampied, N.M. (2016). Assessment of change and outcomes in mental health settings. In Waikaremoana Waitoki, Jacqueline Feather, Neville Robertson, & Julia Rucklidge (Eds.). *Professional Practice of Psychology in Aotearoa New Zealand*

Caveat

Classic RC/RCI developed for clinical measures
(depression, anxiety, etc)

Neuropsychological, cognitive, educational measures etc
have practice effects to consider with repeated testing

RC/RCI formula needs adjusting for practice effect –
RC_{PE}/RCI_{PE}

& neuropsych often uses ±1.645 – covers the 90% of cases; $p<.1$

See Duff, K. (2012). Evidence-based indicators of neuropsychological change in the individual patient: Relevant concepts and methods. *Archives of Clinical Neuropsychology, 27*, 248 - 261

References

Jacobson, N.S., & Truax, P. (1991). Clinical significance: A statistical approach to defining meaningful change in psychotherapy research. *Journal of Consulting & Clinical Psychology, 59*, 12 – 19.

Fitzgerald, J., & Blampied, N.M. (2016). Assessment of change and outcomes in mental health settings. In Waikaremoana Waitoki, Jacqueline Feather, Neville Robertson, & Julia Rucklidge (Eds.). *Professional Practice of Psychology in Aotearoa New Zealand*

Wise, E.A. (2004). Methods for analyzing psychotherapy outcomes: A review of clinical significance, reliable change, and recommendations for future directions. *Journal of Personality Assessment, 82(1)*, 50-59.