



Welcome to the webinar:

Data visualization

Making great graphs with familiar tools

PCRC Investigator Development series
May 7, 2019

Host: Kate Miller, PhD, MPH
Senior Scientist, Ariadne Labs
Research Scientist, Harvard T. H. Chan School of Public Health
kmiller@ariadnelabs.org

Data visualization

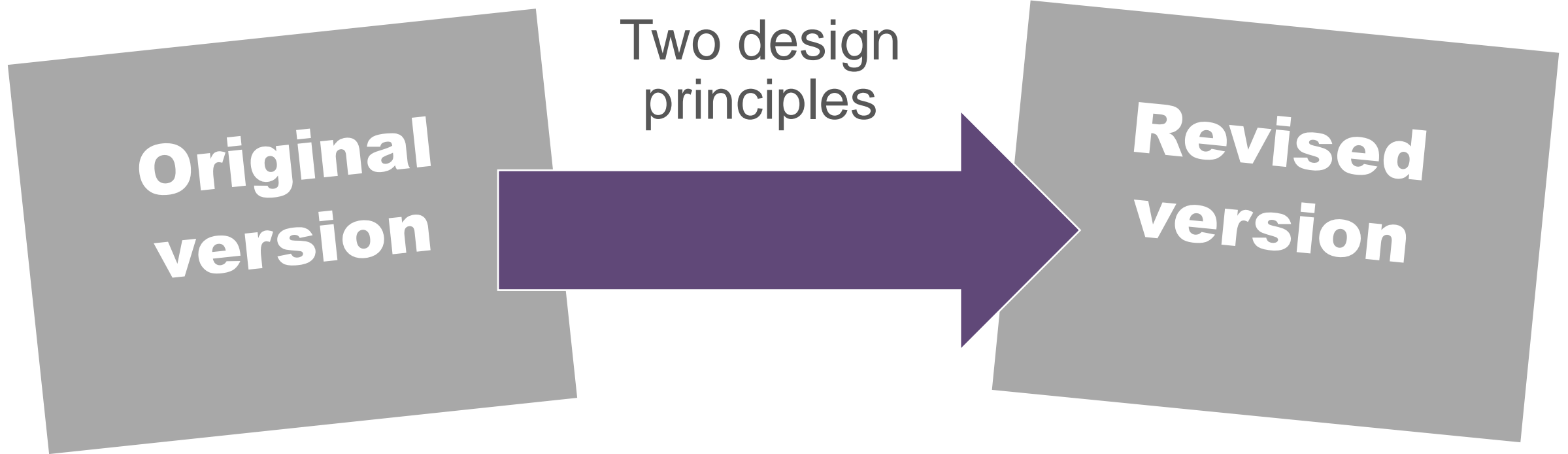
Making great graphs with familiar tools



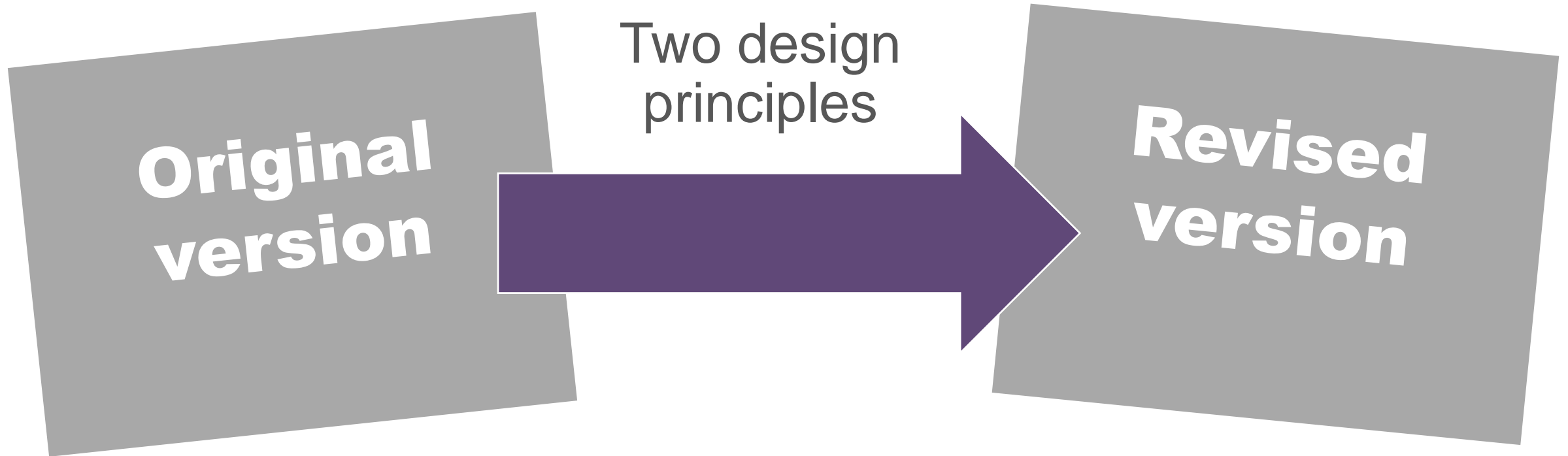
Outline

- | | |
|---|--------|
| 1. Live experiment | 10 min |
| 2. Graph makeover using two design principles | 20 min |
| 3. Presenting data to patients | 10 min |

Captured a graph in the wild



Captured a graph in the wild



Which is more understandable?

Conduct a study right now

1. Pose a question
2. Display the **original** for 5 seconds
3. Display the **revised** for 5 seconds
4. Webinar poll:

Which did you get the answer from?

What is this graph about?

Drug companies (or “the industry”) run clinical trials on new drugs and send the data to the FDA.

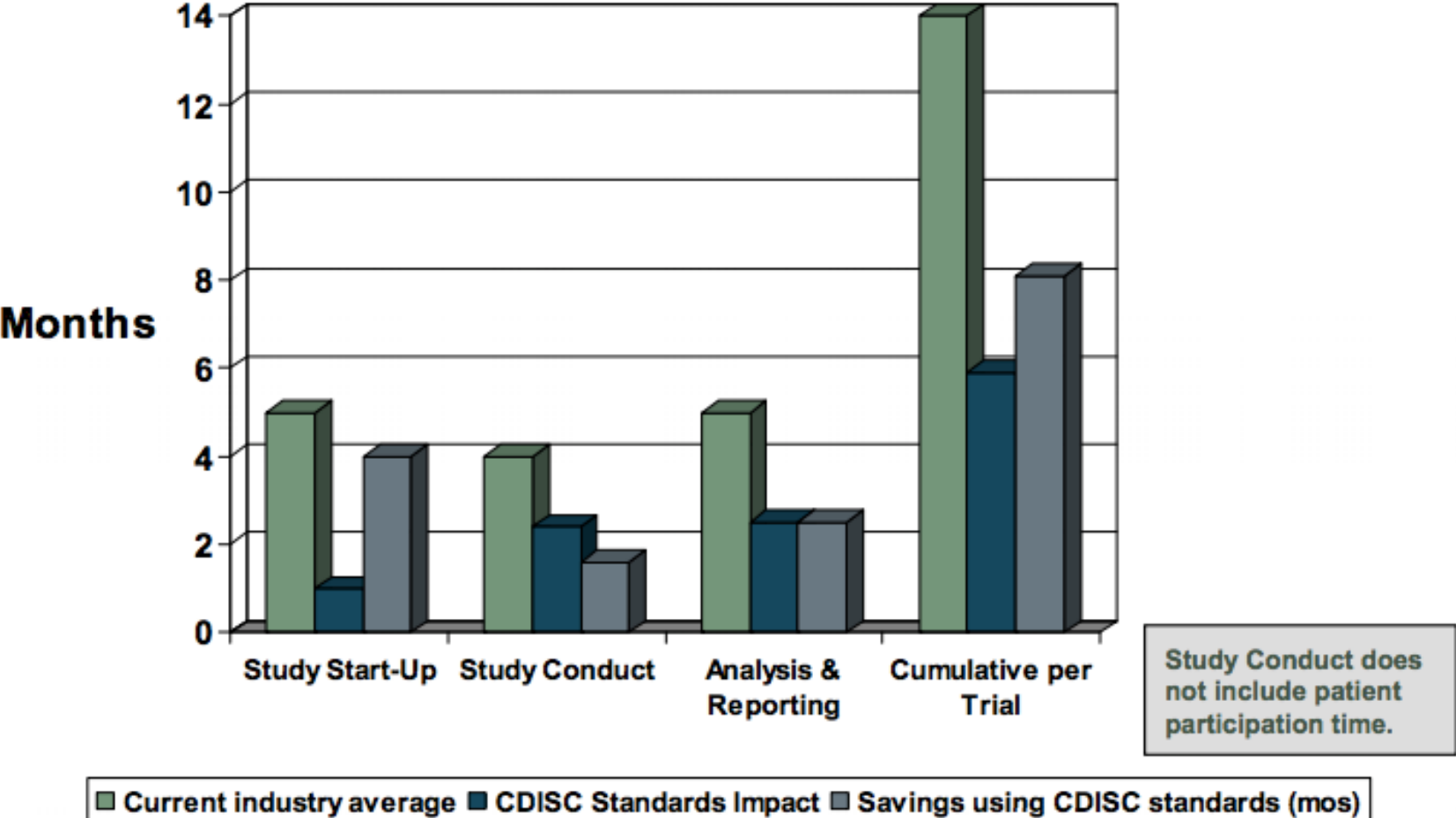
The FDA wants companies to use a standard data format called CDISC.

“Clinical study cycle time” is the total time needed for a drug trial.

Question

On average, how much time
do clinical trials save by using CDISC?

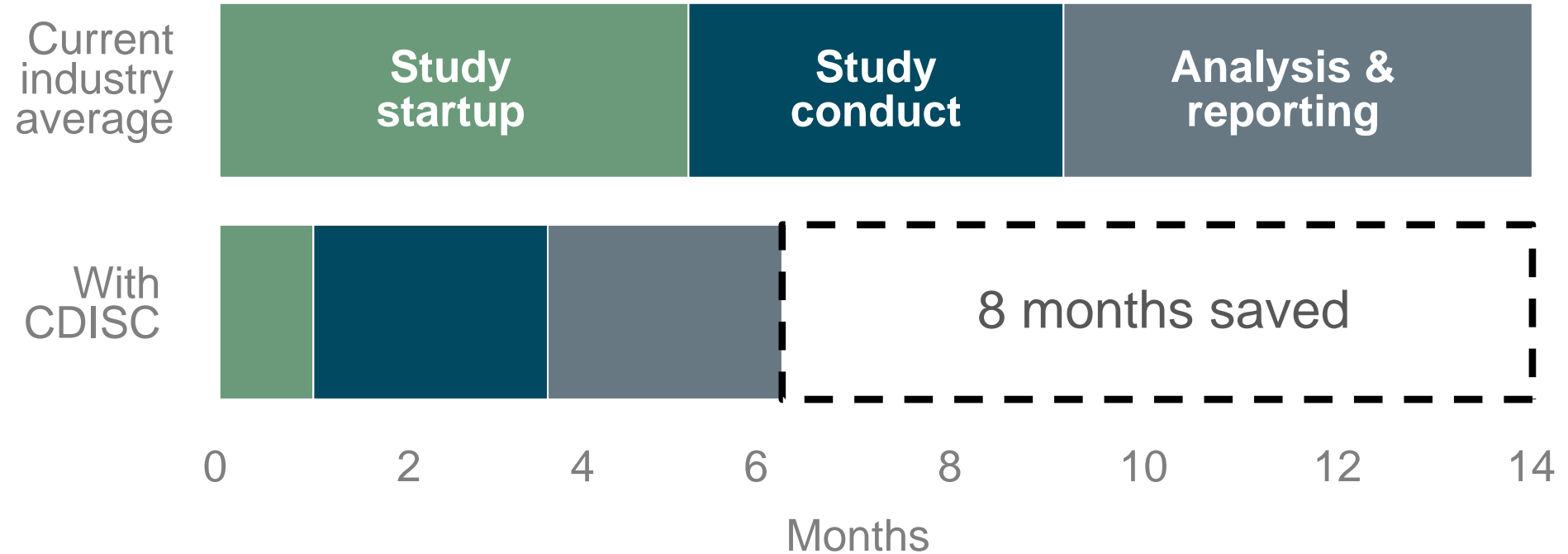
Impact of CDISC Standards on Clinical Study Cycle Time



Note: Figures are benchmarks based on aggregate data; study-specific cycle times and cost metrics will vary.

Revised

CDISC standards save eight months of clinical cycle study time



Study conduct does not include patient participation time.

Figures are benchmarks based on aggregate data; study-specific cycle times and cost metrics will vary.

Webinar poll

Which did you get the answer from?

Why does 5 seconds matter?

We live in a world of abundant data
and scarce attention

Why does 5 seconds matter?

We live in a world of abundant data
and scarce attention

Global scientific output
doubles about every 9 years



RESEARCH ARTICLE

**Growth rates of modern science: A bibliometric analysis
based on the number of publications and cited references**

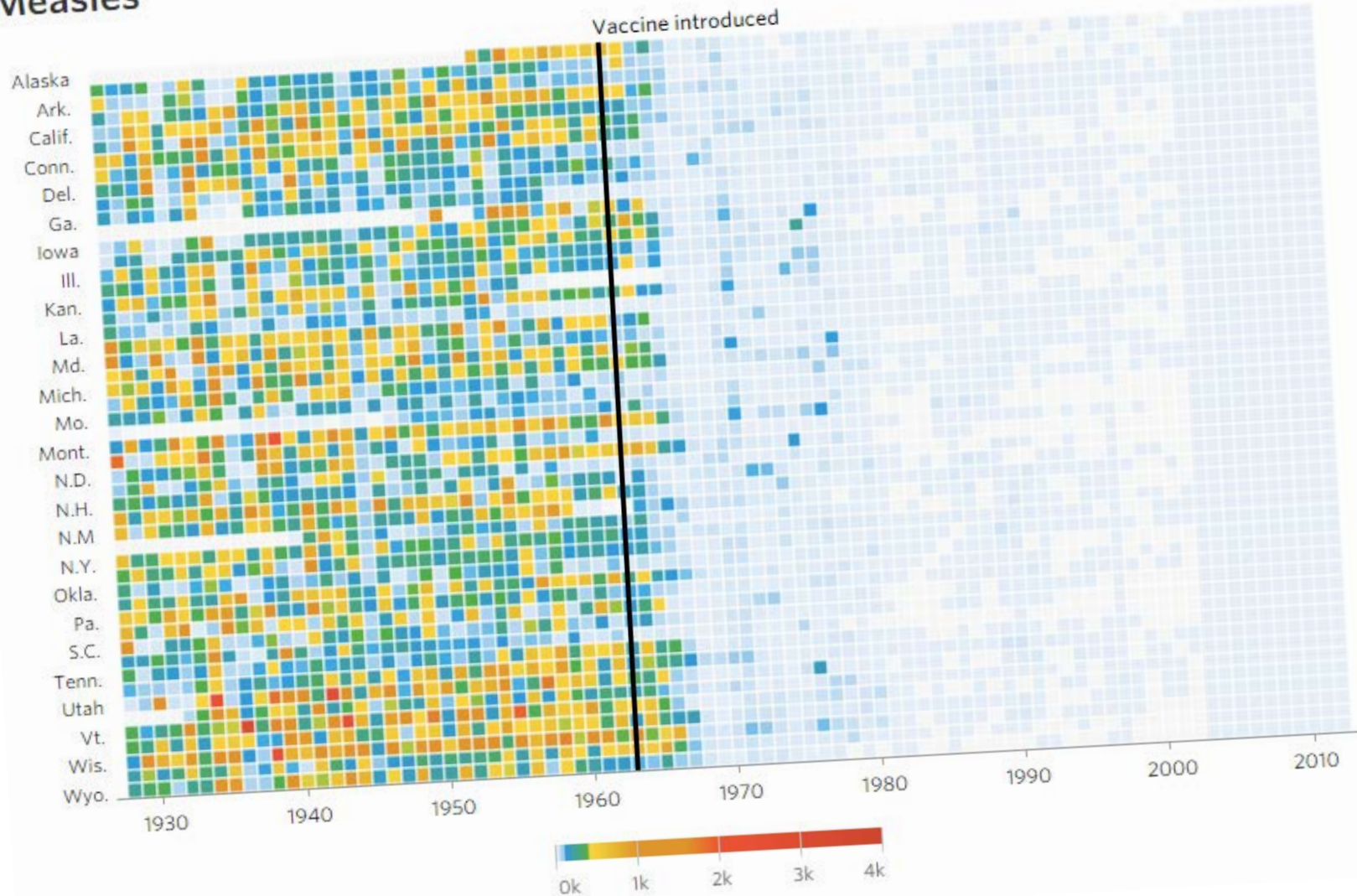
Lutz Bornmann, Rüdiger Mutz

First published: 29 April 2015 [Full publication history](#)

DOI: 10.1002/asi.23329 [View/save citation](#)

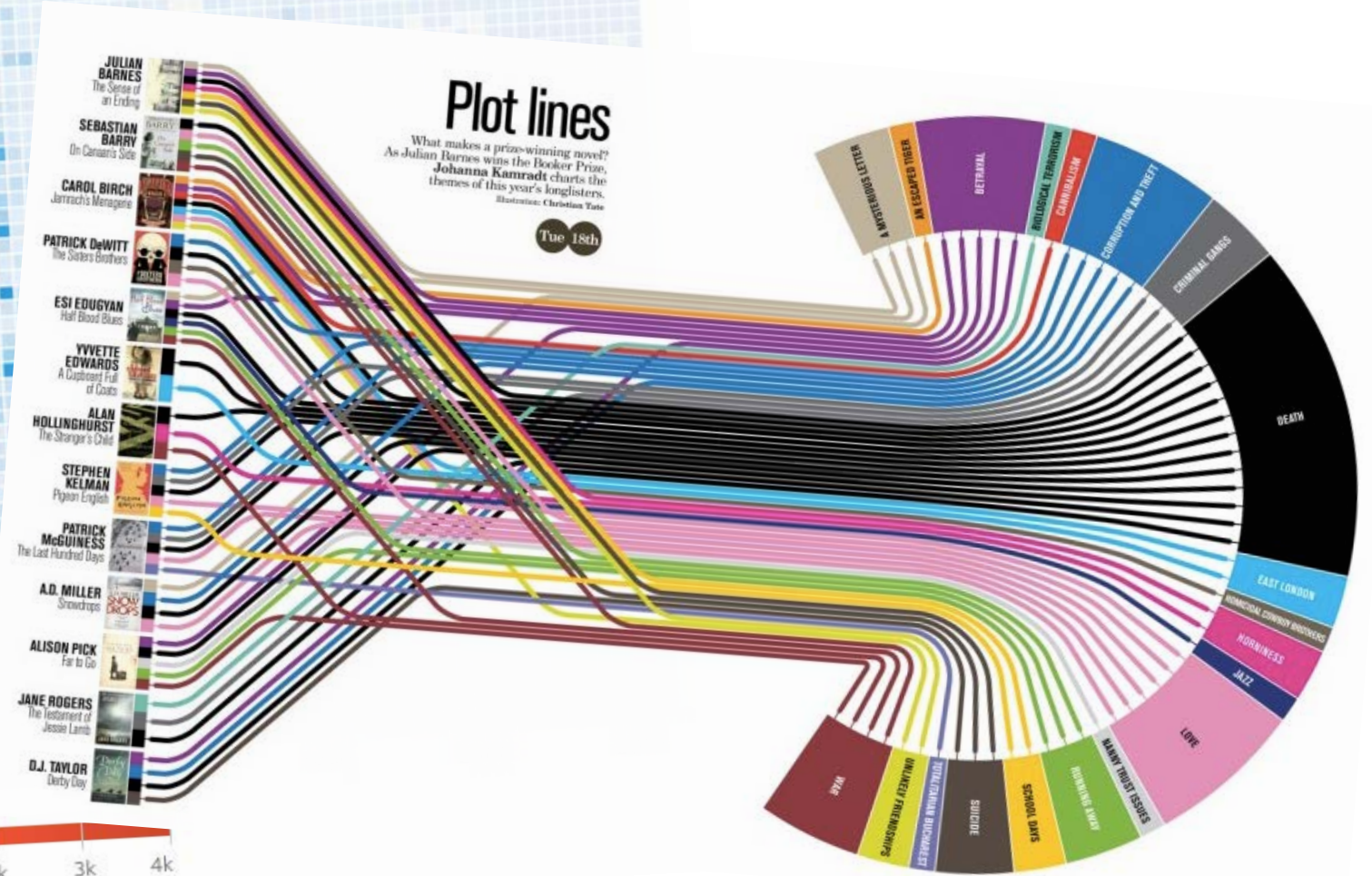
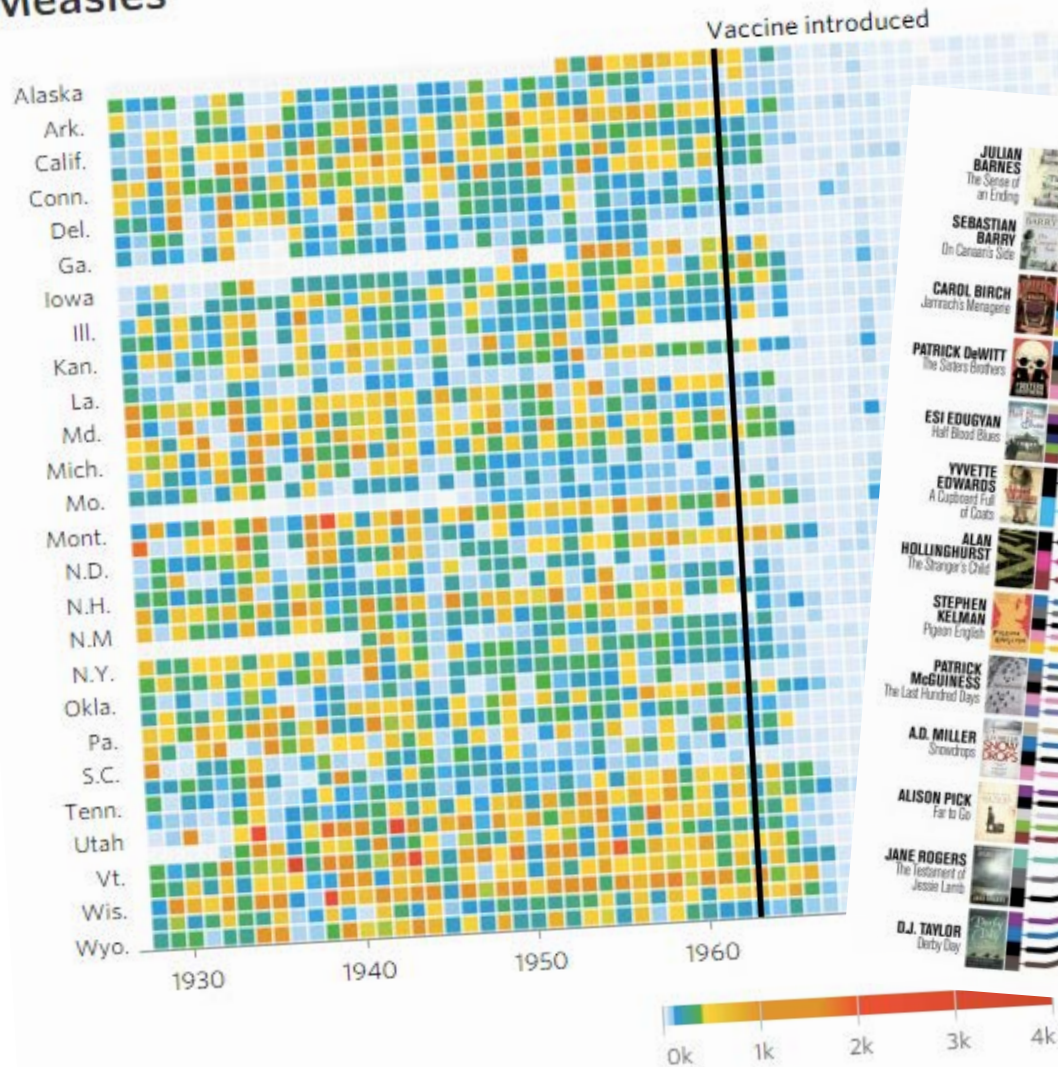
Explosion of the data visualization field

Measles



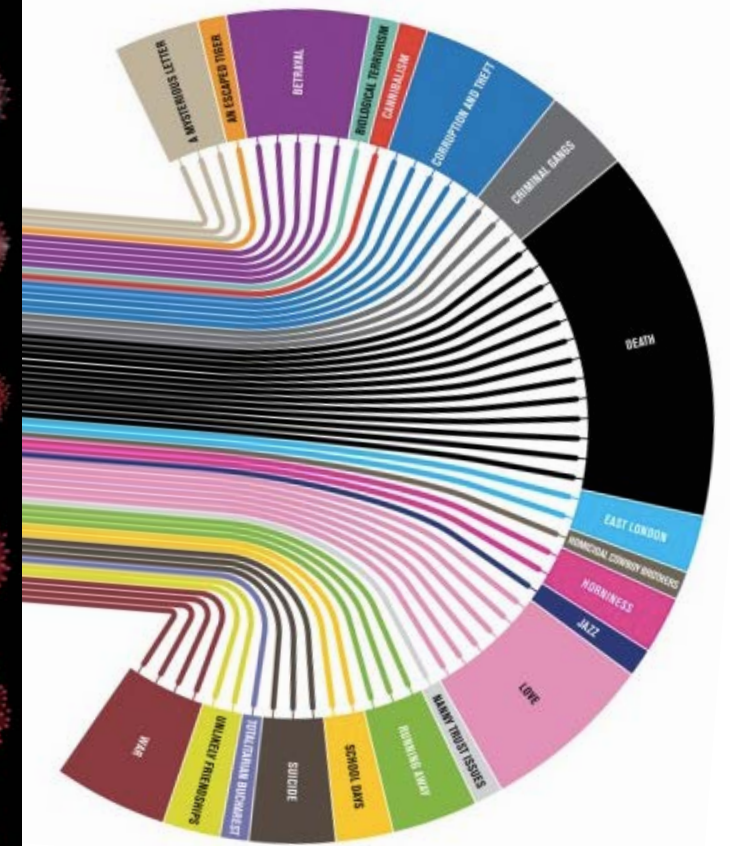
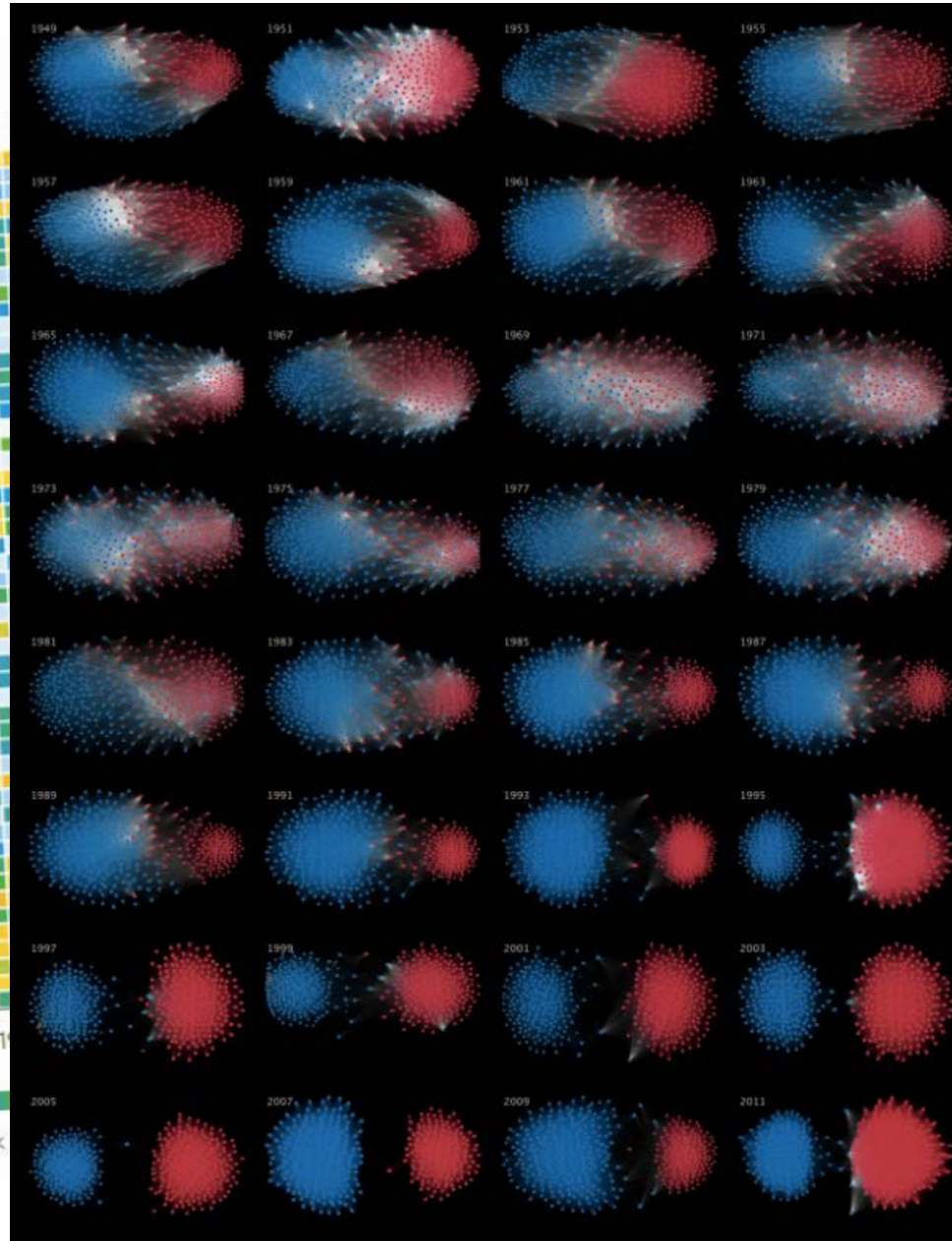
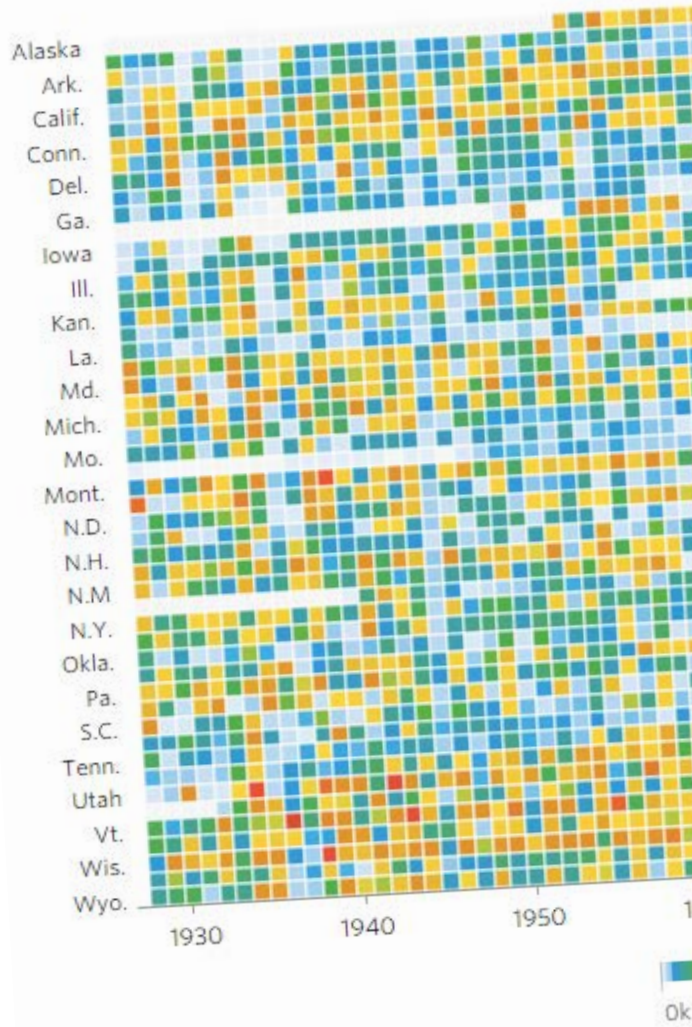
Explosion of the data visualization field

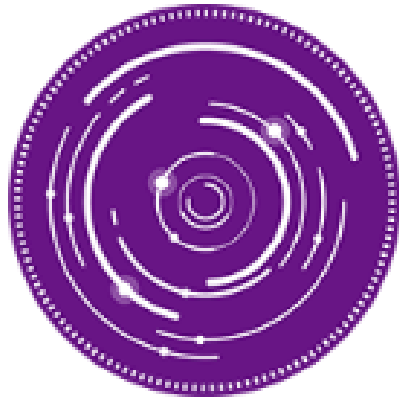
Measles



Explosion of the data visualization field

Measles



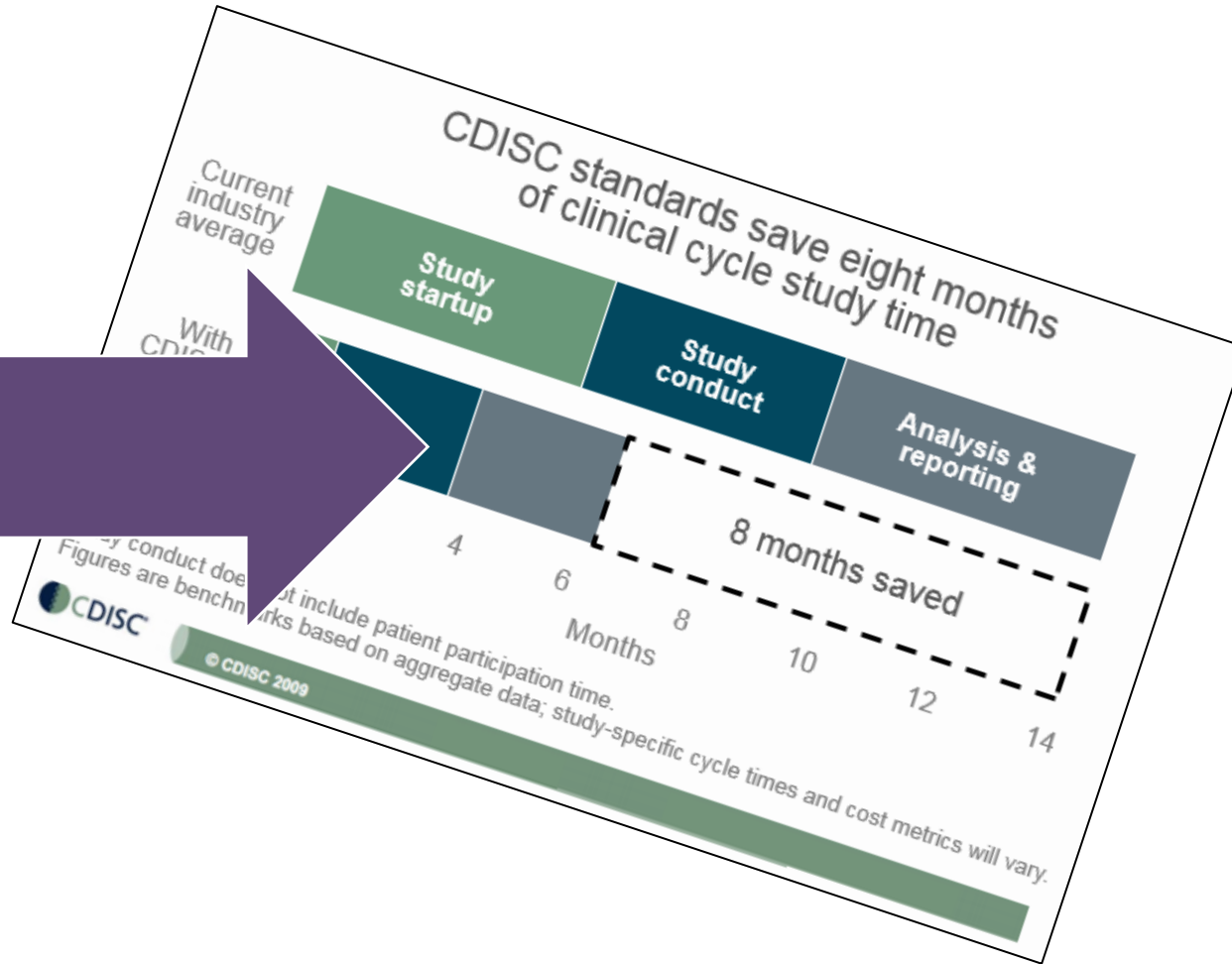
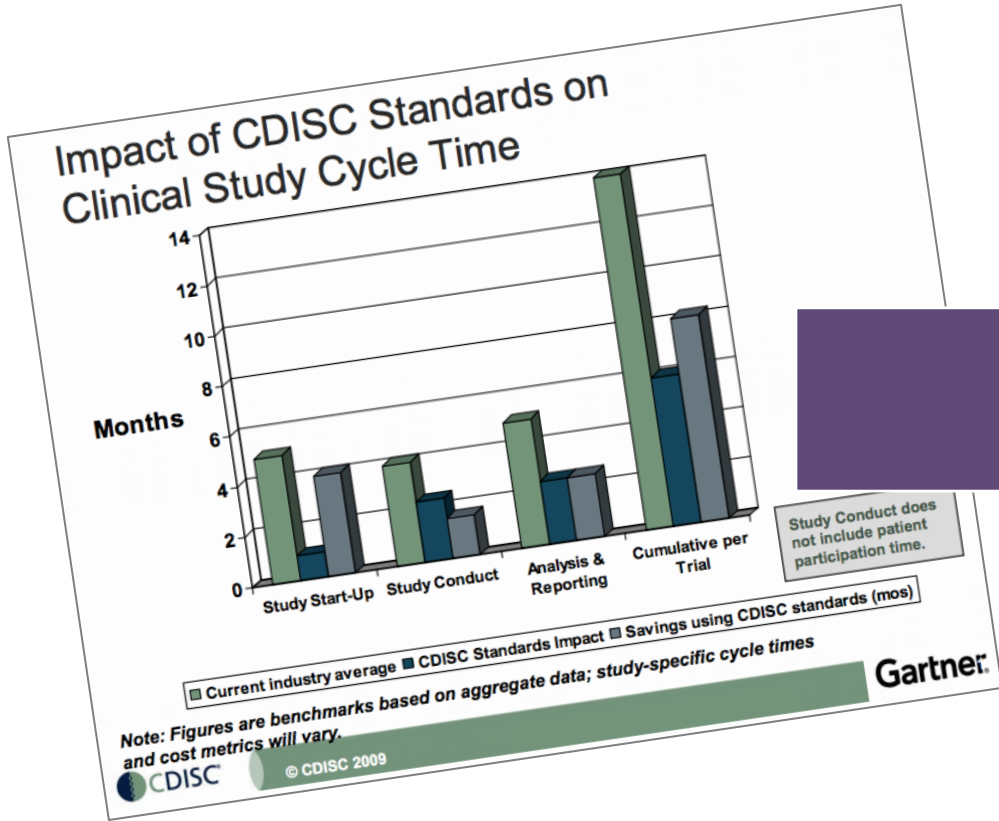


KANTAR

Information is Beautiful

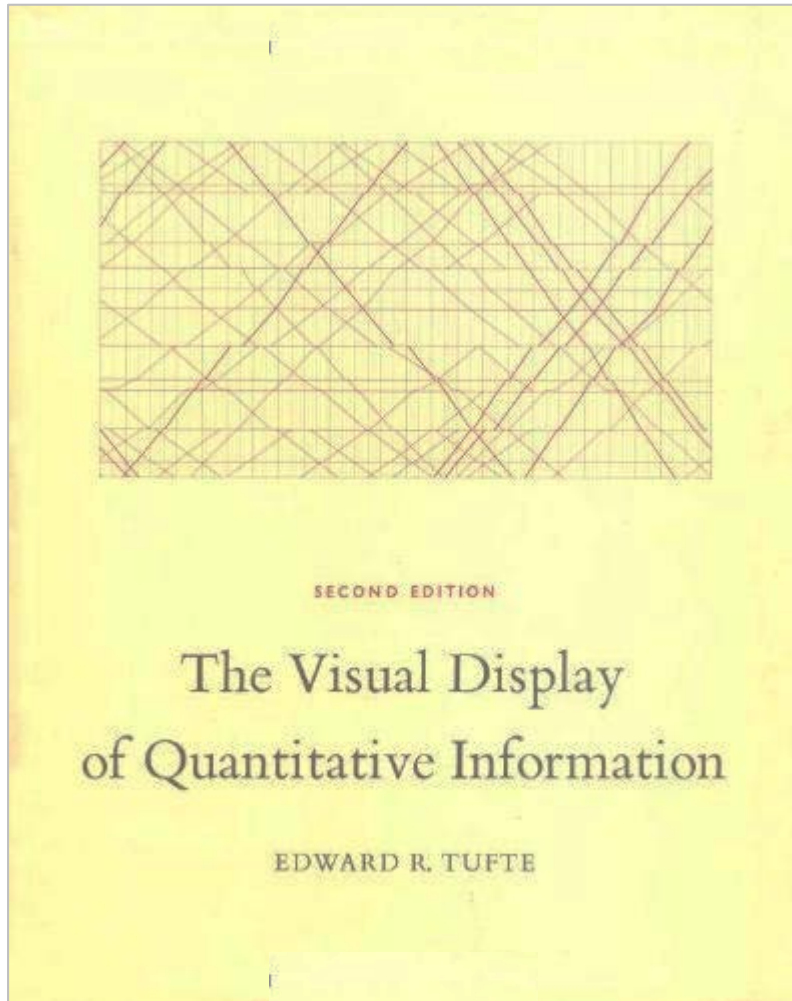
Awards 2018

Two design principles



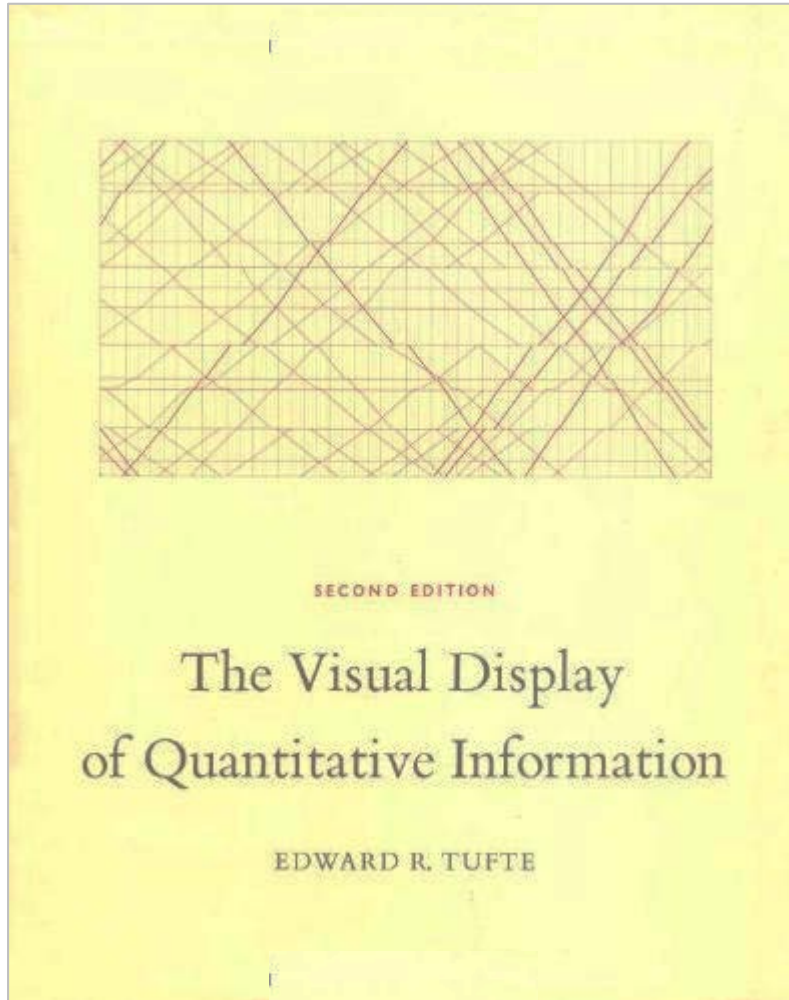
Data-ink ratio

Edward Tufte, 1983



Data-ink ratio

Edward Tufte, 1983

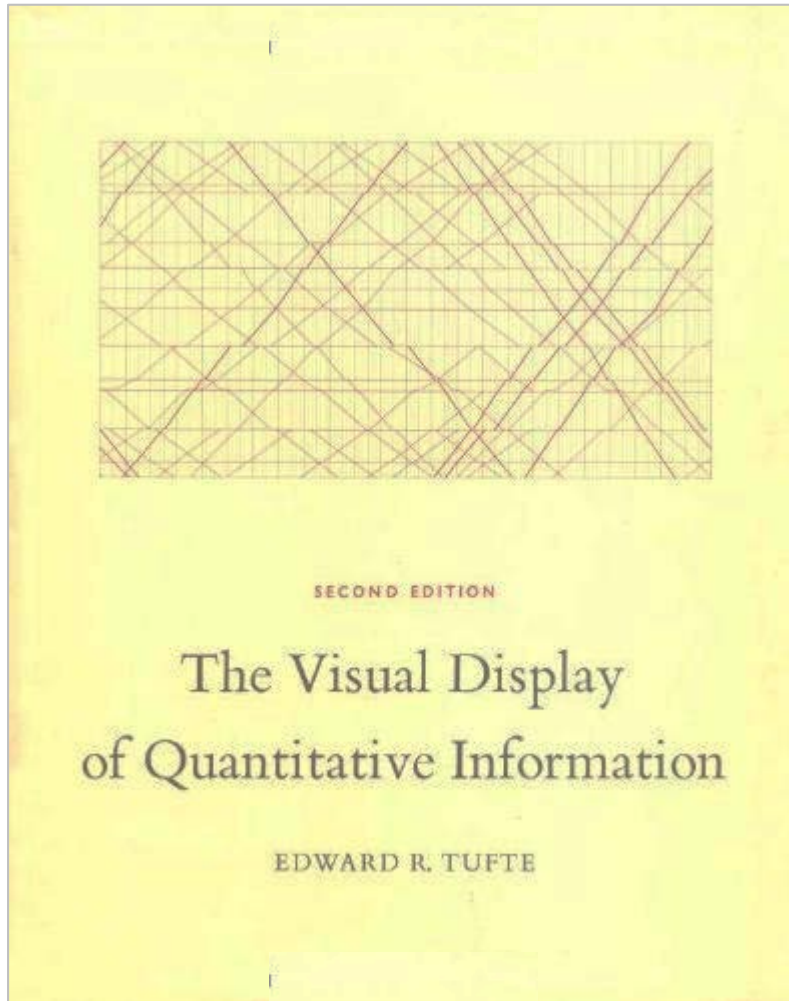


Data ink =

The ink used to display the data itself,
or the “non-erasable core” of a graphic

Data-ink ratio

Edward Tufte, 1983

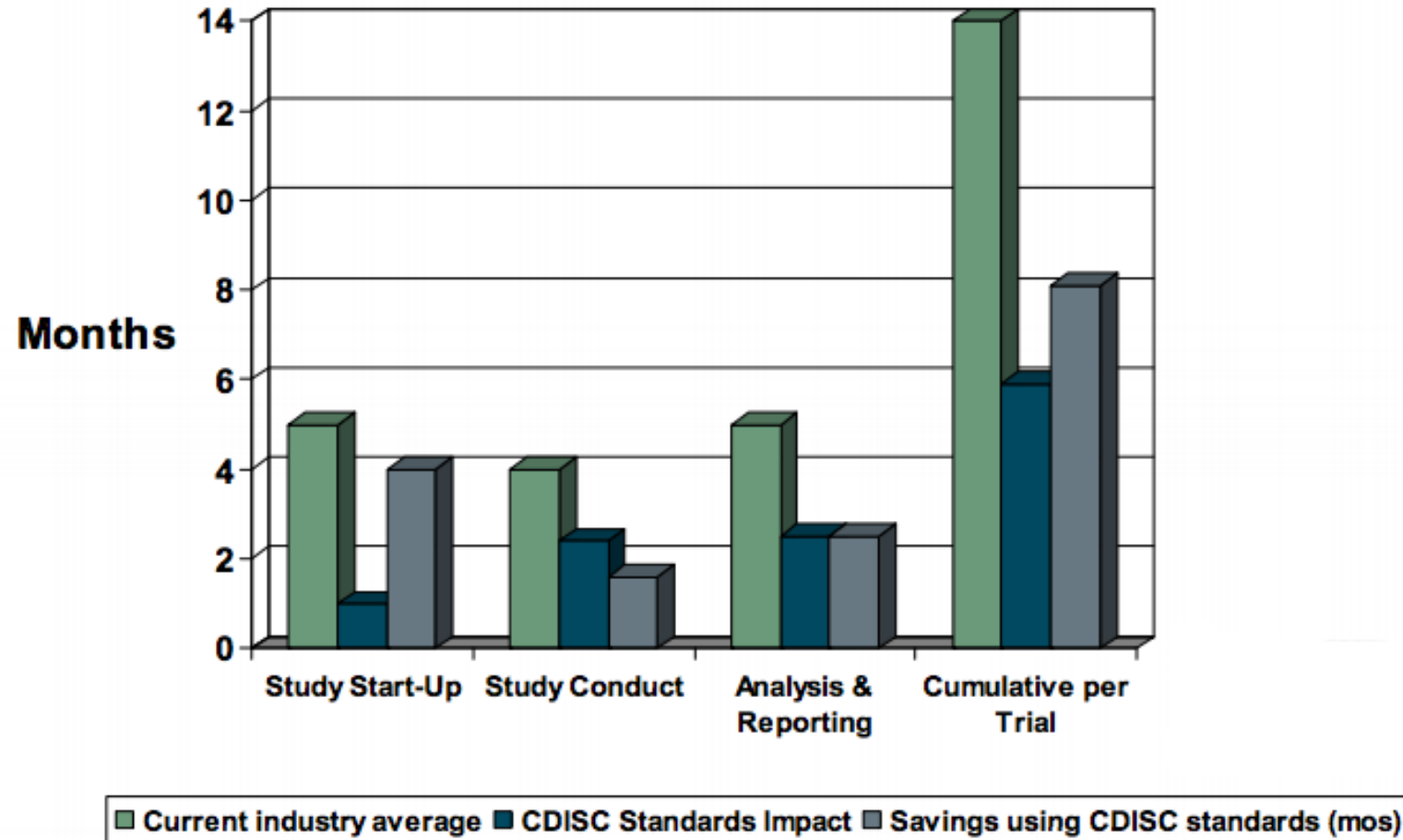


Data ink =

The ink used to display the data itself,
or the “non-erasable core” of a graphic

$$\text{Data ink ratio} = \frac{\text{Data ink}}{\text{Non-data ink}}$$

Identify non-data ink



Identify non-data ink

3-D axis

Gridlines

Months

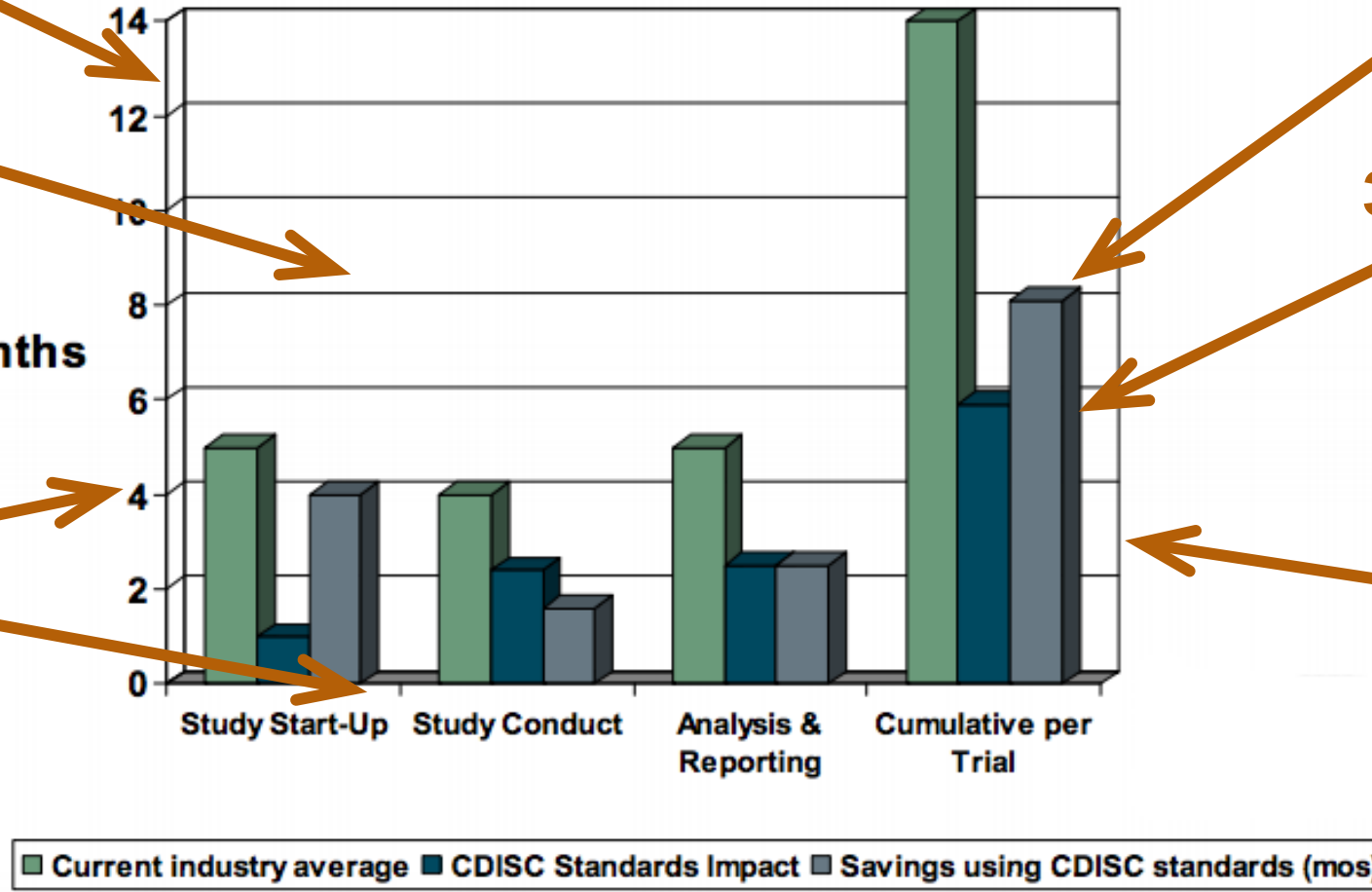
Tick marks

Outline around legend

3-D shapes

3-D shading

Chart area outline



The mortal sin of 3-D

APPLIED COGNITIVE PSYCHOLOGY
Appl. Cognit. Psychol. 14: 151–162 (2000)

Do Irrelevant Depth Cues Affect the Comprehension of Bar Graphs?

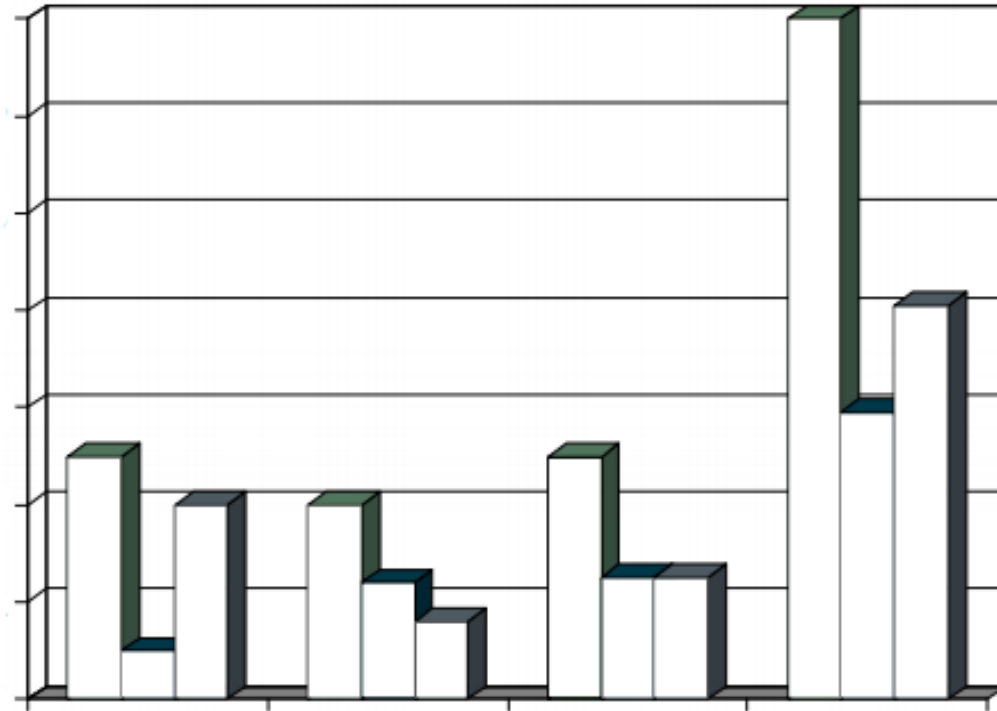
MARTIN H. FISCHER*

Department of Psychology, University of Munich, Germany

SUMMARY

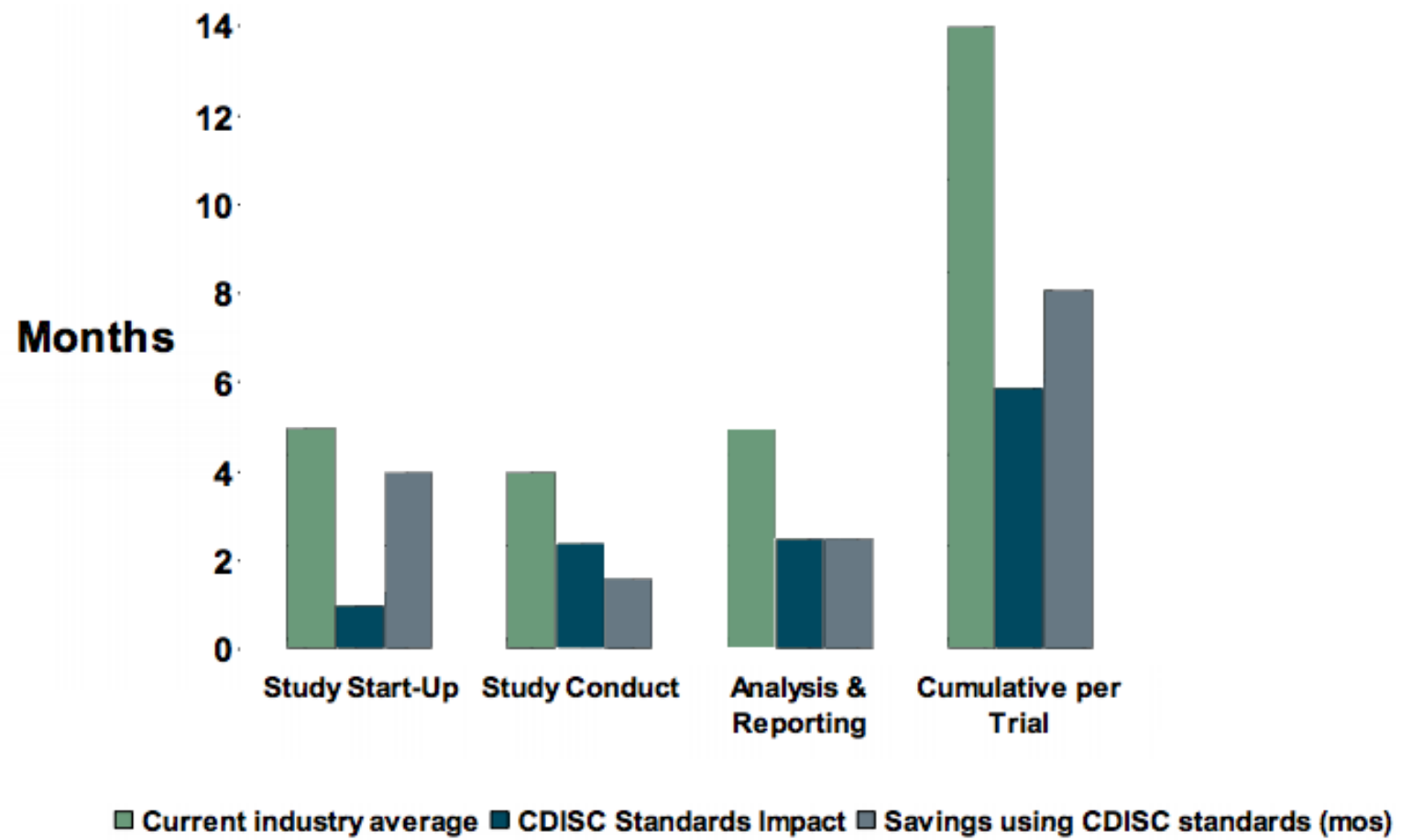
Eight participants decided whether two- or three-dimensional bars embedded within two- or three-dimensional frames were semantically consistent with written inequalities of the form 'A > B'. Inequalities were presented either before (Experiment 1) or after the graphs (Experiment 2). In Experiment 1, irrelevant depth cues were associated with slower decision times and there was no processing cost associated with an inconsistency between the

This is all the non-data ink



This is all the non-data ink





Cognitive ergonomics

Cognitive ergonomics



Make life easy and
comfortable for the
body at work

Cognitive ergonomics



Make life easy and comfortable for the **mind** at work



Make life easy and comfortable for the body at work

Cognitive ergonomics



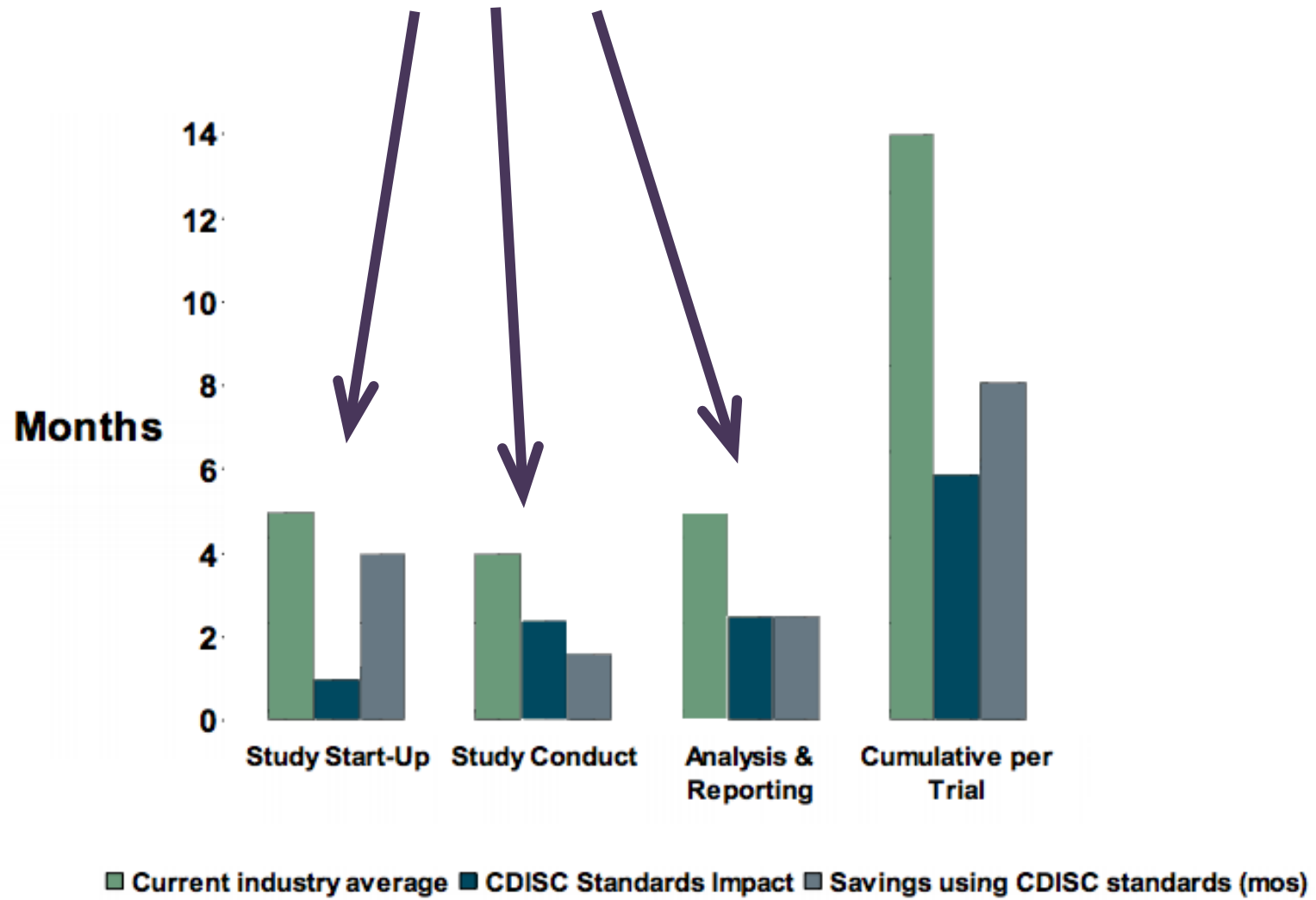
Make life easy and comfortable for the **mind** at work



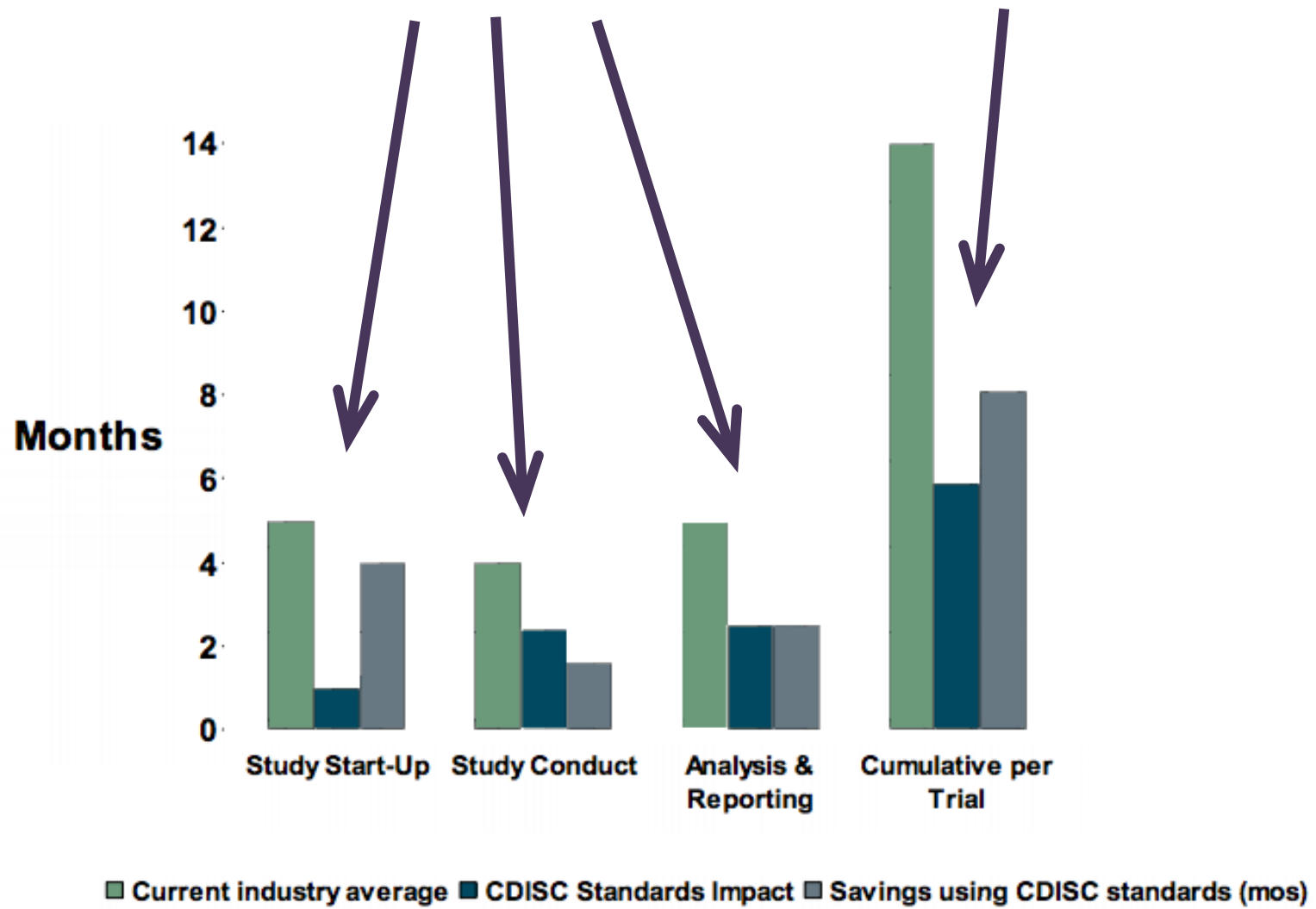
Make life easy and comfortable for the body at work

Reduce mental workload, decision-making, cognition, executive functioning, attention management, etc.

Parts

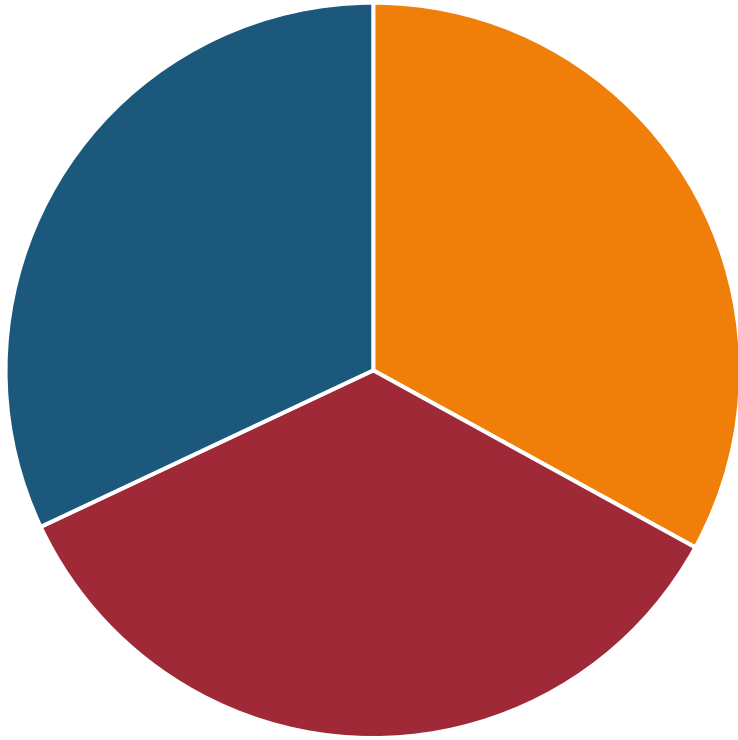


Parts to whole

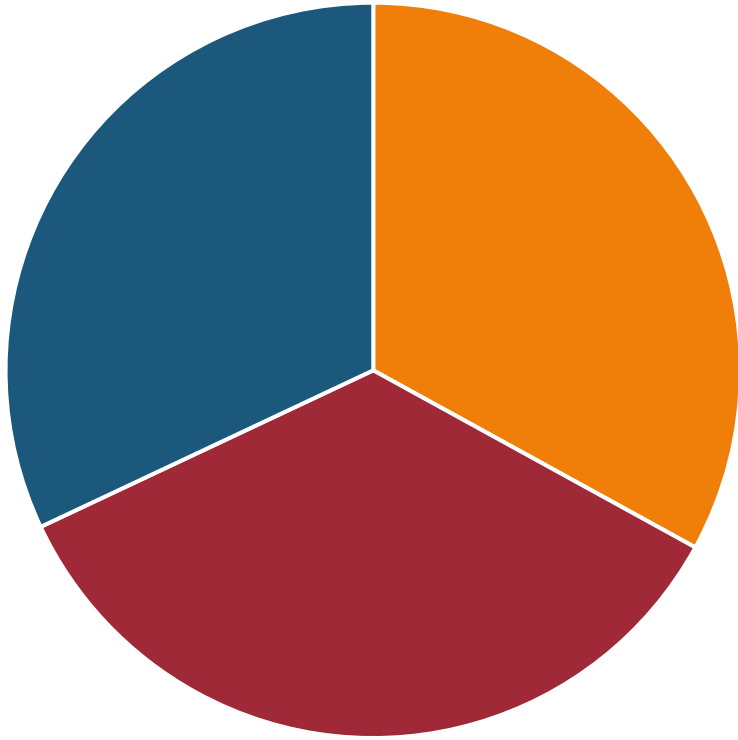


The mortal sin of pie charts

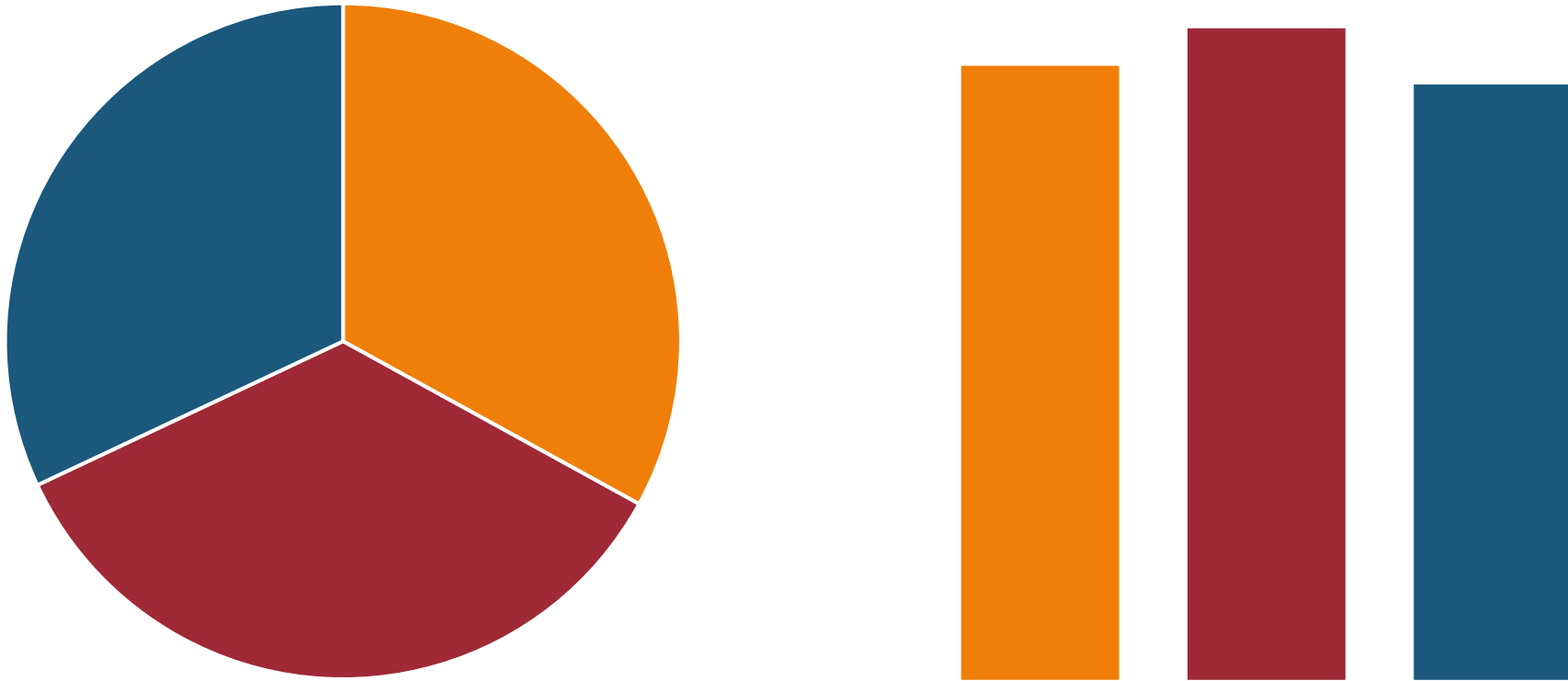
The mortal sin of pie charts



The mortal sin of pie charts

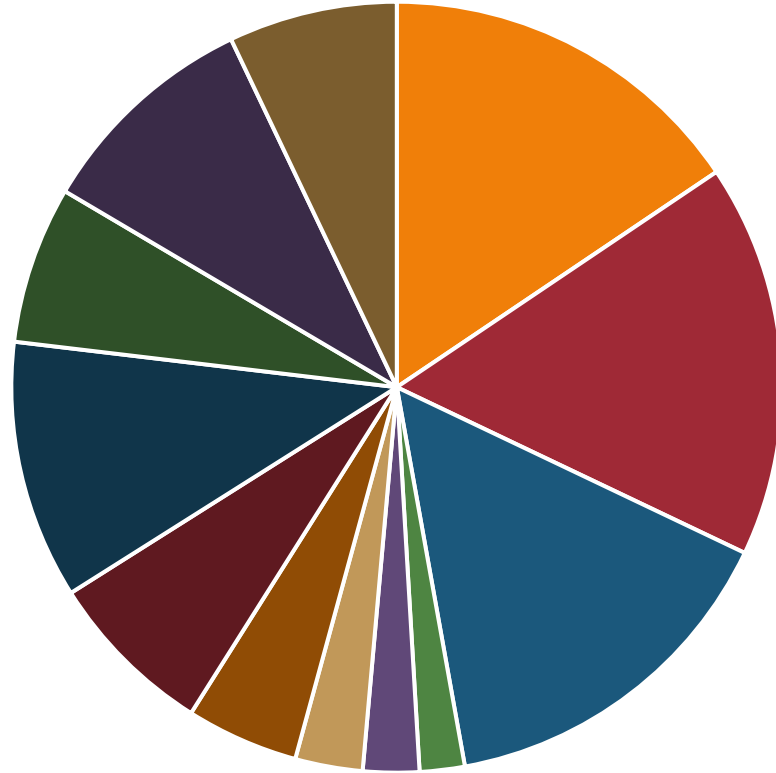


The mortal sin of pie charts



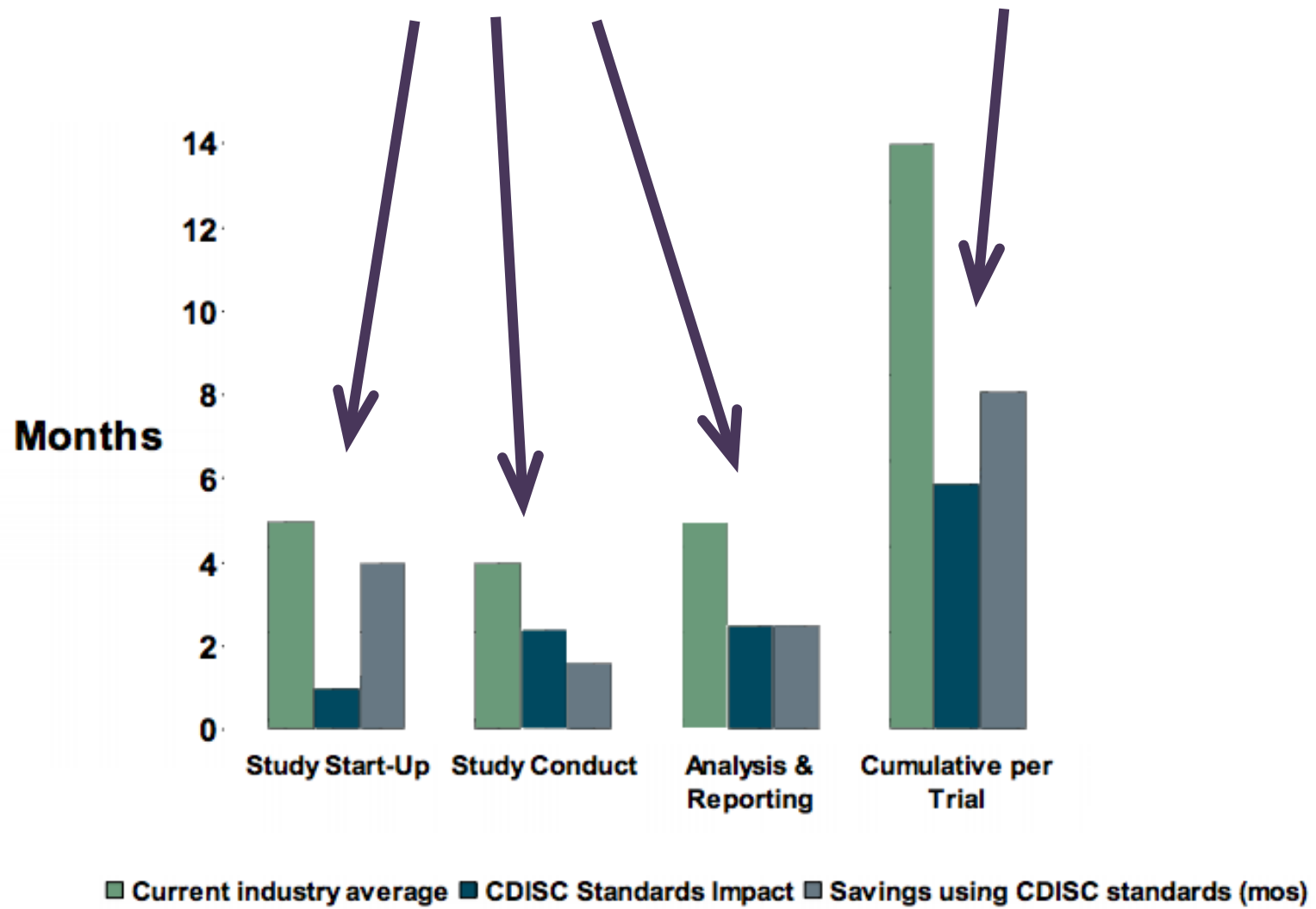
Humans are bad at judging area,
much better at judging length

The mortal sin of pie charts

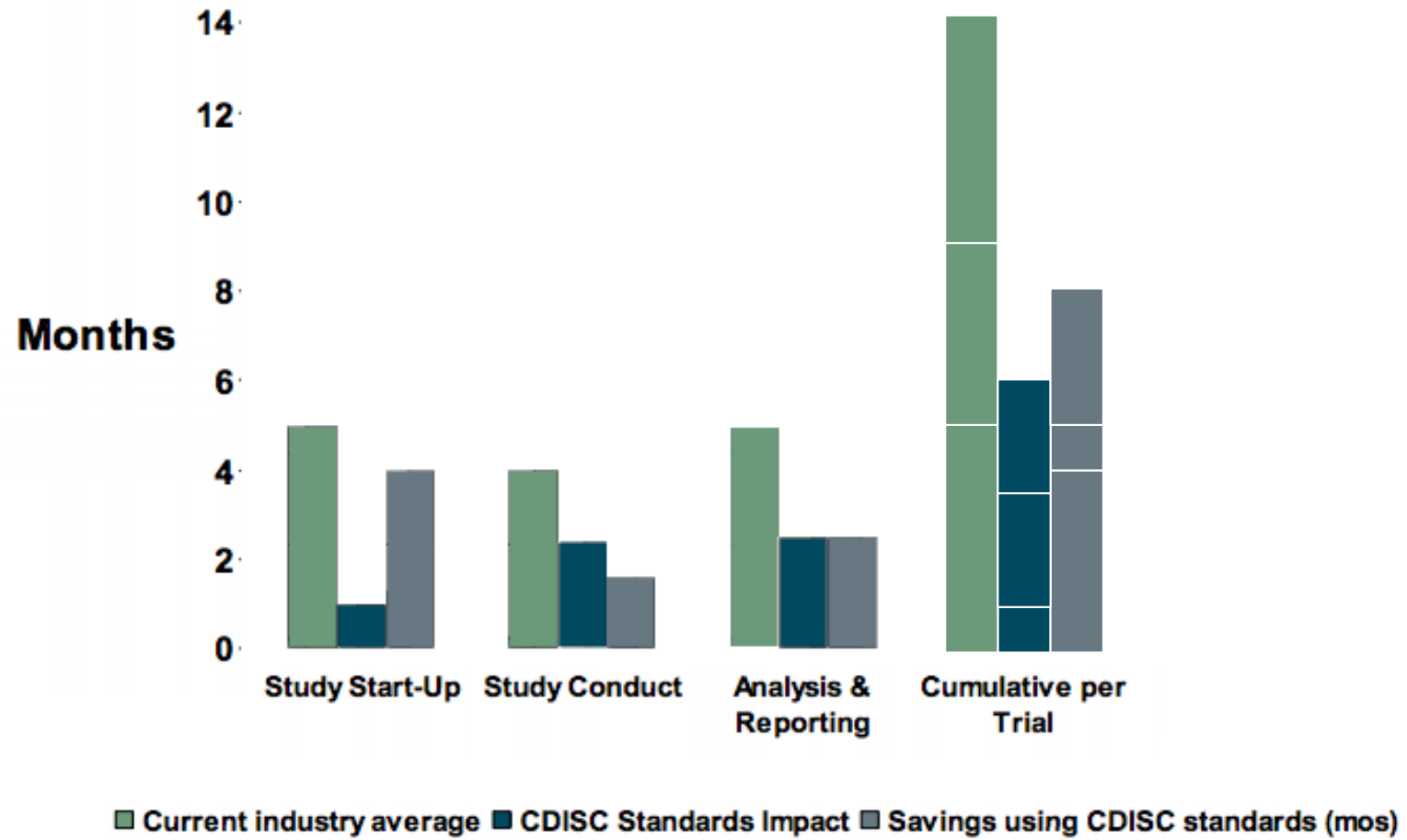


More than about 5 categories are unintelligible

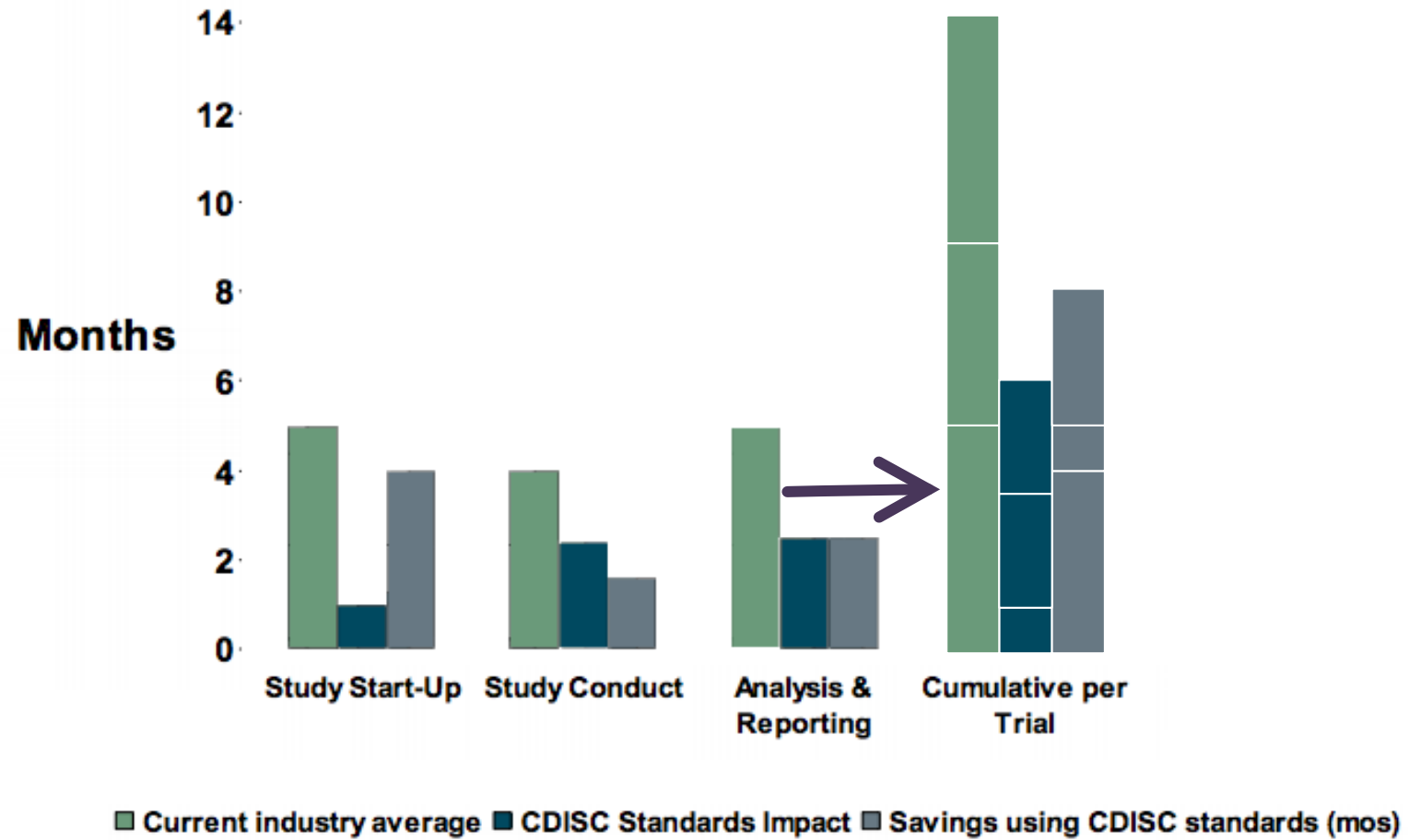
Parts to whole



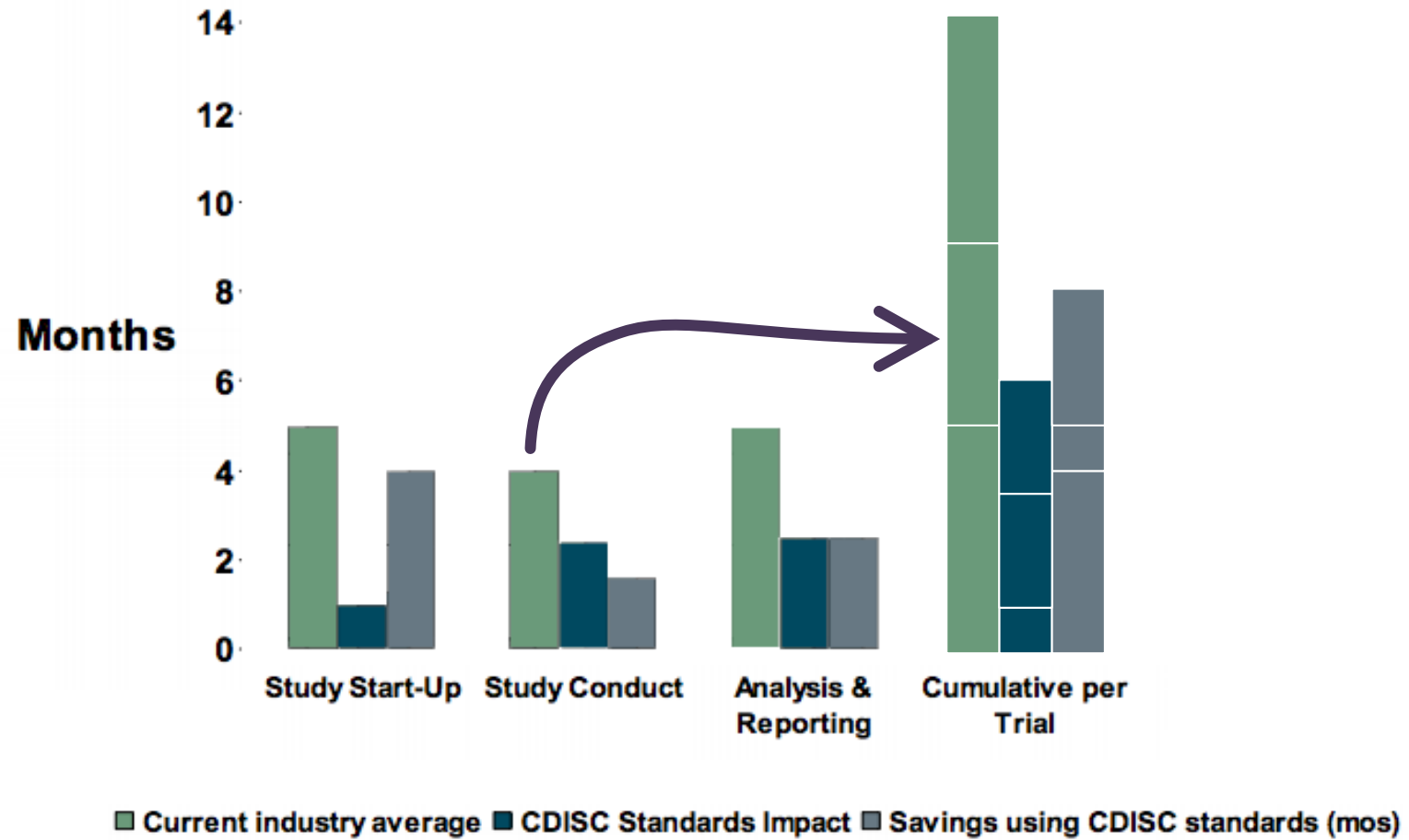
Make a stacked bar



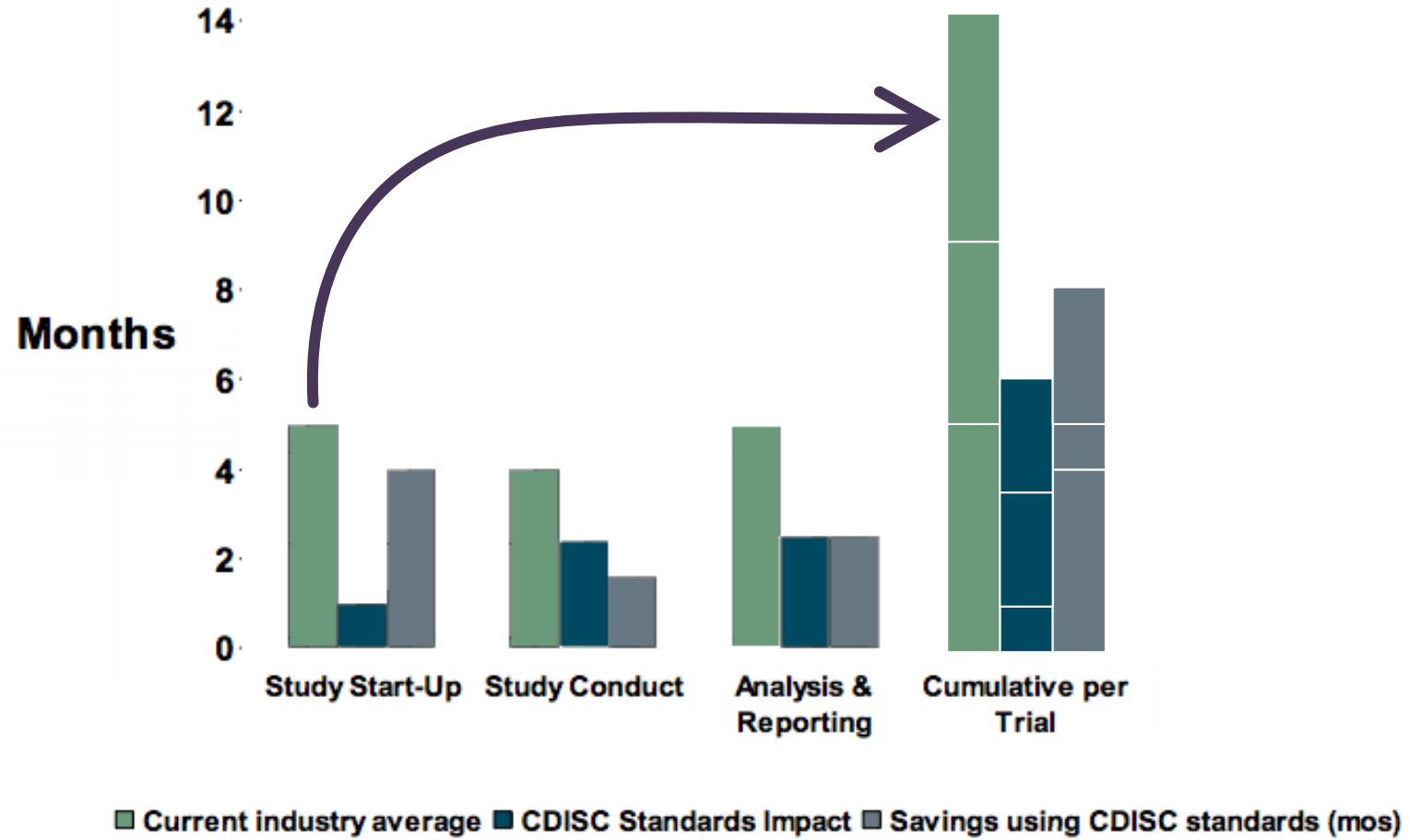
Make a stacked bar



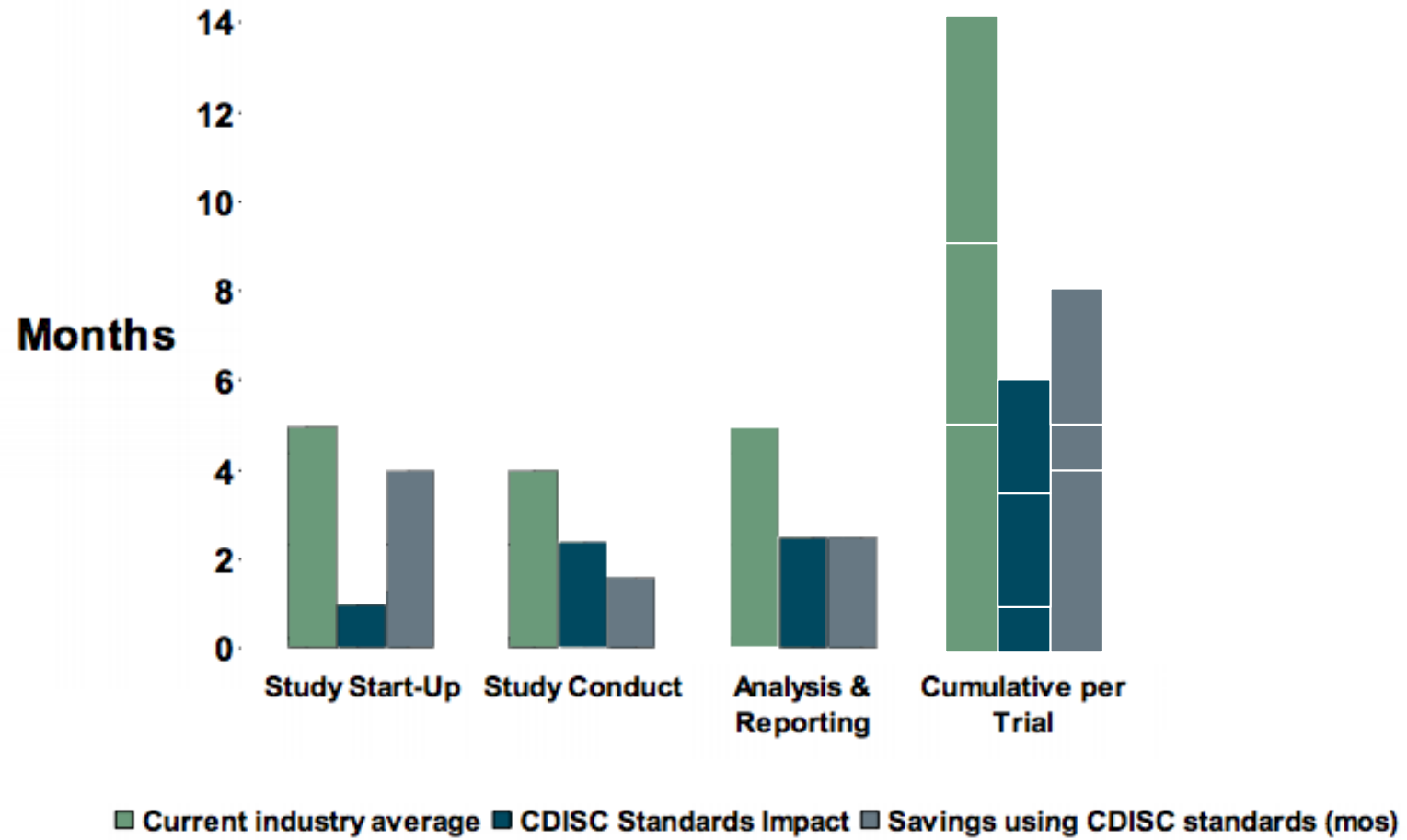
Make a stacked bar



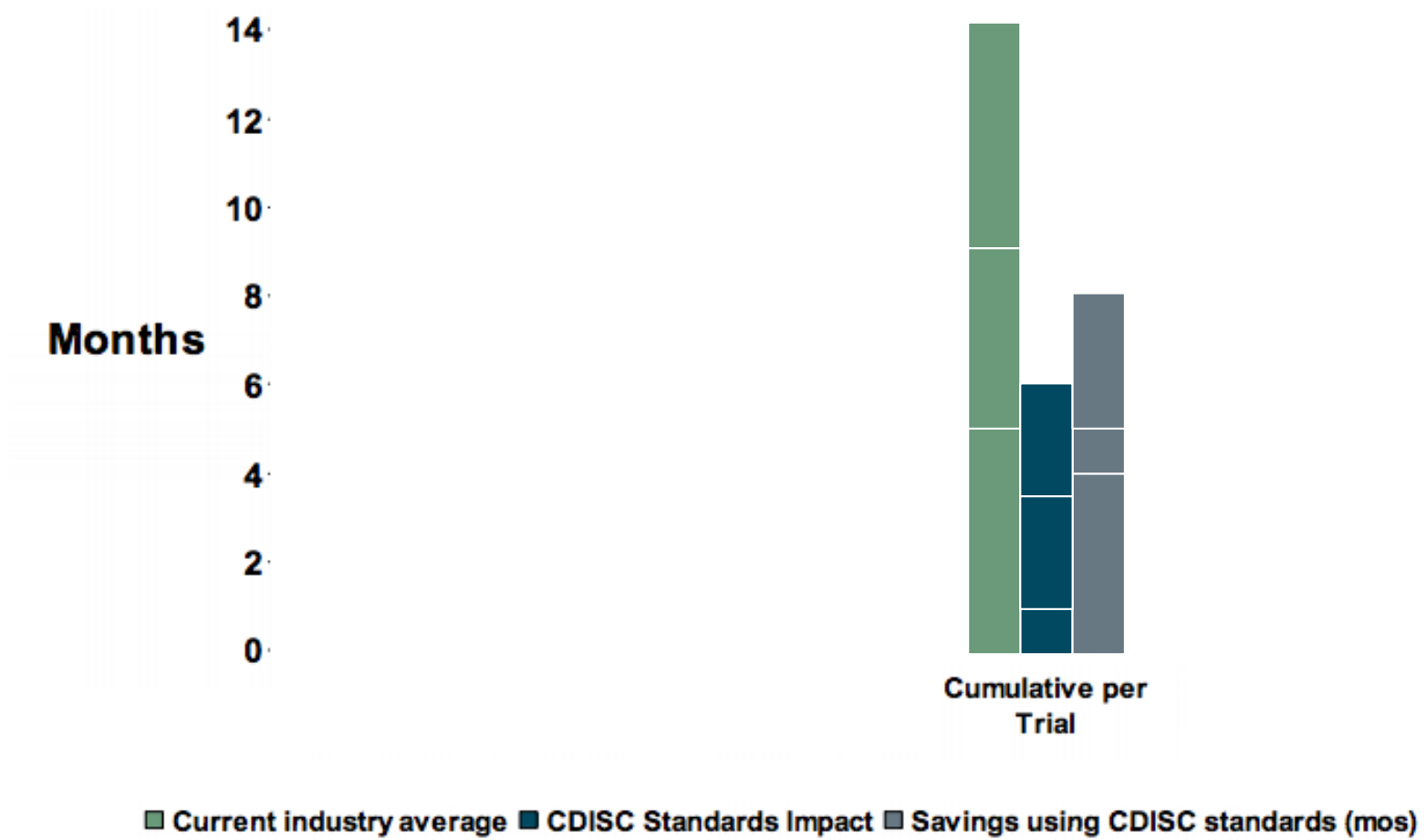
Make a stacked bar

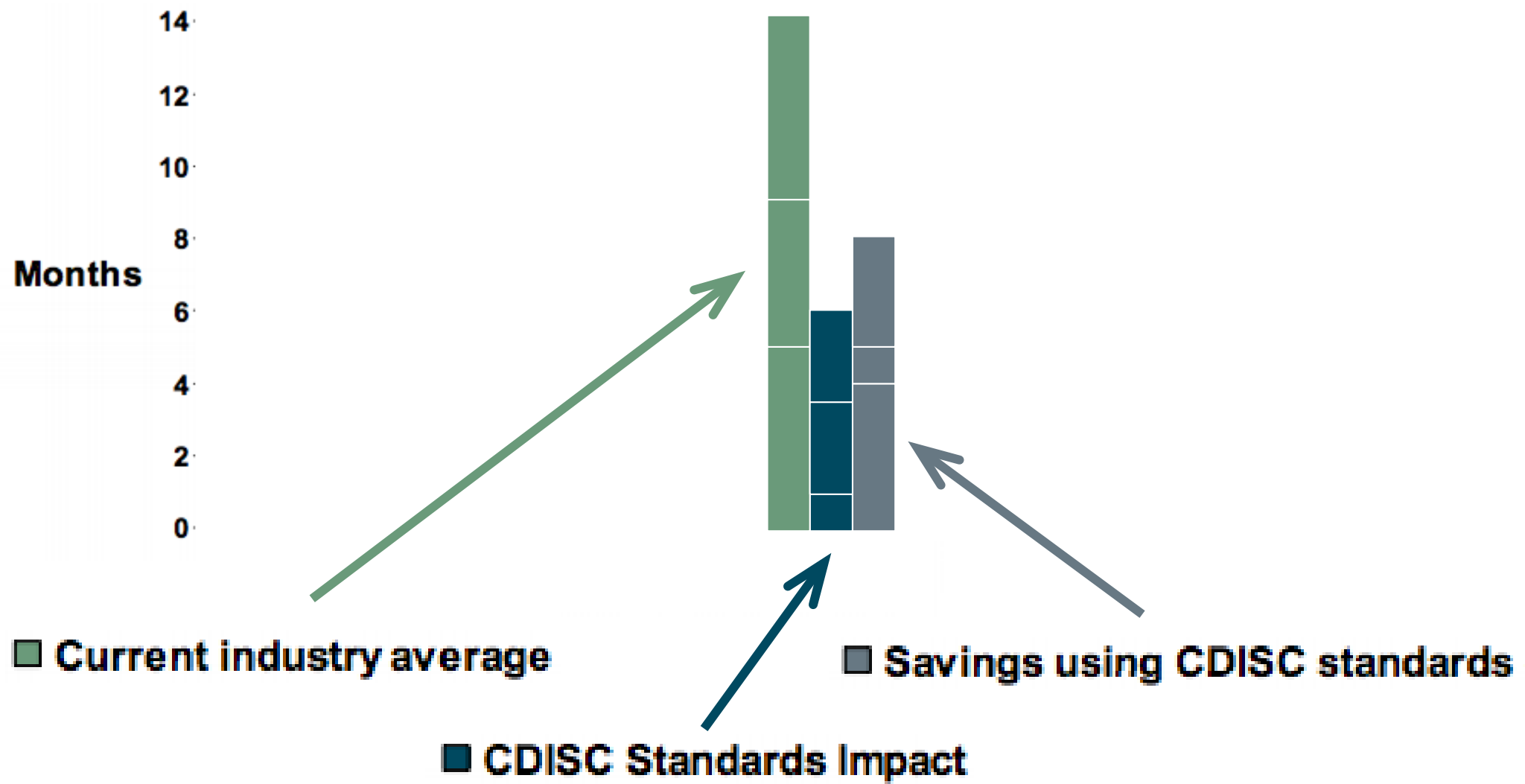


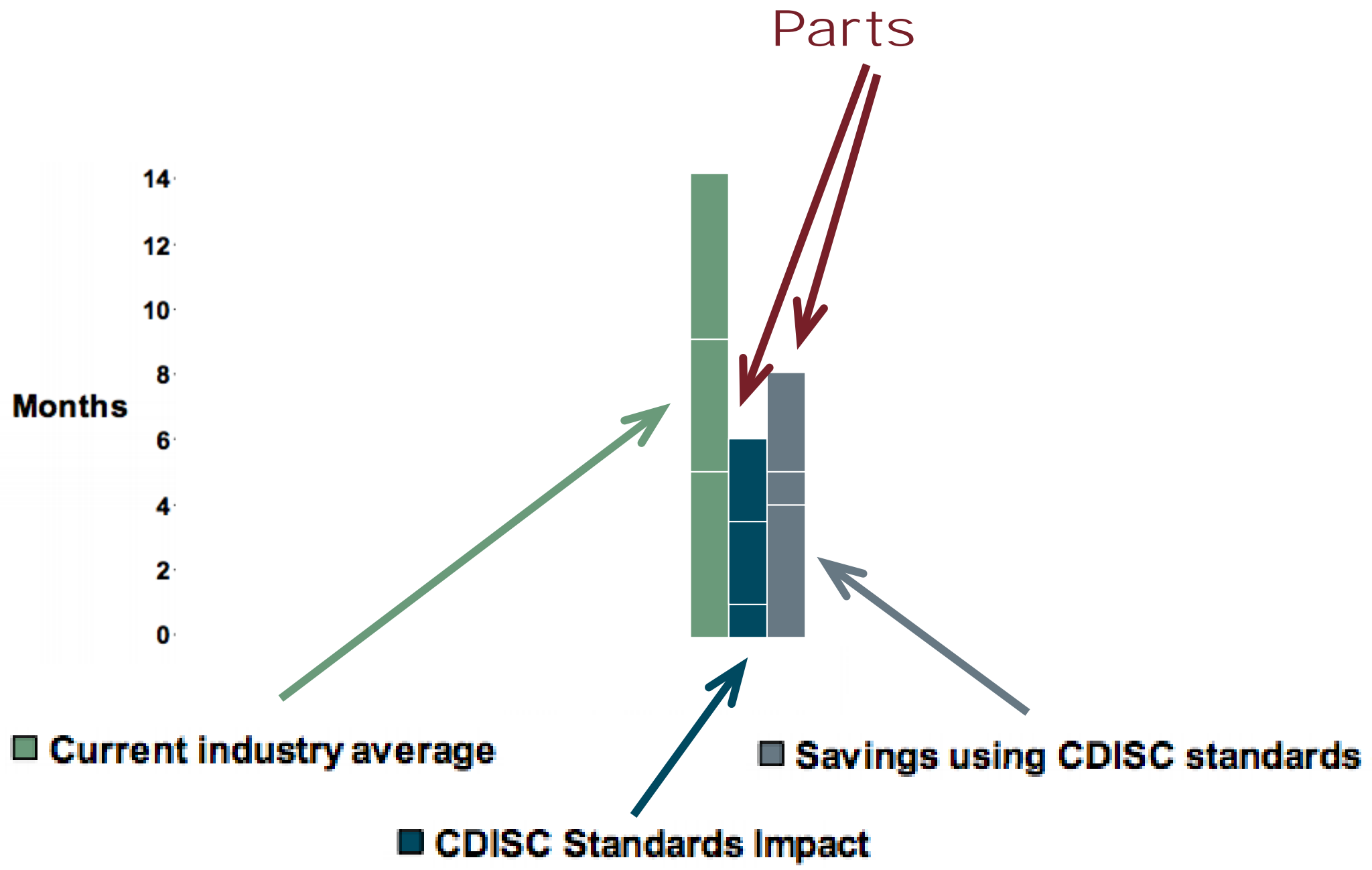
Make a stacked bar

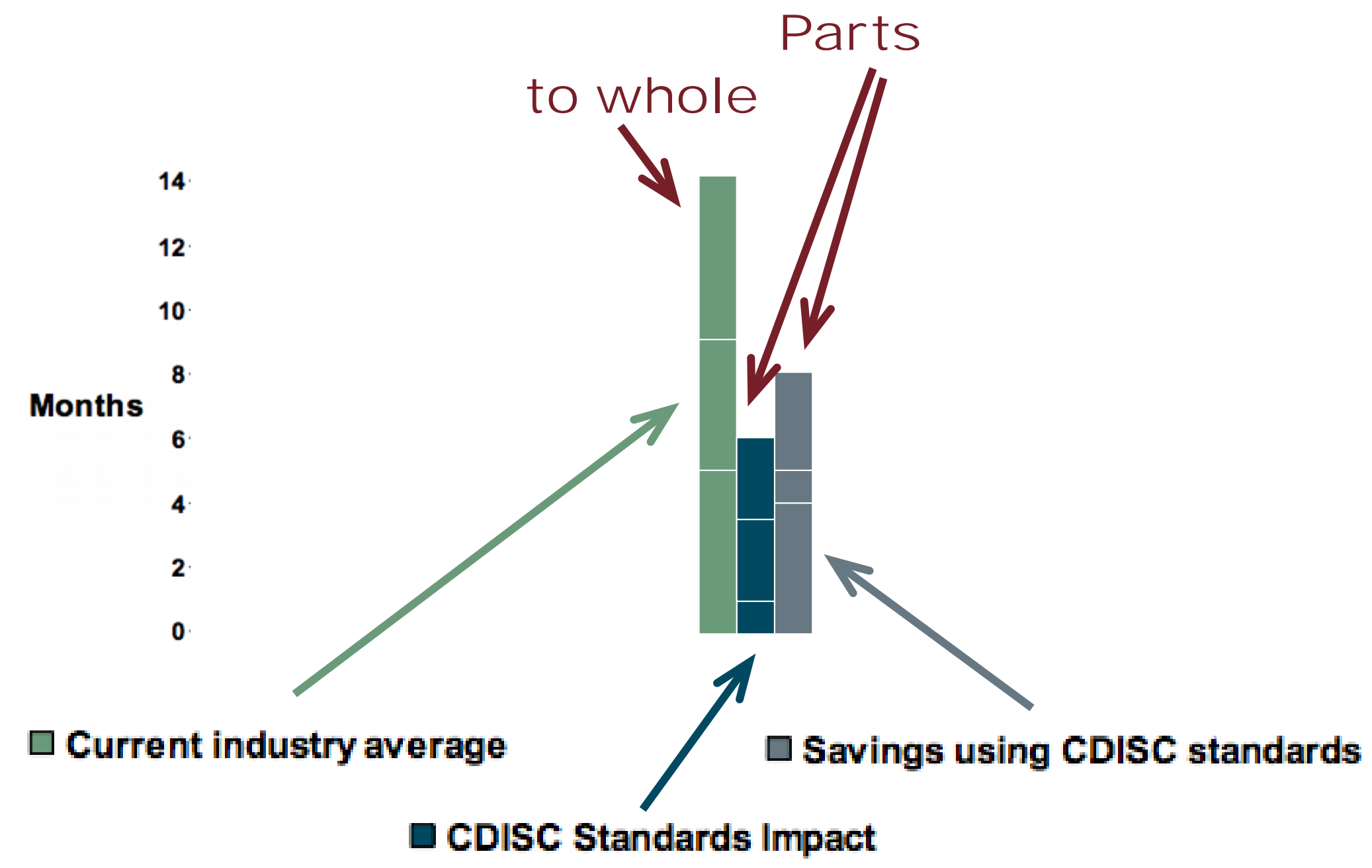


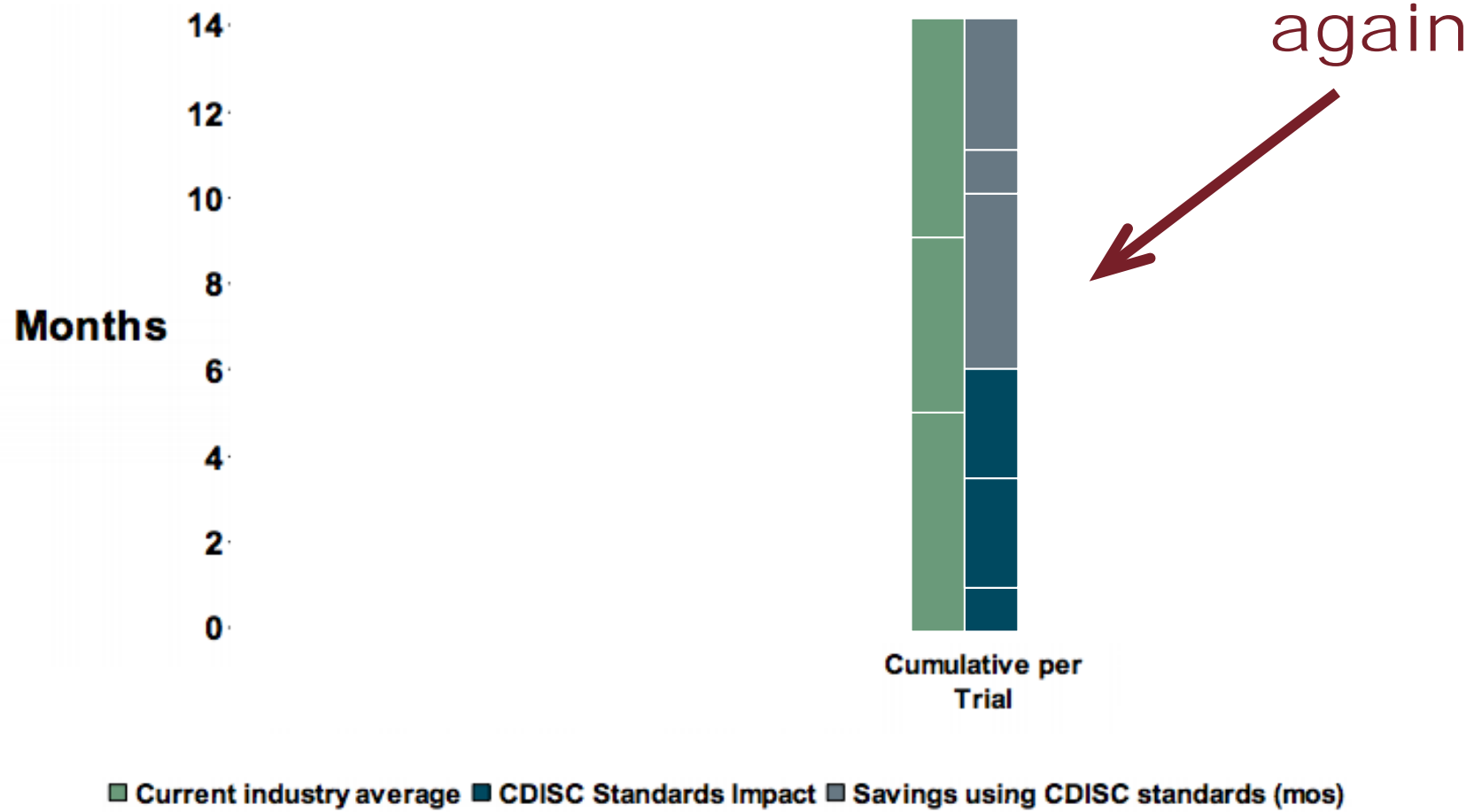
Make a stacked bar



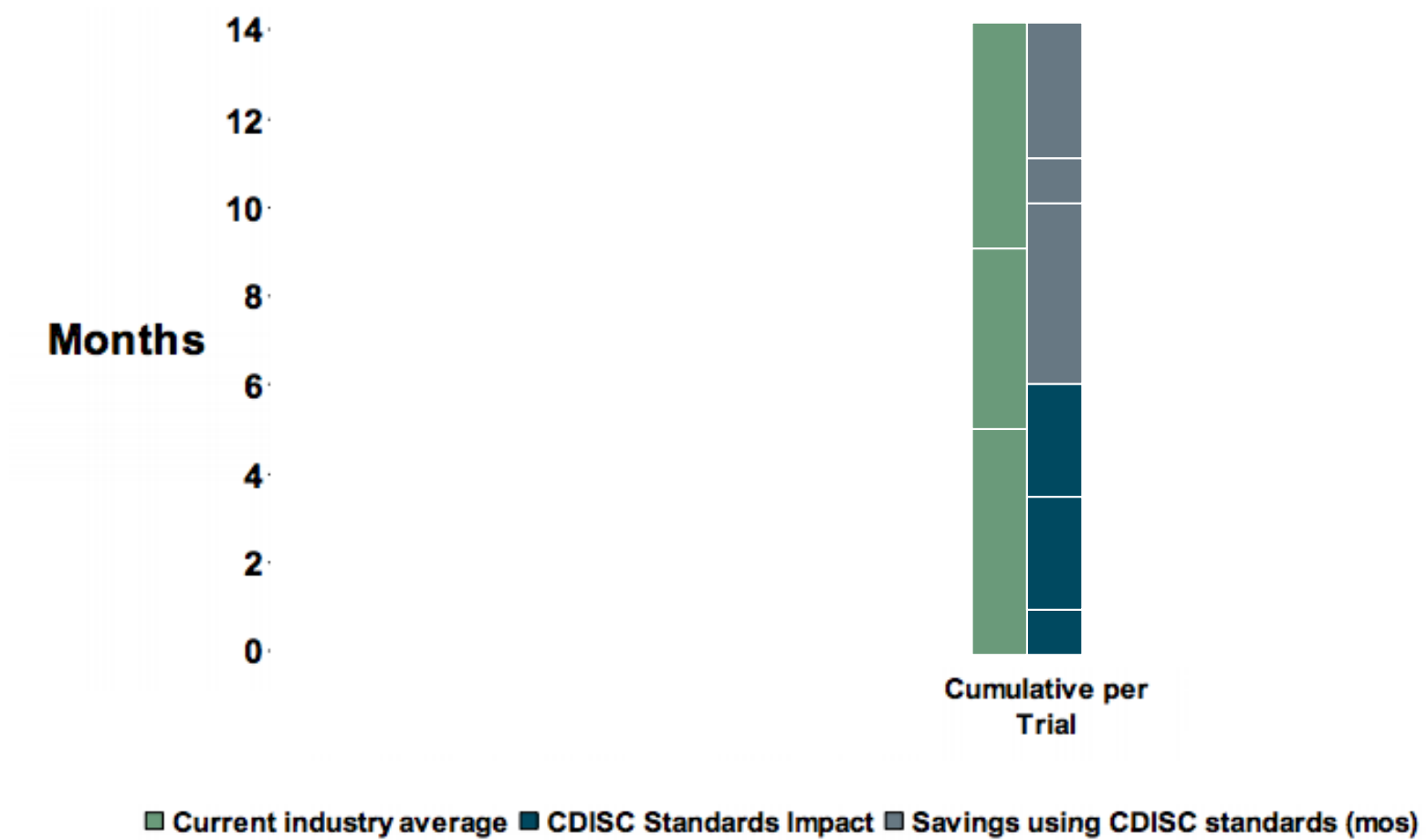




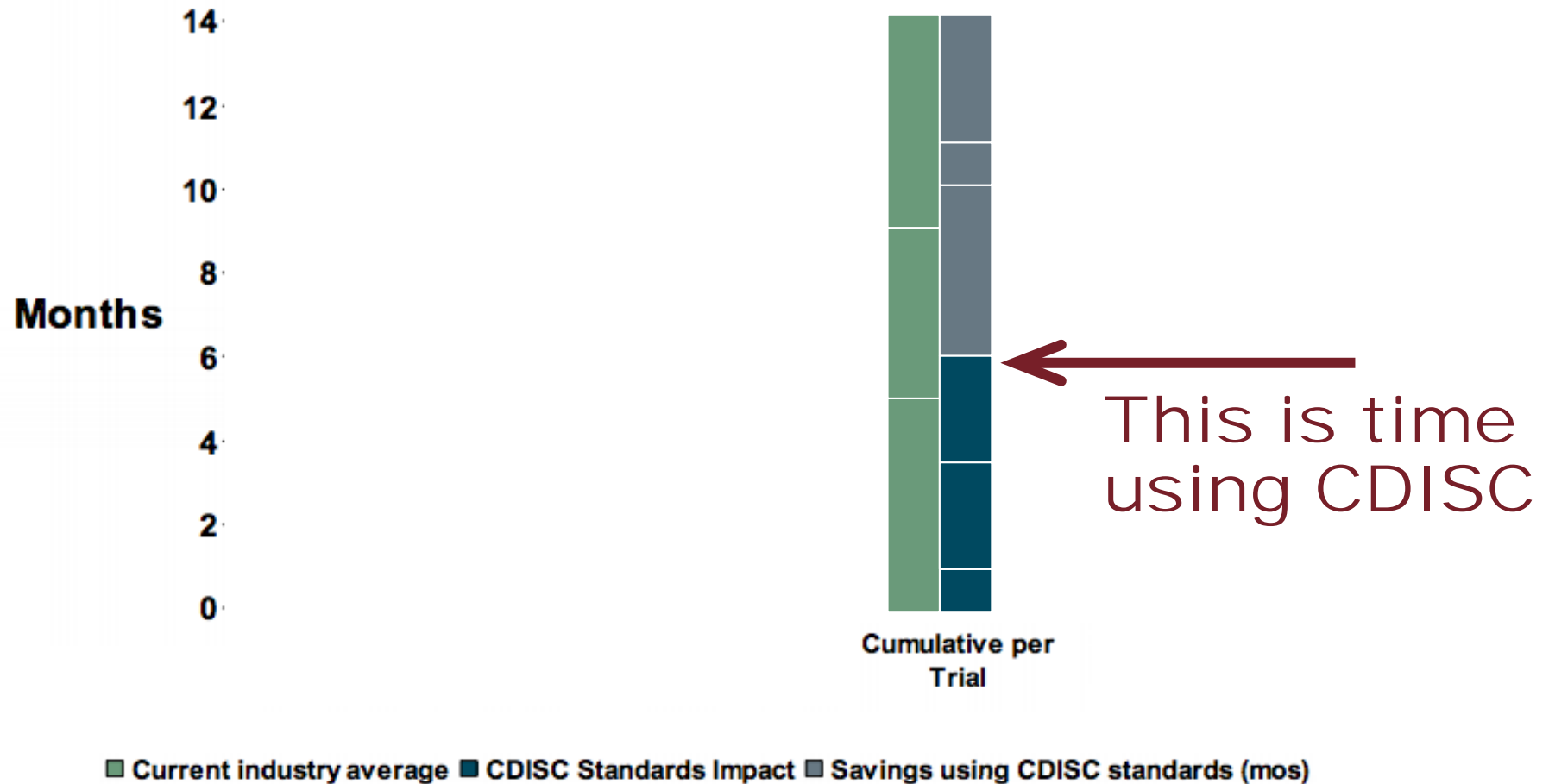




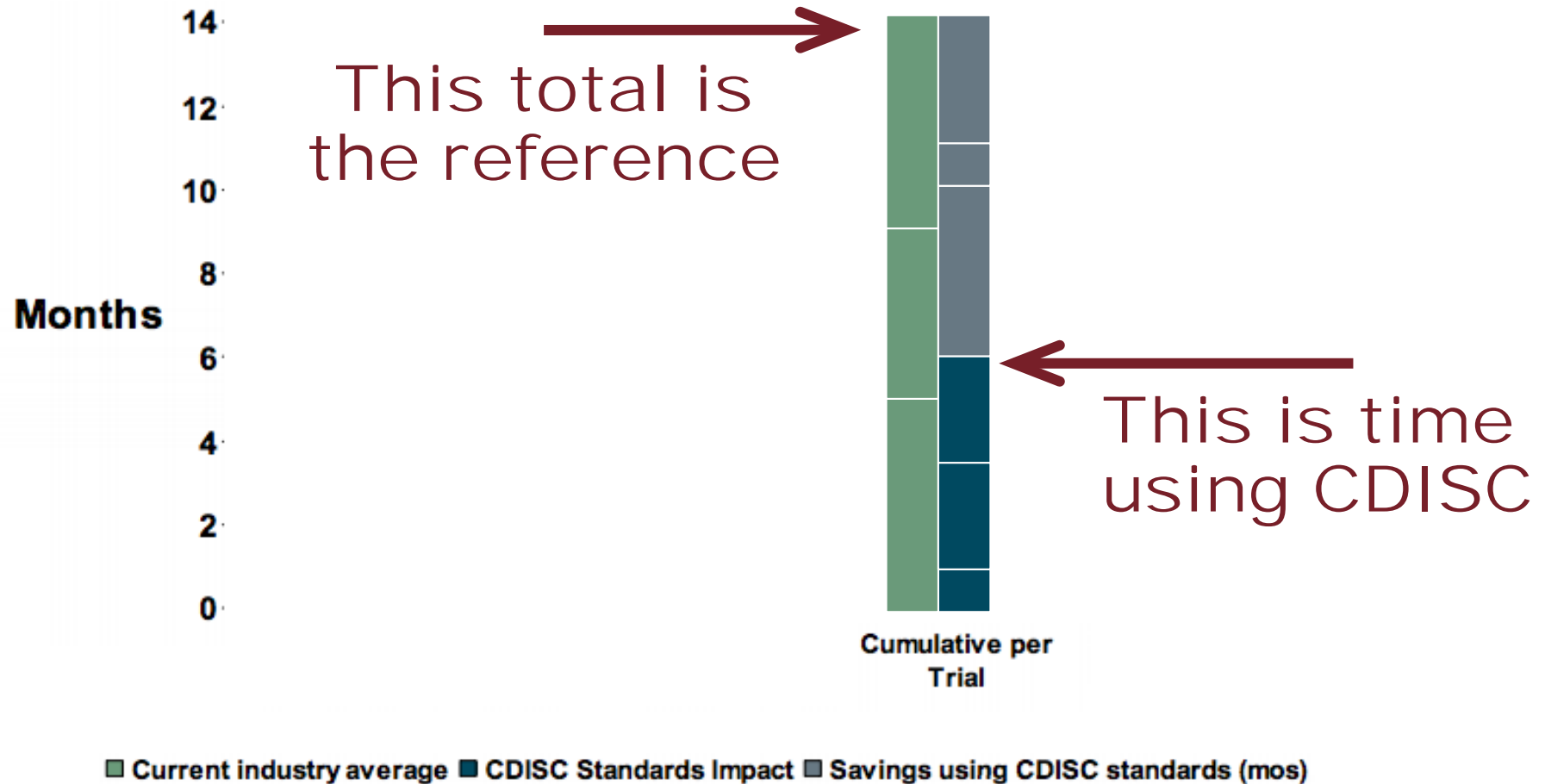
Use a reference to make your point



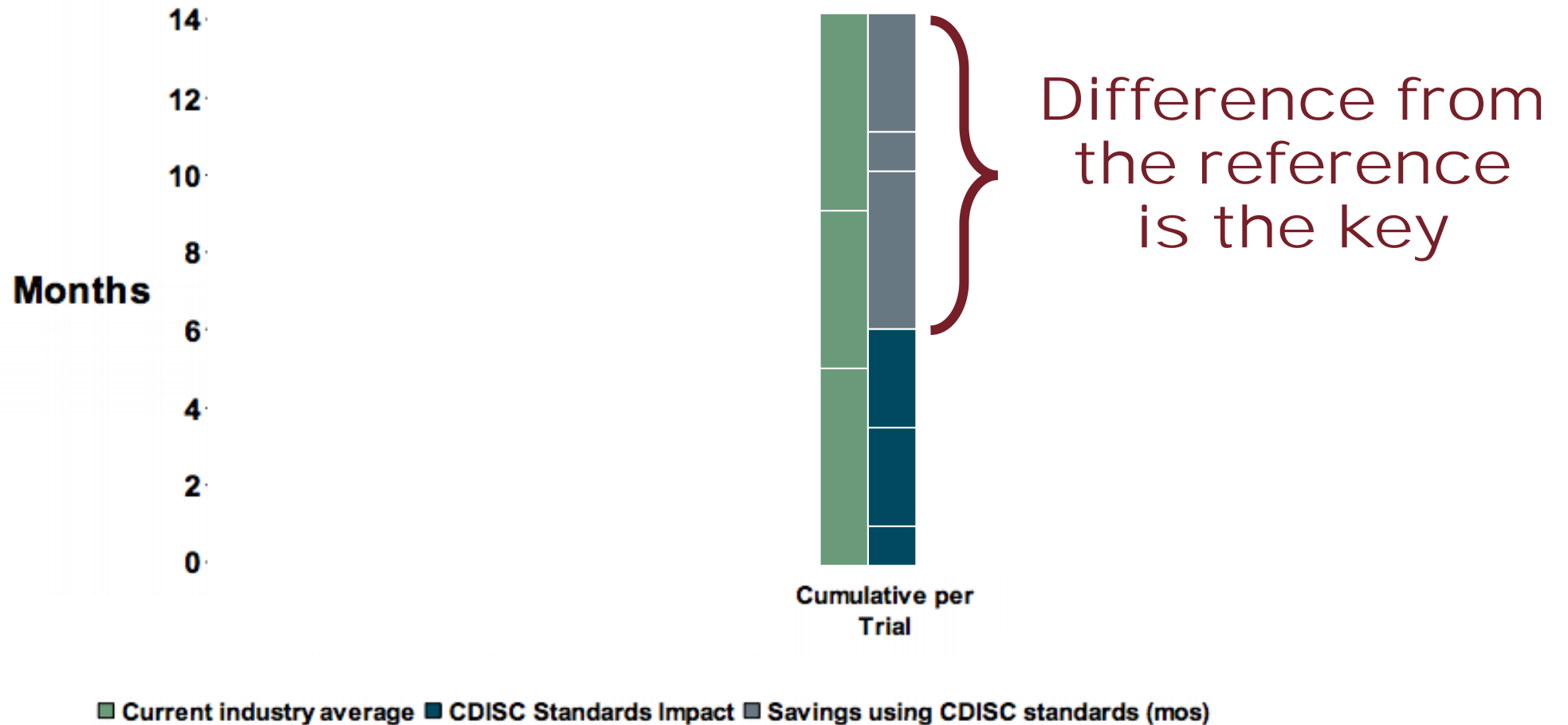
Use a reference to make your point



Use a reference to make your point



Use a reference to make your point



THE WALL STREET JOURNAL.

**GUIDE TO
INFORMATION
GRAPHICS**

**THE DOS & DON'TS
OF PRESENTING
DATA, FACTS,
AND FIGURES**

DONA M. WONG

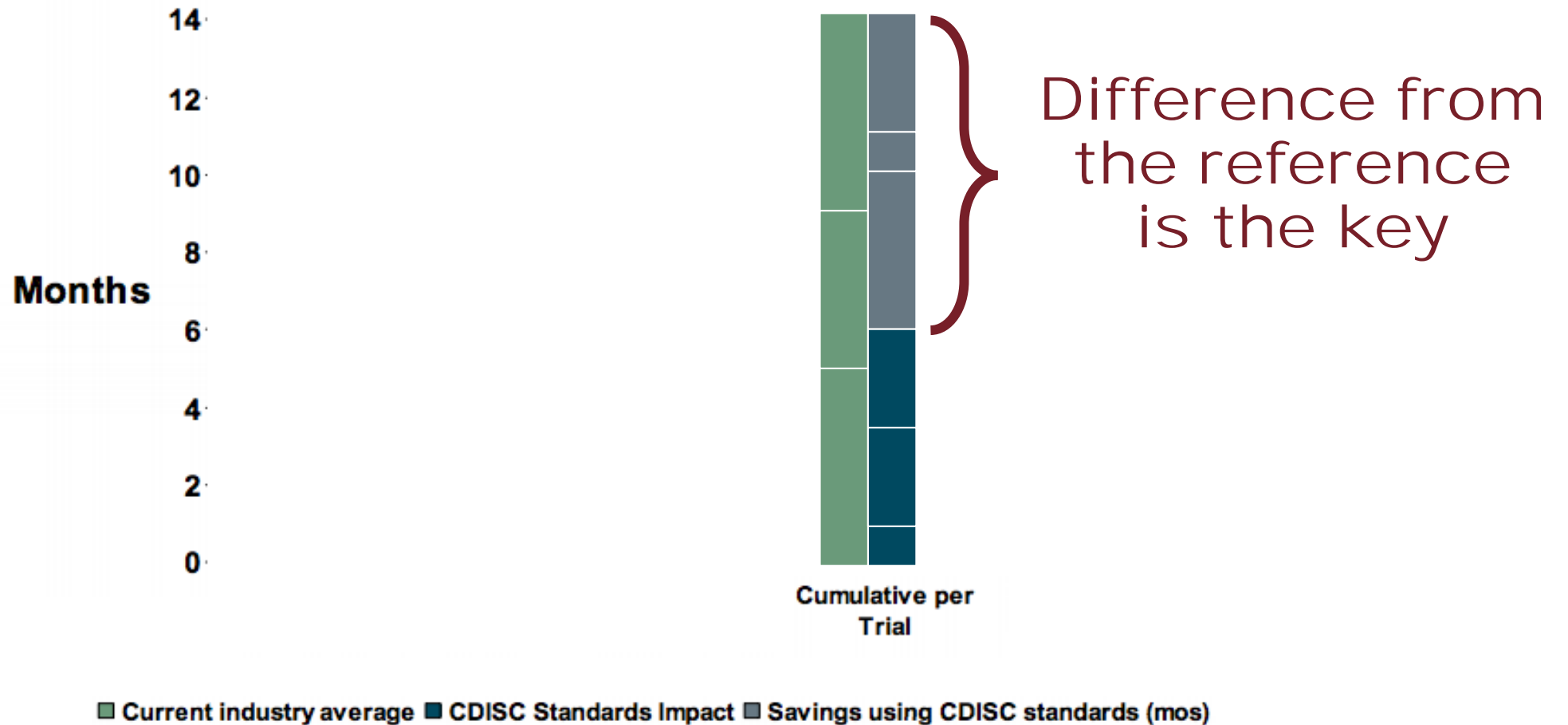
"INVALUABLE." —HOW DESIGN



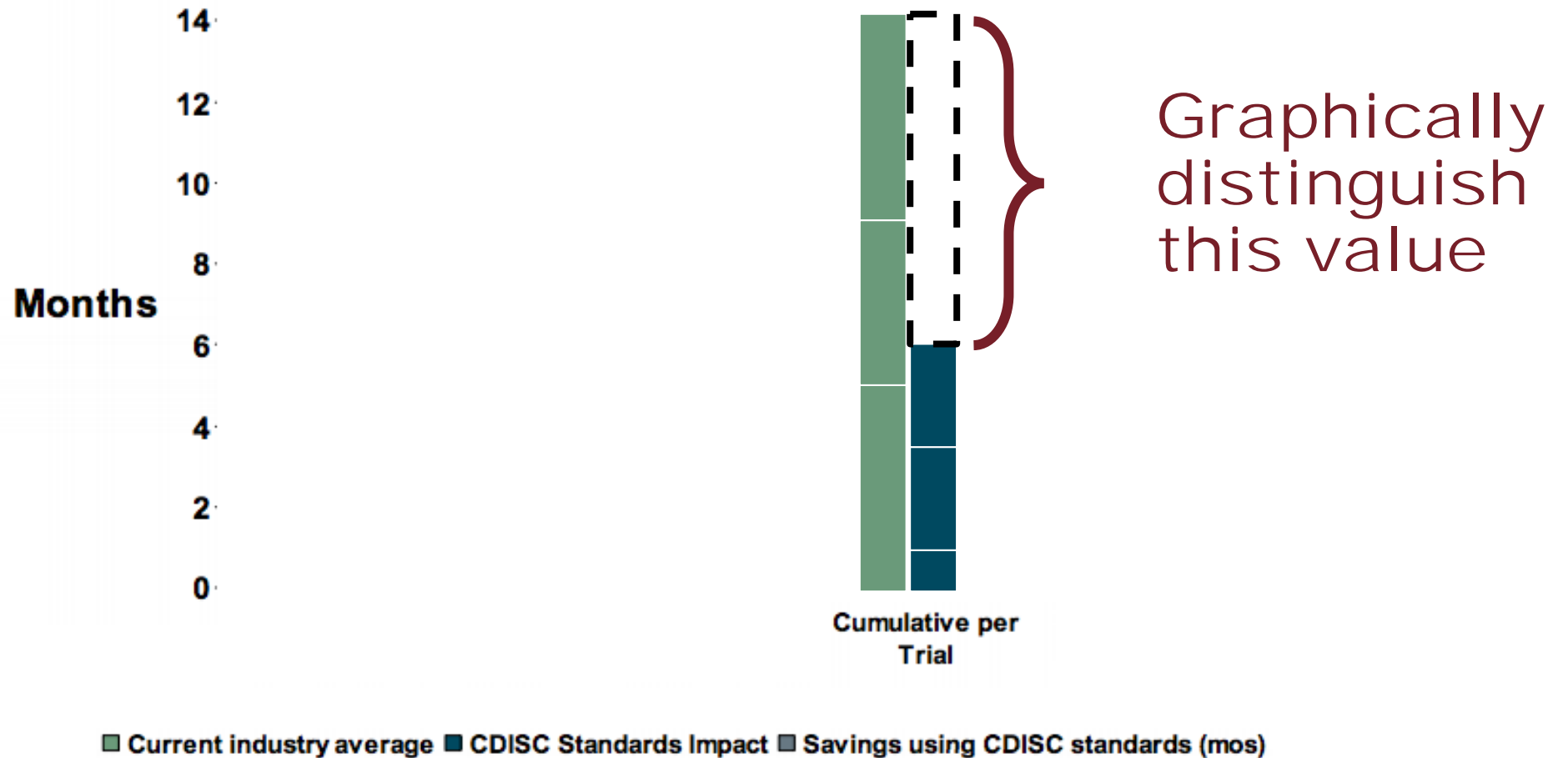
Whoever controls the reference
controls the message.

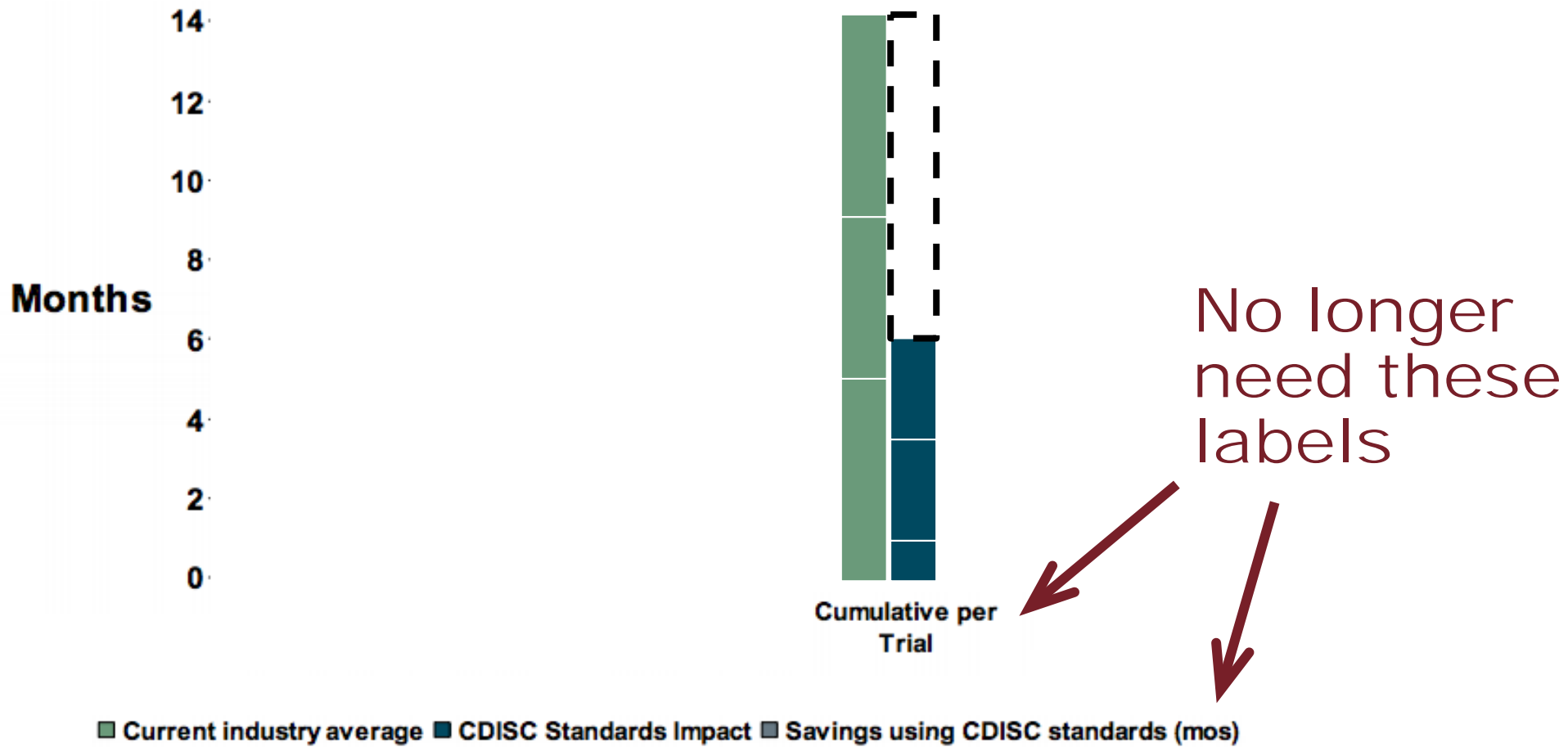
Dona Wong

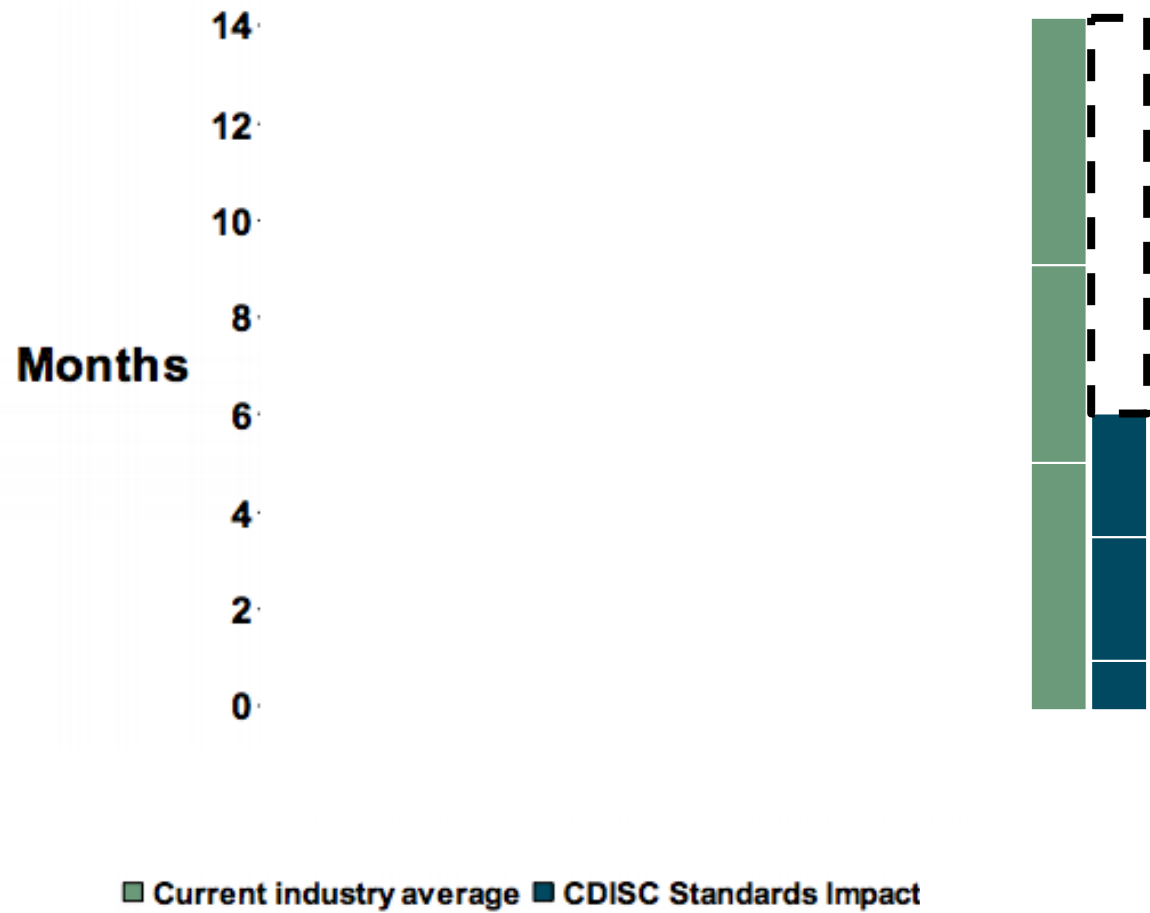
Use a reference to make your point



Use a reference to make your point



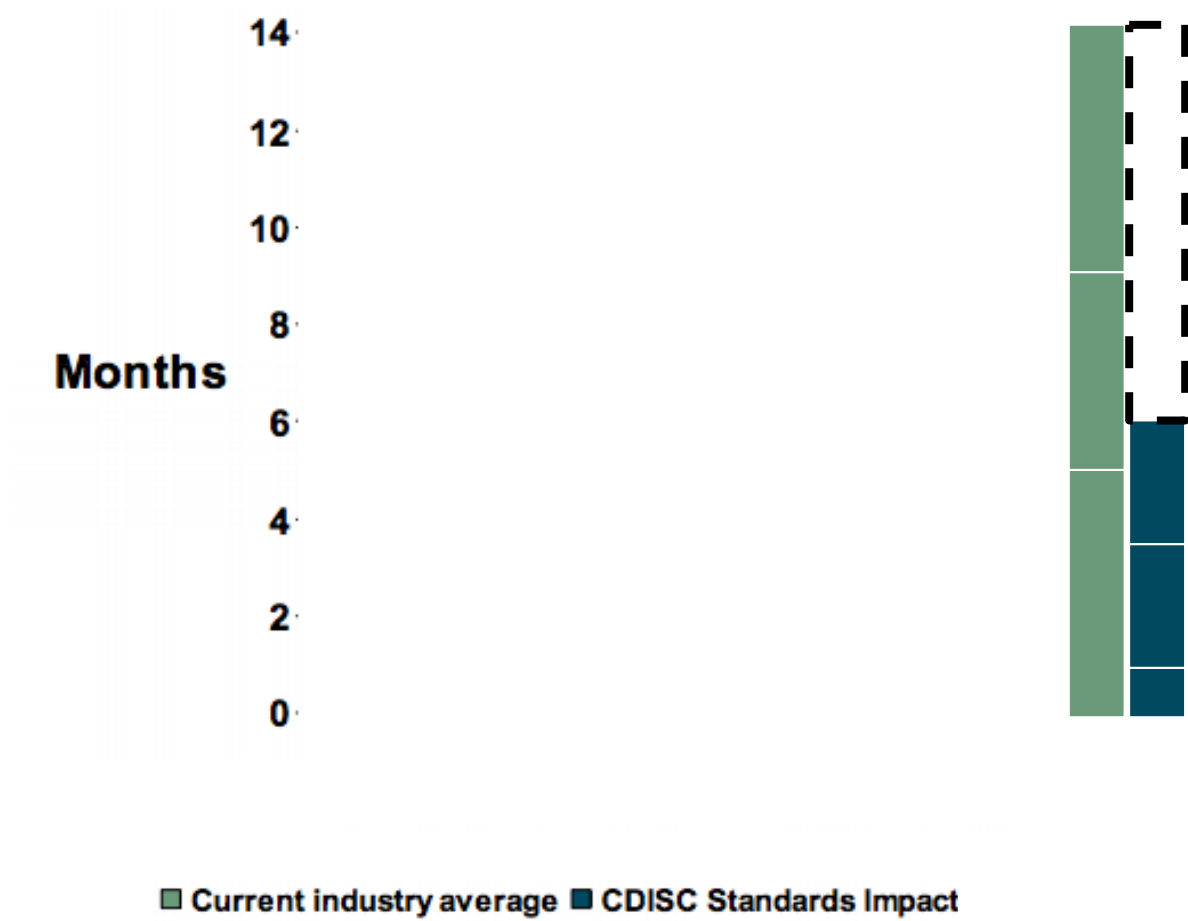




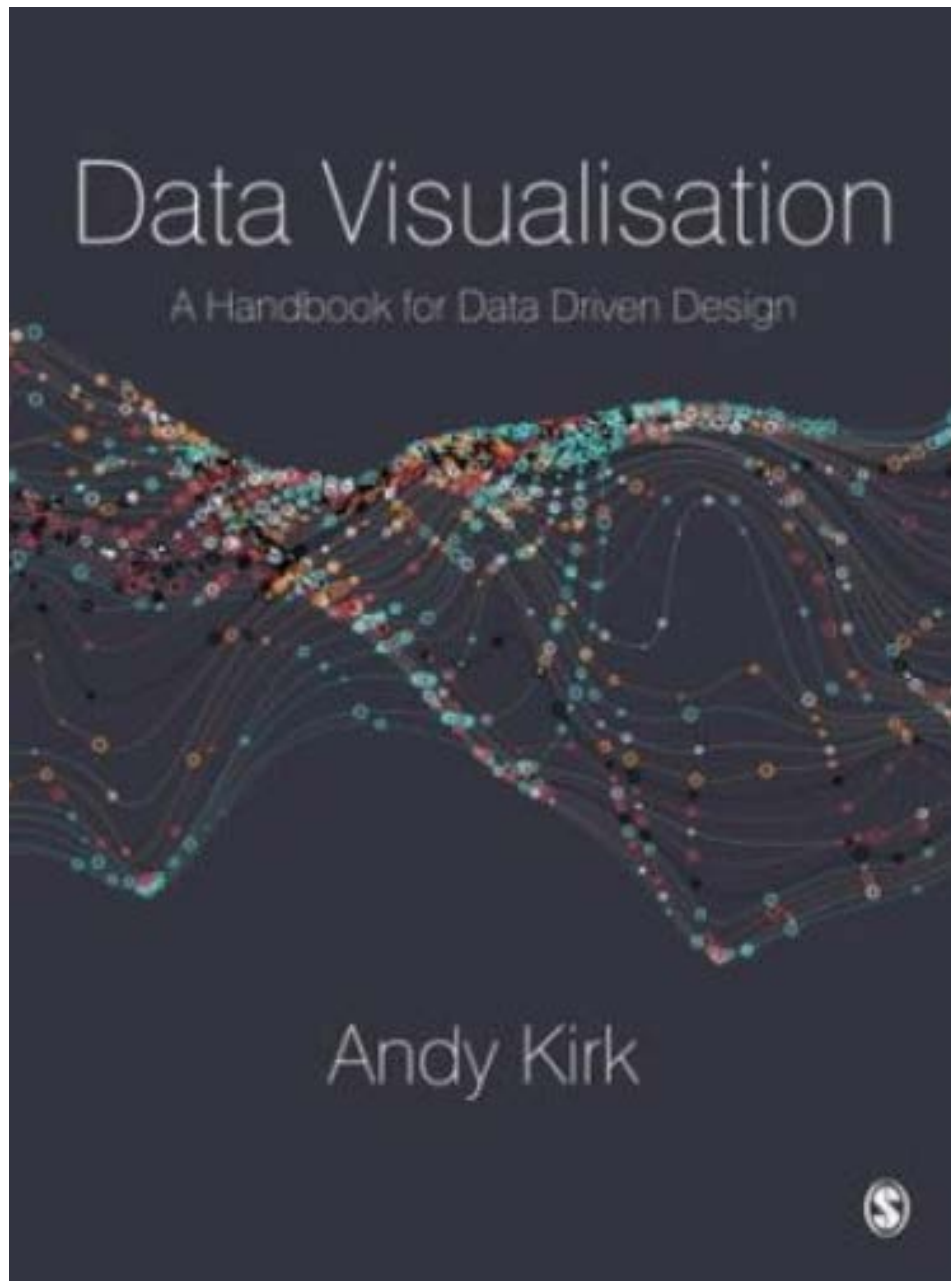
No longer
need these
labels



Where we are



A pause in honor of white space



The courage of emptiness

Andy Kirk

[Gmail](#) [Images](#)



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Recommended



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The Late Show with Stephen C...
475K views • 4 weeks ago



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brigadeir998
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The Eric Andre Show | Best Moments

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VIEW



SORT



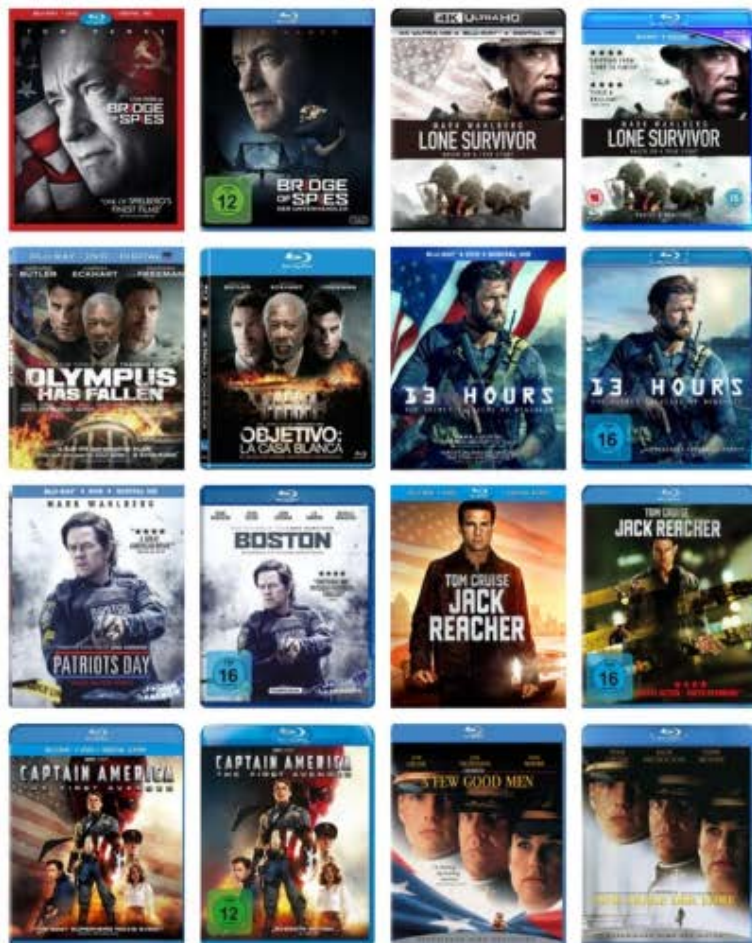
UNITED STATES

ALL STATES

↑ 25.2k ↓

r/movies · Posted by u/sanderobros 3 hours ago

Movie studios often remove American flags from international Blu-Ray releases. Trivia



r/popular

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ウェブ 画像 動画 辞書 知恵袋 地図 リアルタイム 一覧

検索

▶ 台風12号に関する最新情報と注意点 ▶ あすは「肉の日」 食べ放題や限定プランがお得に ▶ ジャパンネット銀行の口座開設で1,000円進呈

主なサービス 一覧

- ショッピング
- ヤフオク
- LOHACO
- トラベル
- 一休.com
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- ニュース
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- 不動産
- 自動車
- textream
- ブログ
- TRU

動画 LIVE ニュース 経済 エンタメ スポーツ

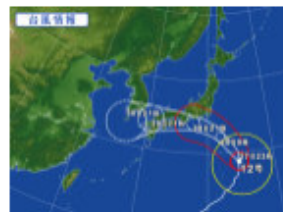
08時11分更新

- 危険な台風12号 要注意の地域
- 国と沖縄県 再び法廷闘争へ
- 米Disneyプラ製ストロー廃止 NEW
- 豪雨で水没 アップル無償修理 NEW
- 洞窟の救助班 ダム決壊で活動 NEW
- 最高齢115歳 死ぬ気せんです NEW
- 日大報告書「圧迫的」と総括
- 石橋貴明Abema出演 民放激震



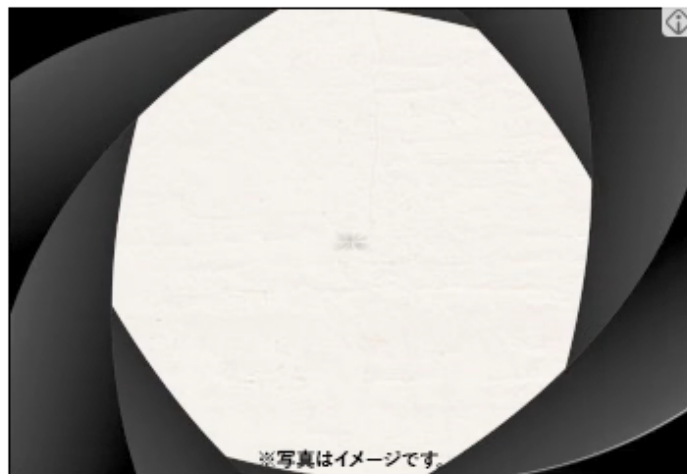
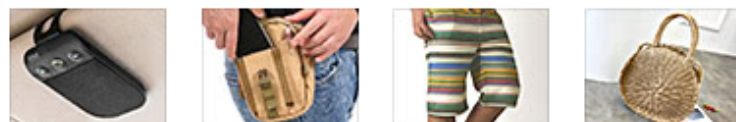
ノーノー達成を祝福
7月27日20時44分配信
時事通信

もっと見る トピックス一覧



台風情報 2018年7月27日 23時45分現在
 台風12号は父島の北東約310kmを北に移動中
 速さ 35km/h
 中心気圧 965hPa
 最大風速 中心付近で40m/s

欲しいものがきっとみつける、ランキングTOP20



※写真はイメージです。

ログイン

IDでもっと便利に[新規取得]

ログイン履歴 登録情報

メールアドレス取得	ポイント確認	カード新規入会

2018年7月28日(土)

今日の天気 (東京) 100% 29°C / 21°C 熱中症指数 雨雲レーダー	明日の天気 (東京) 70% 32°C / 26°C 熱中症指数
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新宿区

運行情報

中央総武線(各停) 列車遅延(23時20分)



- 女装精品 >
- 内衣/男装 >
- 鞋品 箱包 >
- 饰品 配件 >
- 运动 户外 >
- 家具 家电 >
- 居家 家纺 >
- 手机 数码 >
- 汽车 家电/旅行 >
- 母婴 玩具 >
- 办公 娱乐 >
- 美妆 个护 >

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支持送達美加, 歐新, 日本, 澳門



支持国际信用卡付款

支持國際信用卡付款 VISA



买家保障&购物无忧

有好货 品质生活指南



FERRAGAMO 荔枝纹马蹄扣皮鞋

真皮的材质, 穿着的脚感更佳。

0人说好



美式乡村儿童高低床

高低床能大大节省空间, 同时还能给孩子最安全的保护。

181人说好



百利金圆珠笔帝王

经过数十道手工精制而成, 彰显你的不凡身份

4人说好



Gucci 格子西装长裤

格子元素装饰裤身, 腰部纽扣闭合穿脱快捷。

0人说好



Gucci 格纹西装长裤

格子元素装饰裤身, 两侧斜插口袋方便实用。

0人说好



意大利尚尼不锈钢调味罐

内外双盒保护设计, 隔绝调料串味。

0人说好



Prada 纯黑漆皮商务鞋

牛皮的材质, 舒适又透气。

0人说好



Senreve 牛皮单肩手提包

简洁的纯色元素, 凸显女性优雅气质。

0人说好

换一组看看

A search input field with a thin grey border. The text "Search Google or type URL" is displayed in a light grey font. On the right side of the field, there is a small, colorful microphone icon.

White space is cognitively comfortable

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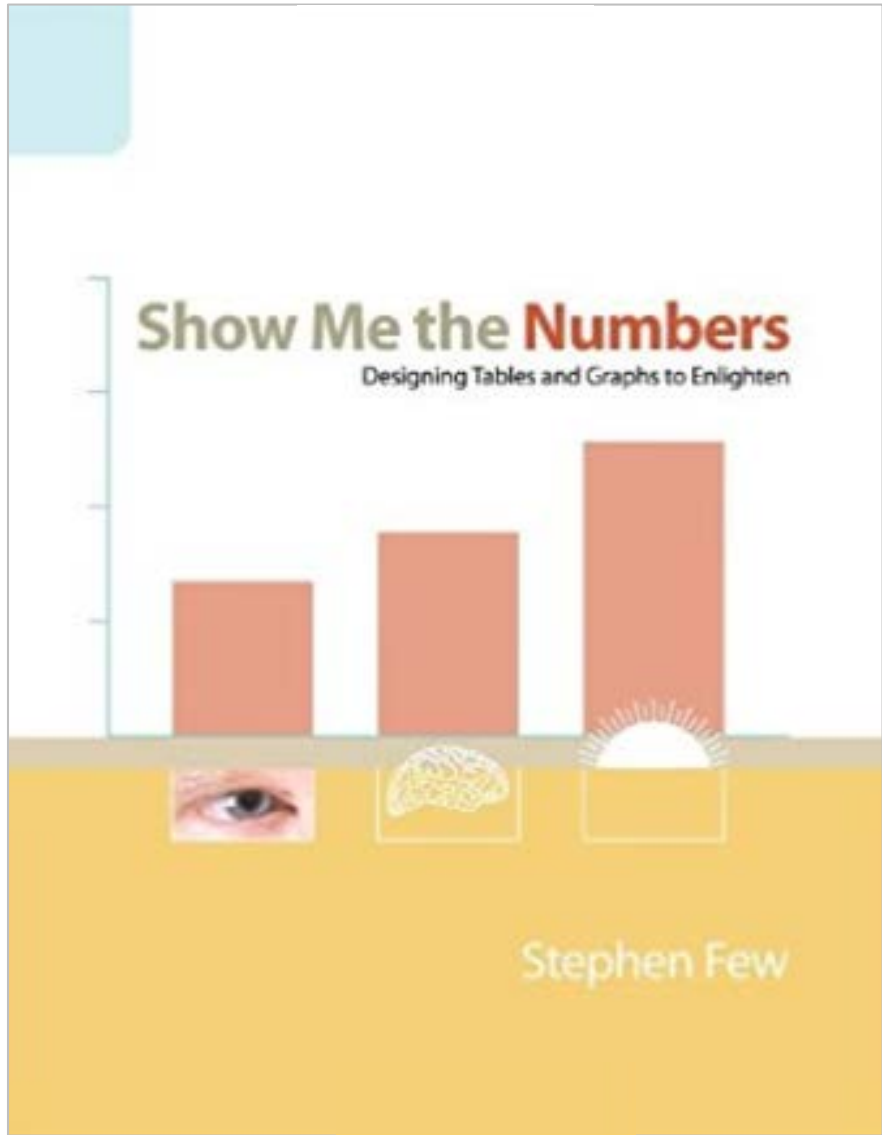
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White space can be used as virtual ink

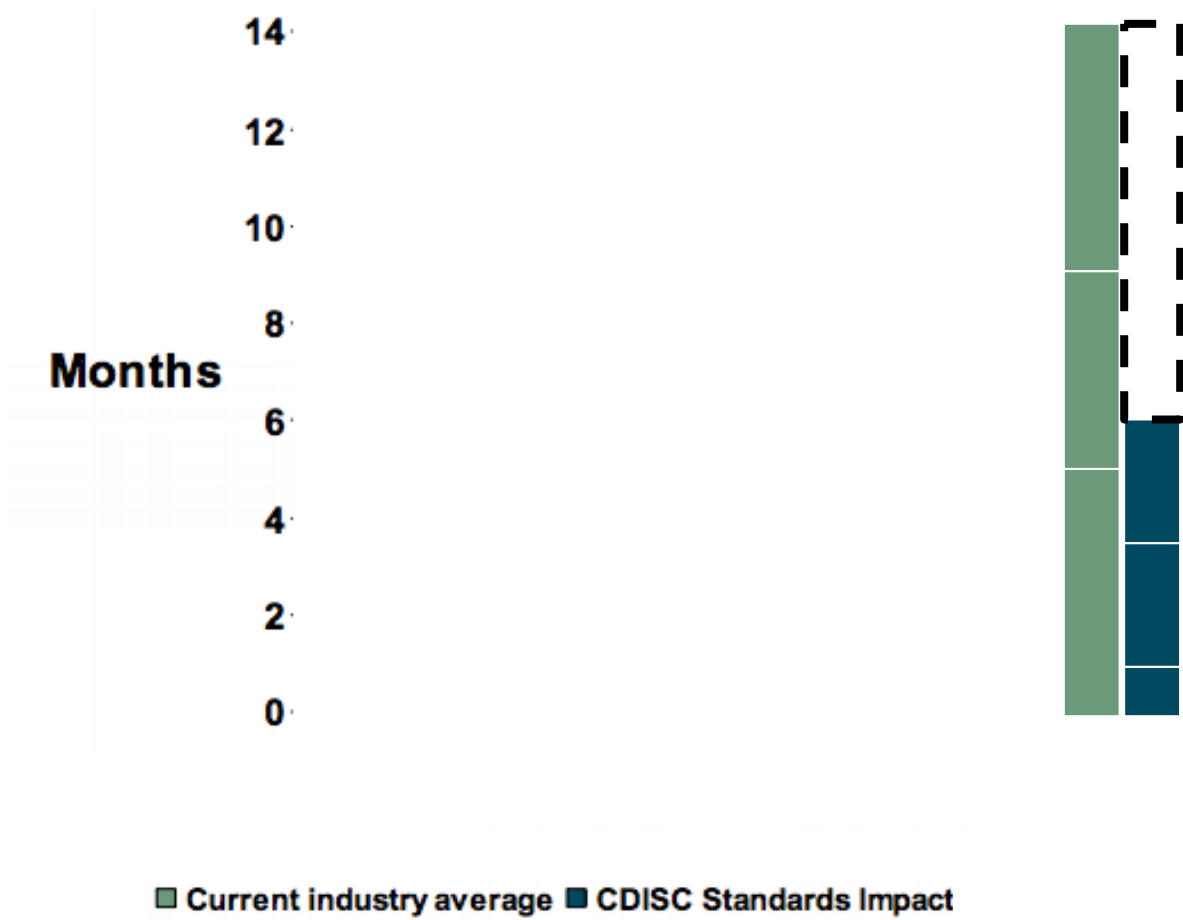


Supporting text

Stephen Few

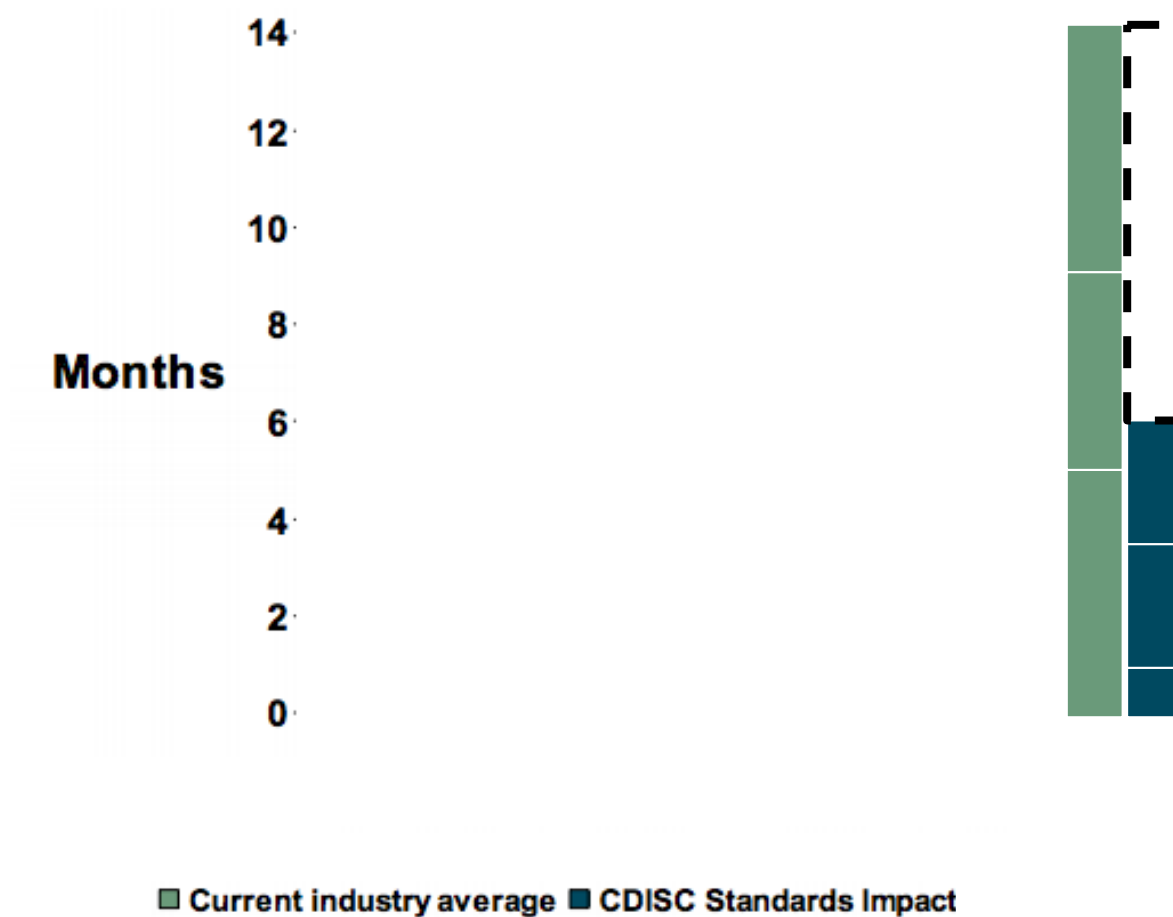
Supporting text

Stephen Few



Supporting text

Stephen Few



Text needed to understand the data, but not the data itself

Supporting text

Stephen Few



Text needed to understand the data, but not the data itself

Regularize supporting text

One font only *Arial, Times New Roman, etc.*

No variants *narrow, condensed, SMALL CAPS, etc.*

Same background as slide

De-emphasize supporting text

Smaller than other text

No underline, bold, highlight, italics

Use % black

% black drives % attention

Hey, look at me!

I am less important

Nothing to see here

Notes on original graph

Study Conduct does not include patient participation time.

Note: Figures are benchmarks based on aggregate data; study-specific cycle times and cost metrics will vary.

Notes on original graph

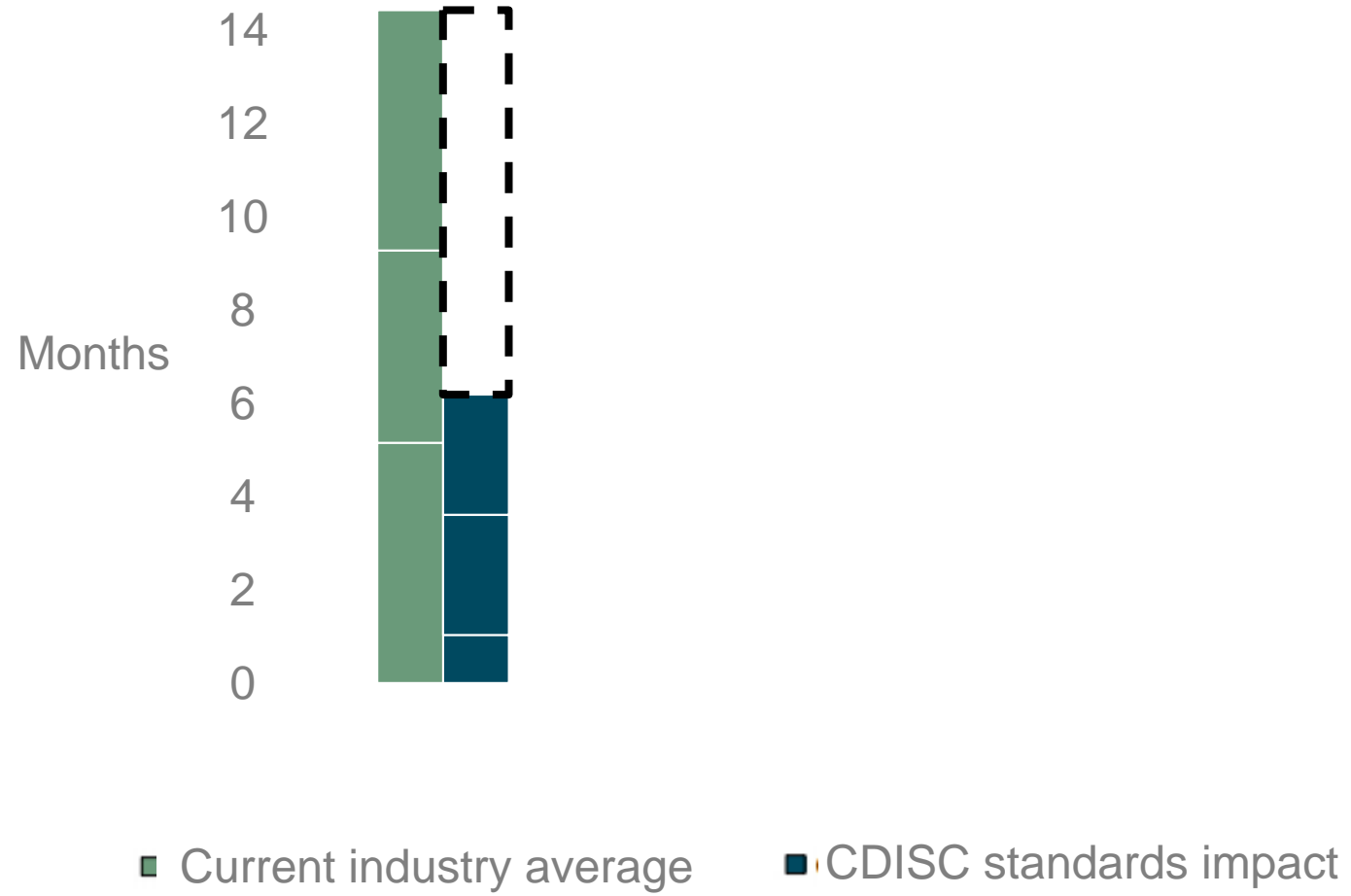
Study conduct does not include patient participation time.

Figures are benchmarks based on aggregate data; study-specific cycle times and cost metrics will vary.

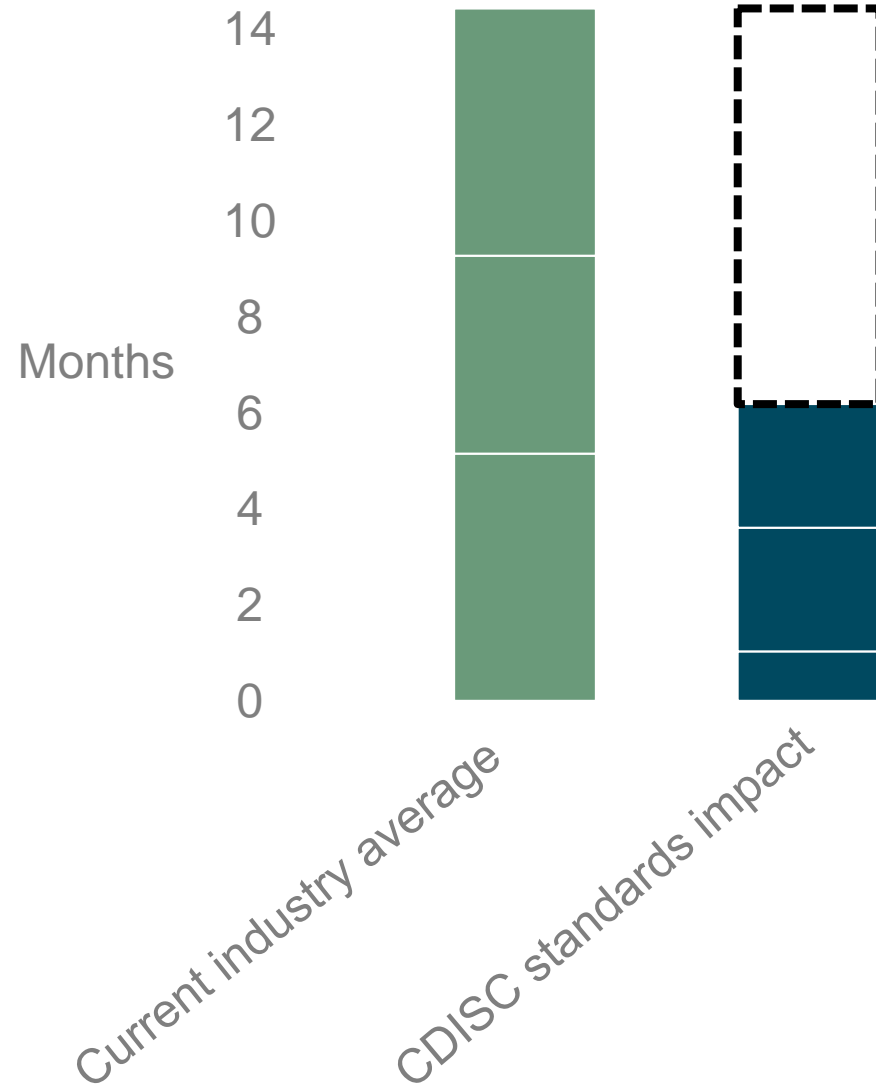
Regularize & de-emphasize supporting text



Column labels



Column labels



Text orientation and legibility

Best legibility

Worse legibility

Truly awful

Just terrible

Text orientation and legibility

Best legibility

Worse legibility

Truly awful

Just terrible

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Other text disasters to avoid

ALL CAPS IS YELLING

Other text disasters to avoid

ALL CAPS IS YELLING

Different colors **by** word **is** very distracting

Other text disasters to avoid

ALL CAPS IS YELLING

Different colors **by** word **is** very **distracting**

This font is illegible

This font is also illegible

This font too is illegible

Other text disasters to avoid

ALL CAPS IS YELLING

Different colors **by** word **is** very distracting

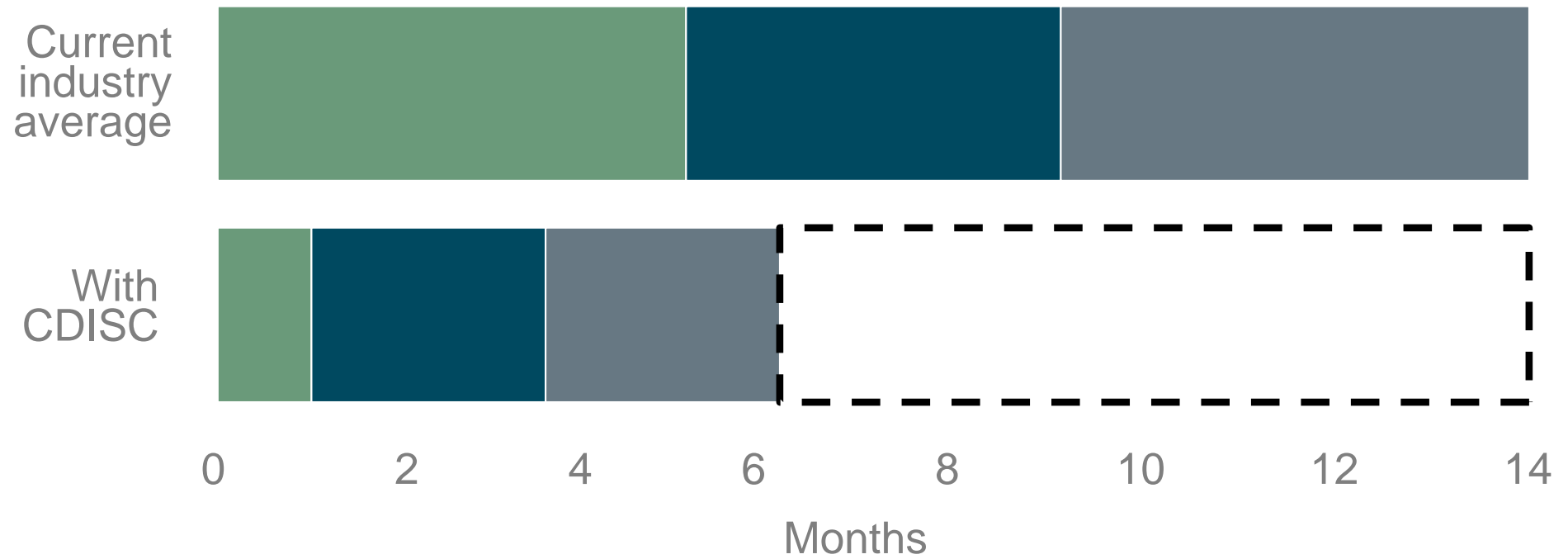
This font is illegible

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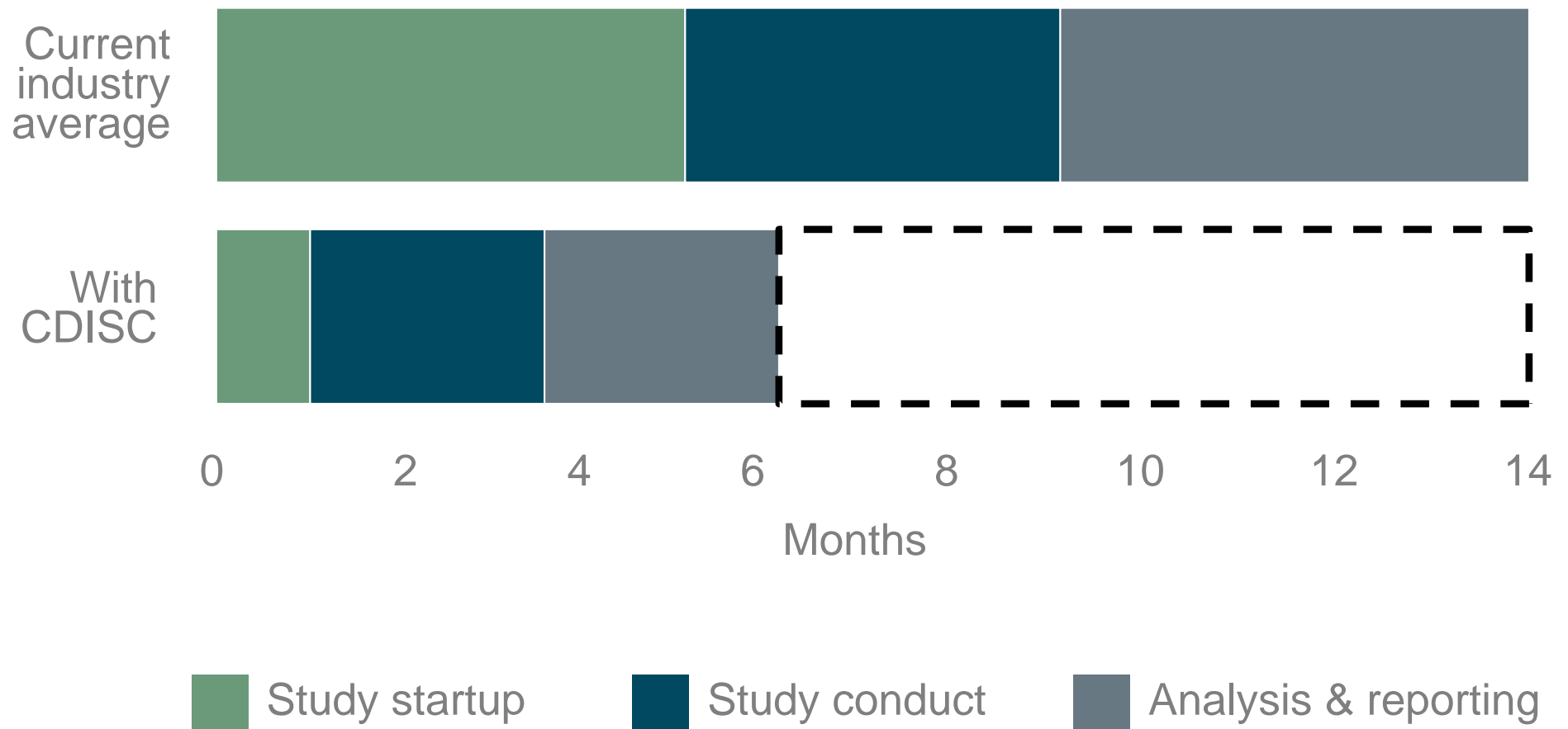
This font too is illegible

Using Comic Sans will gain you enemies

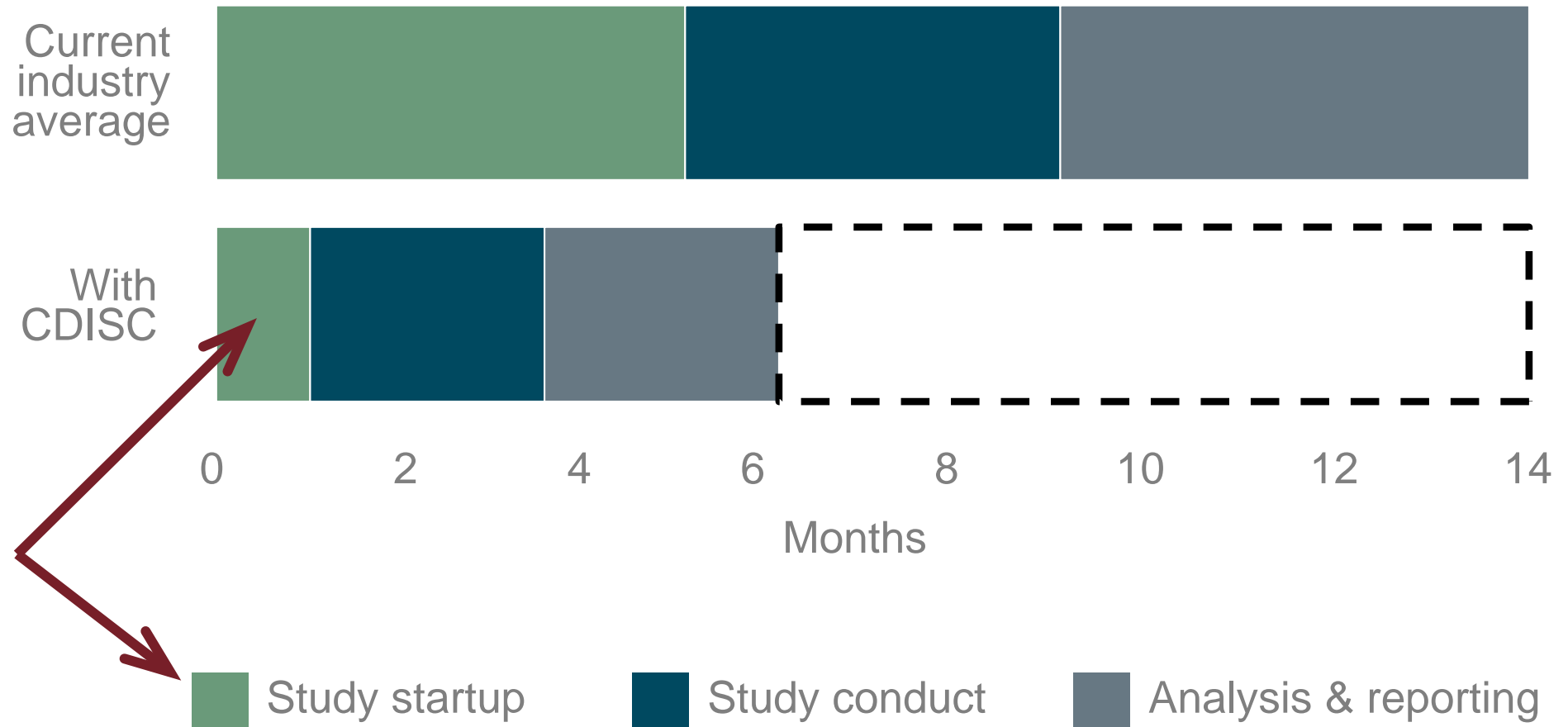
Convert to bar chart for label legibility



Add series labels

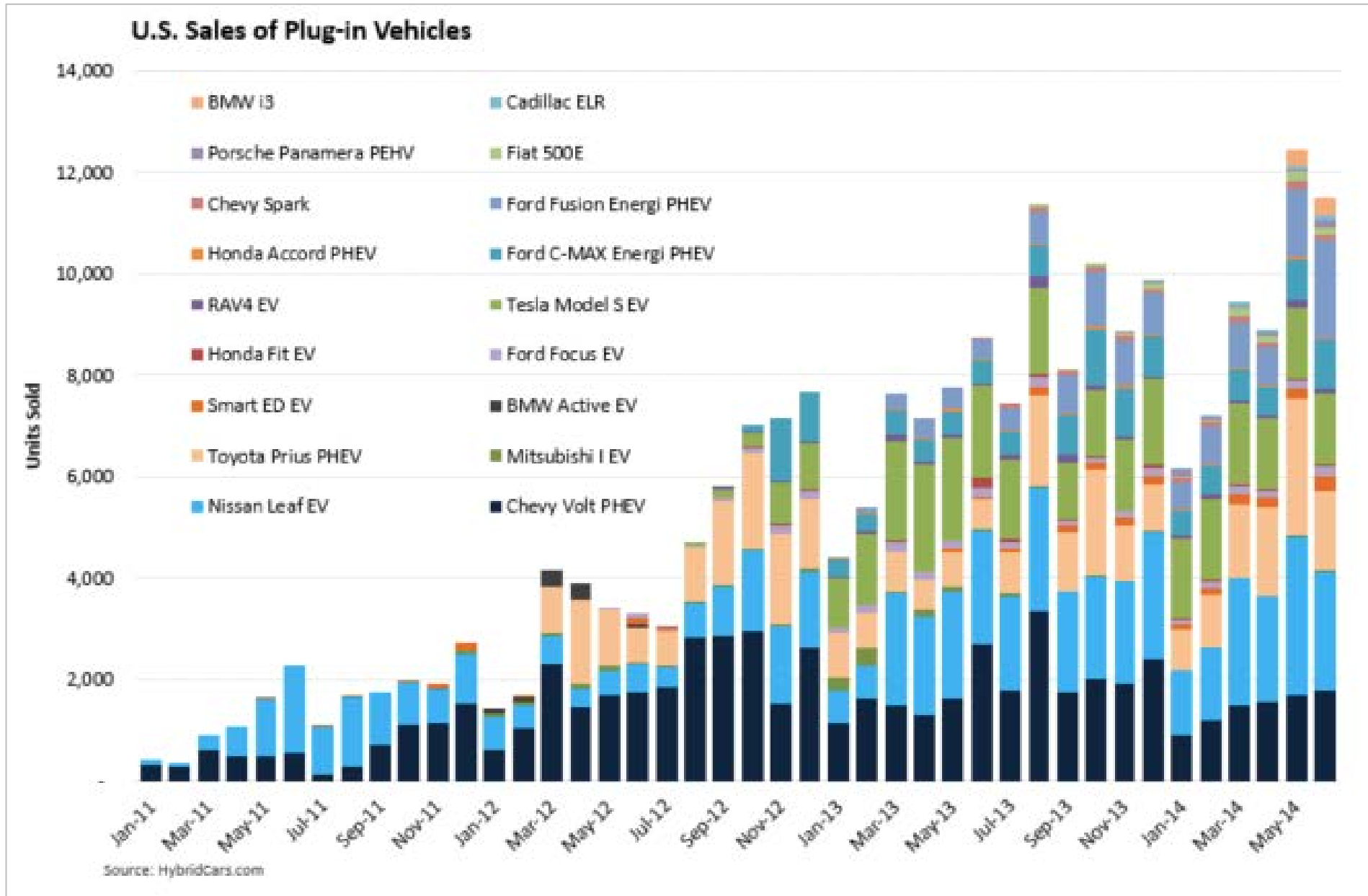


Add series labels

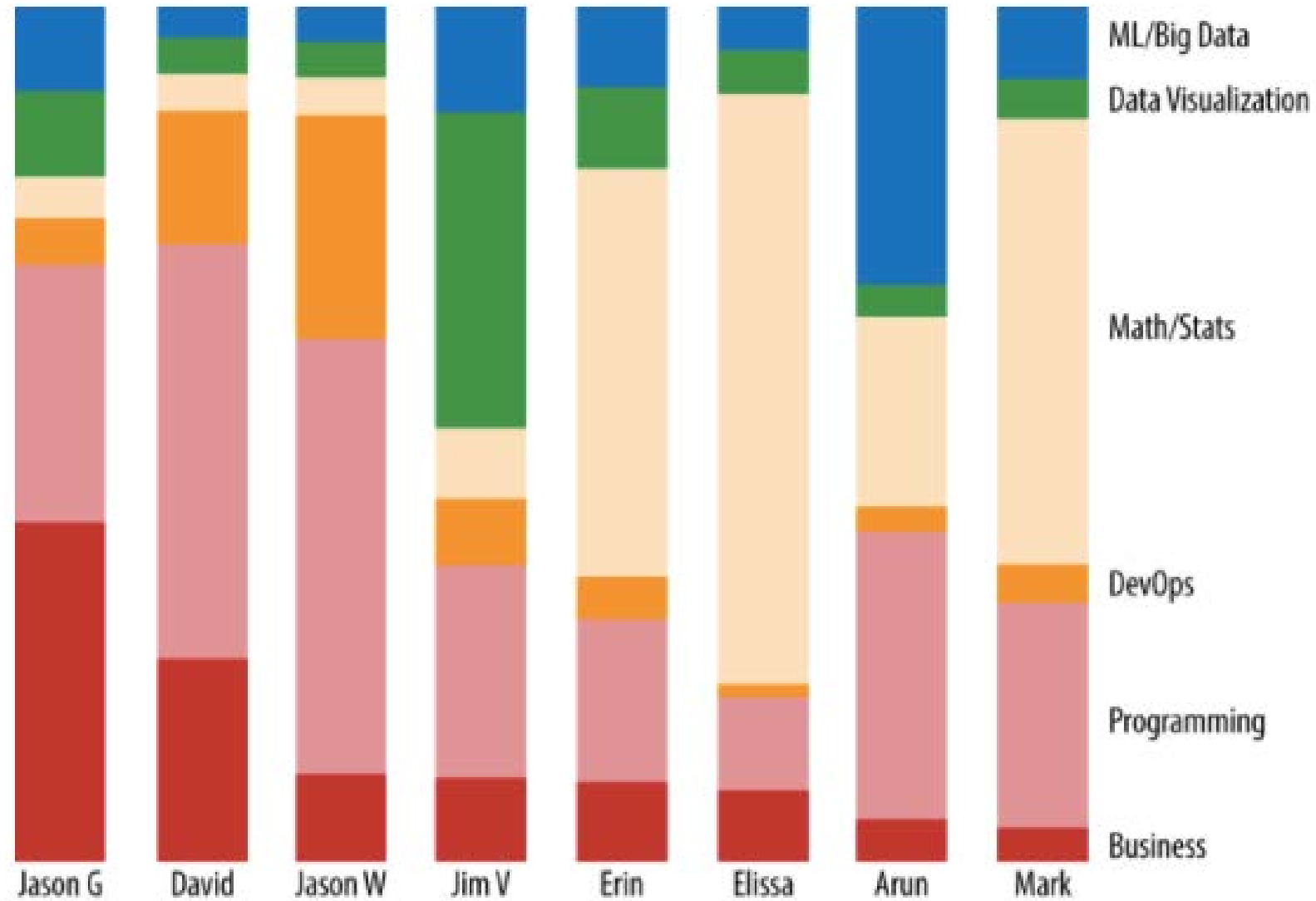


Distance between data and its label

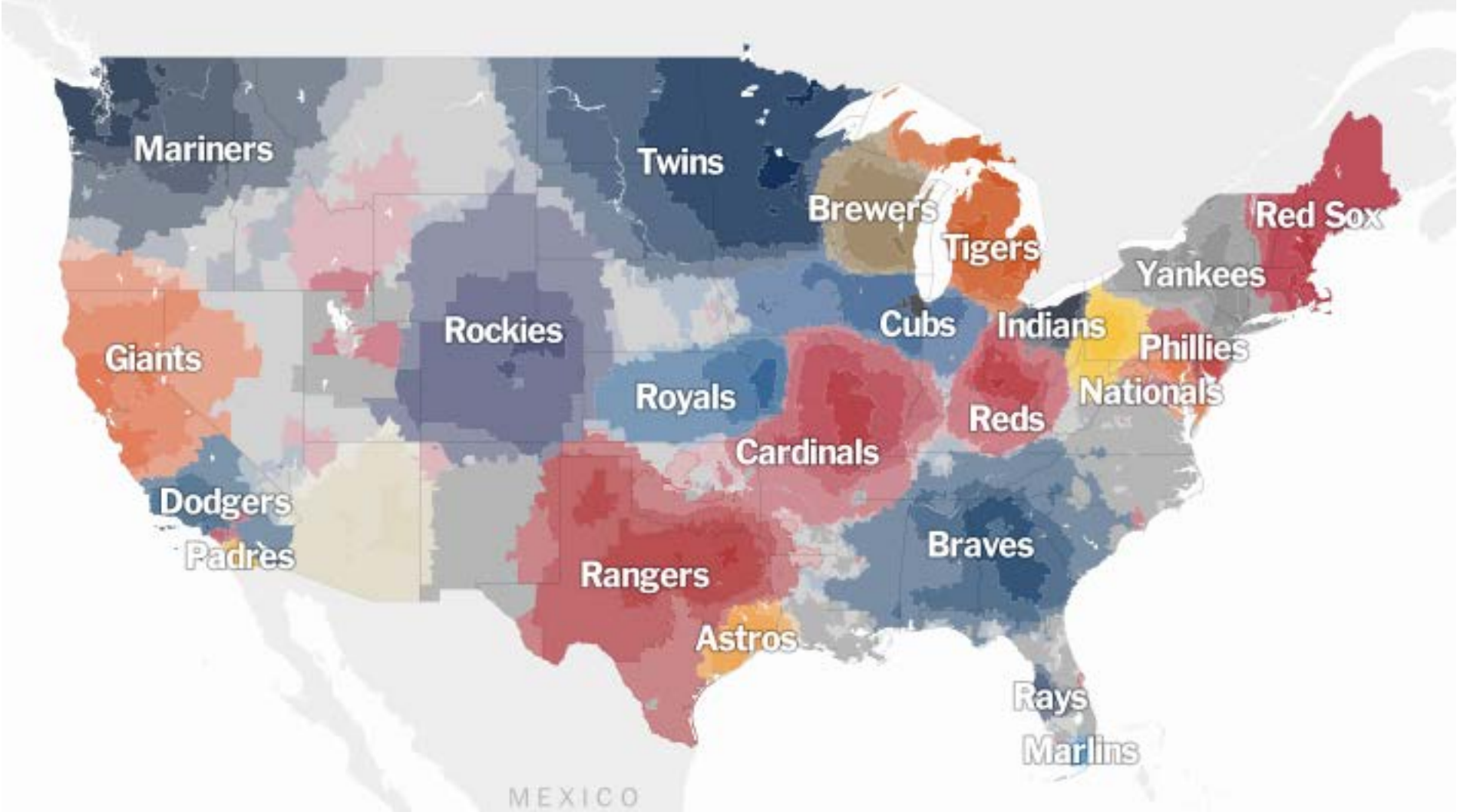
Distance between data and its labels: Too far



Distance between data and its labels: Closer...



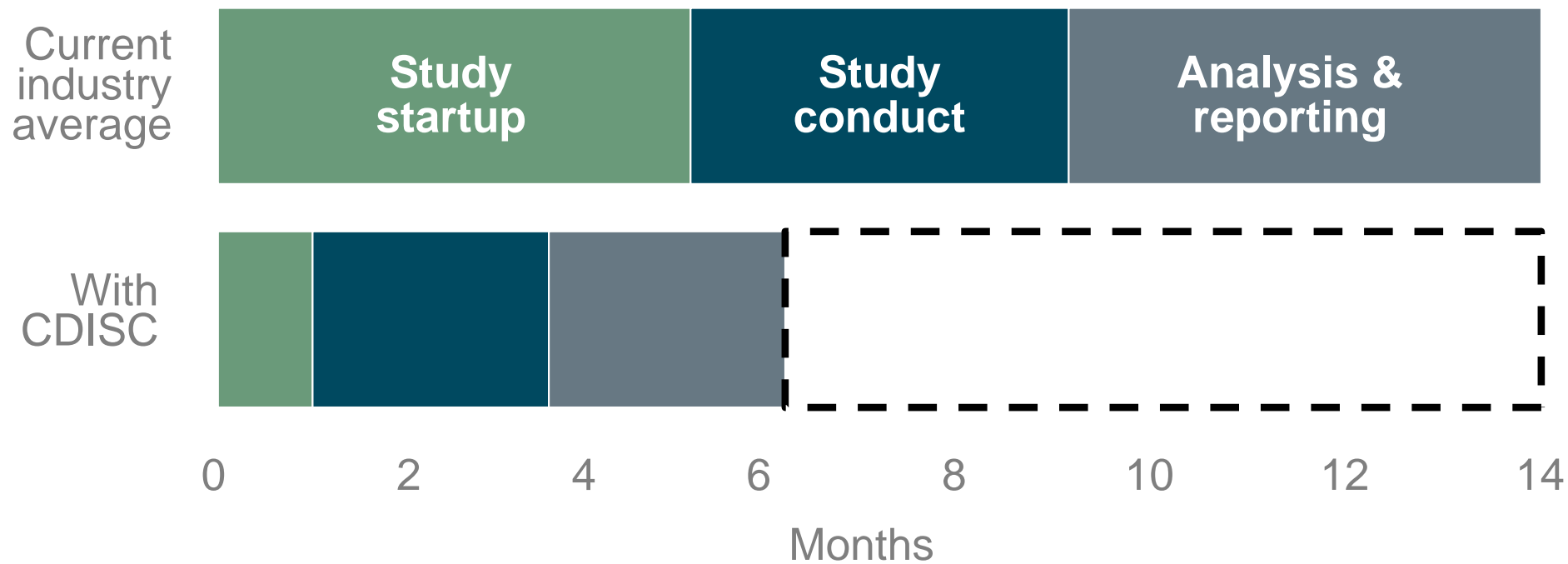
Distance between data and its labels: **Right on top**



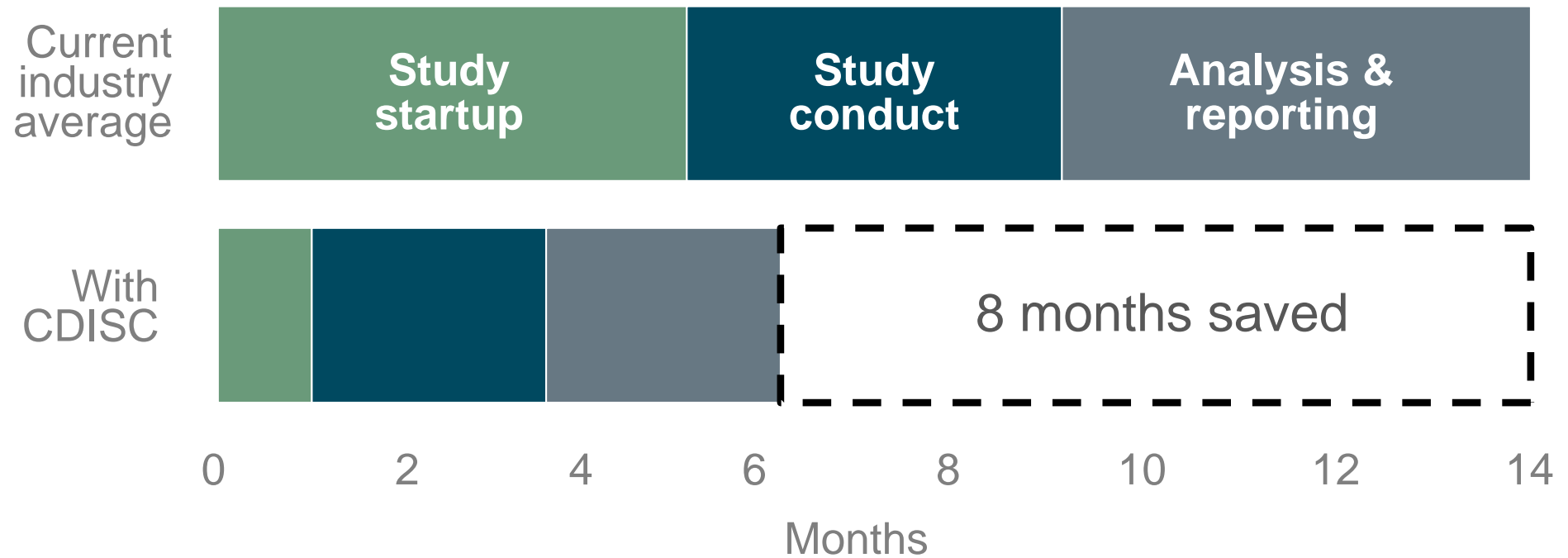
Distance between data and its labels: *Data is the label*



Put labels right on top of series

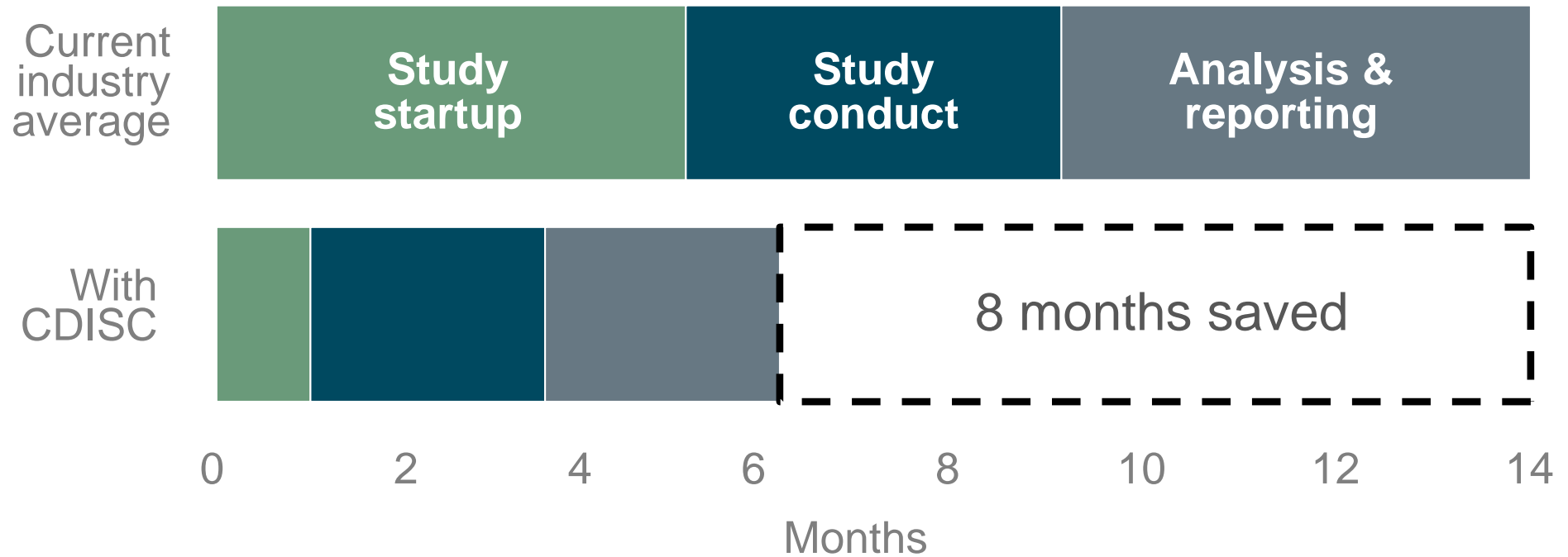


Finally, draw attention to the message



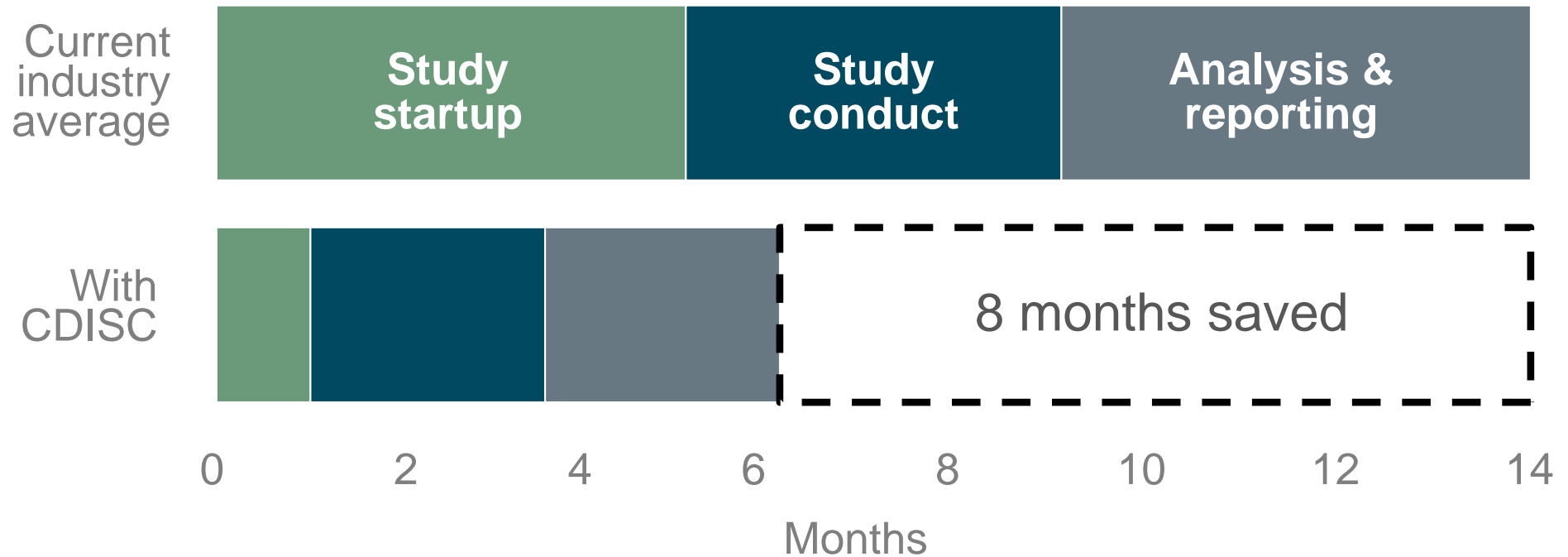
Tell the story right in the title

CDISC standards save eight months of clinical cycle study time



Replace notes and logo

CDISC standards save eight months of clinical cycle study time



Study conduct does not include patient participation time.

Figures are benchmarks based on aggregate data; study-specific cycle times and cost metrics will vary.

When you make a new graph....

Clarify your main message.

Look at a book for inspiration.

Maximize your data-ink.

Consider cognitive ergonomics.

Presenting graphs to patients

Why present data to patients as visualizations?

Show magnitude of specific risks or benefits

Boost understanding of numbers presented in text form

Garcia-Retamero 2010, 2012, 2013

Establish trust

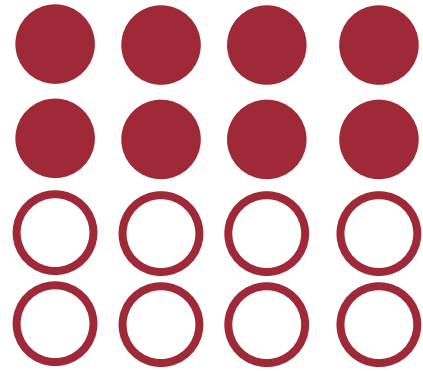
Gurmankin 2004

How we present data really matters

$$\frac{1}{2}$$

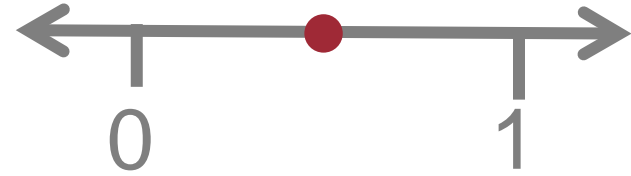
How we present data really matters

Half



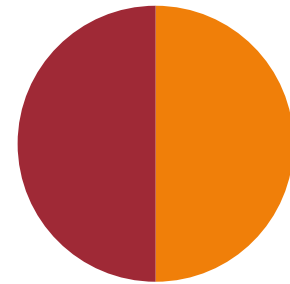
0.5

7/14



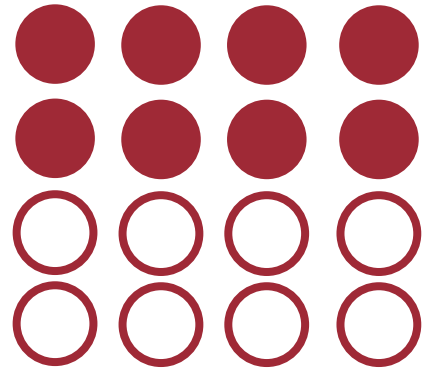
$\frac{1}{2}$

50%



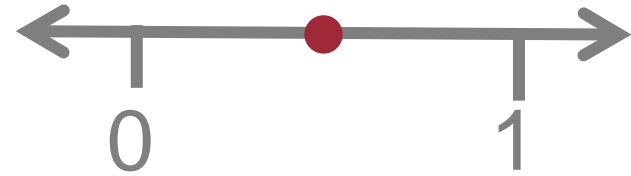
How we present data really matters

Half



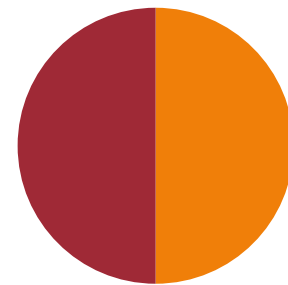
0.5

$7/14$



$\frac{1}{2}$

50%



Mathematically identical, cognitively different

Literature on patient graph comprehension

Fairly young literature, but growing

Literature on patient graph comprehension

Fairly young literature, but growing

Typical study:

Show patients various layouts, then measure:

Objective comprehension

Perceived comprehension

Preferences

Individual traits affect graph comprehension

Individual traits affect graph comprehension

Age: Comprehension declines after about age 70

Individual traits affect graph comprehension

Age: Comprehension declines after about age 70

Gender: No strong differences

Individual traits affect graph comprehension

Age: Comprehension declines after about age 70

Gender: No strong differences

Socioeconomic status, race, ethnicity:

Differences are just a function of...

Individual traits affect graph comprehension

Age: Comprehension declines after about age 70

Gender: No strong differences

Socioeconomic status, race, ethnicity:
Differences are just a function of...

Education level: Positive correlation

Individual traits affect graph comprehension

Age: Comprehension declines after about age 70

Gender: No strong differences

Socioeconomic status, race, ethnicity:

Differences are just a function of...

Education level: Positive correlation

In turn, these differences are just a function of...

Individual traits affect graph comprehension

Literacy

Numeracy

Individual traits affect graph comprehension

Literacy

Numeracy

Graphacy

“Graphicacy”

“Graph literacy”

Icon arrays

Hawley 2008, Kim 2017, Kurz 2008, Ancker 2006

Icon arrays

“Pictographs”
“Pictograph arrays”
“Population diagrams”

Icon arrays

Baseline risk

The risk of heart attack
in the next 10 years for
100 people like you



 82 People DO NOT
HAVE a heart attack

 18 People DO
HAVE a heart attack

Icon arrays

Baseline risk

The risk of heart attack in the next 10 years for 100 people like you



● 82 People DO NOT HAVE a heart attack

● 18 People DO HAVE a heart attack

Stop smoking, aspirin

The risk of heart attack in the next 10 years for 100 people like you



● 91 People DO NOT HAVE a heart attack

● 9 People DO HAVE a heart attack

Icon arrays

Baseline risk

The risk of heart attack in the next 10 years for 100 people like you



● 82 People DO NOT HAVE a heart attack

● 18 People DO HAVE a heart attack

Stop smoking, aspirin

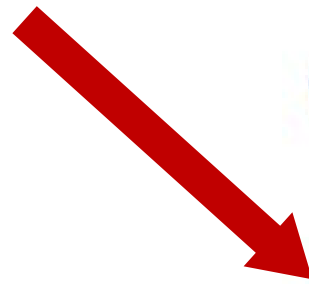
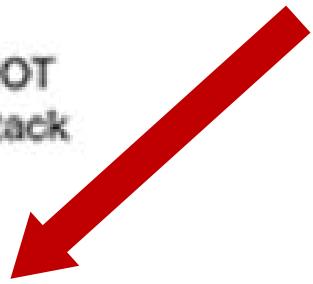
The risk of heart attack in the next 10 years for 100 people like you



● 91 People DO NOT HAVE a heart attack

● 9 People DO HAVE a heart attack

50%
reduction
in risk



When presenting data to patients:

Use both text and graphs

Use icon arrays to display risks and tradeoffs

Use natural frequencies, not rates or percentages

Consider the individual patient

Over 70?

Low graphacy?

Low numeracy?

Colorblind?

Thanks.