

How does your password measure up?

The effect of strength meters on password creation

A strong password helps prevent unauthorized access to your email account.

Type new password:

8-character minimum; case sensitive

Password strength: Please enter a password in the box above.


Retype new password:

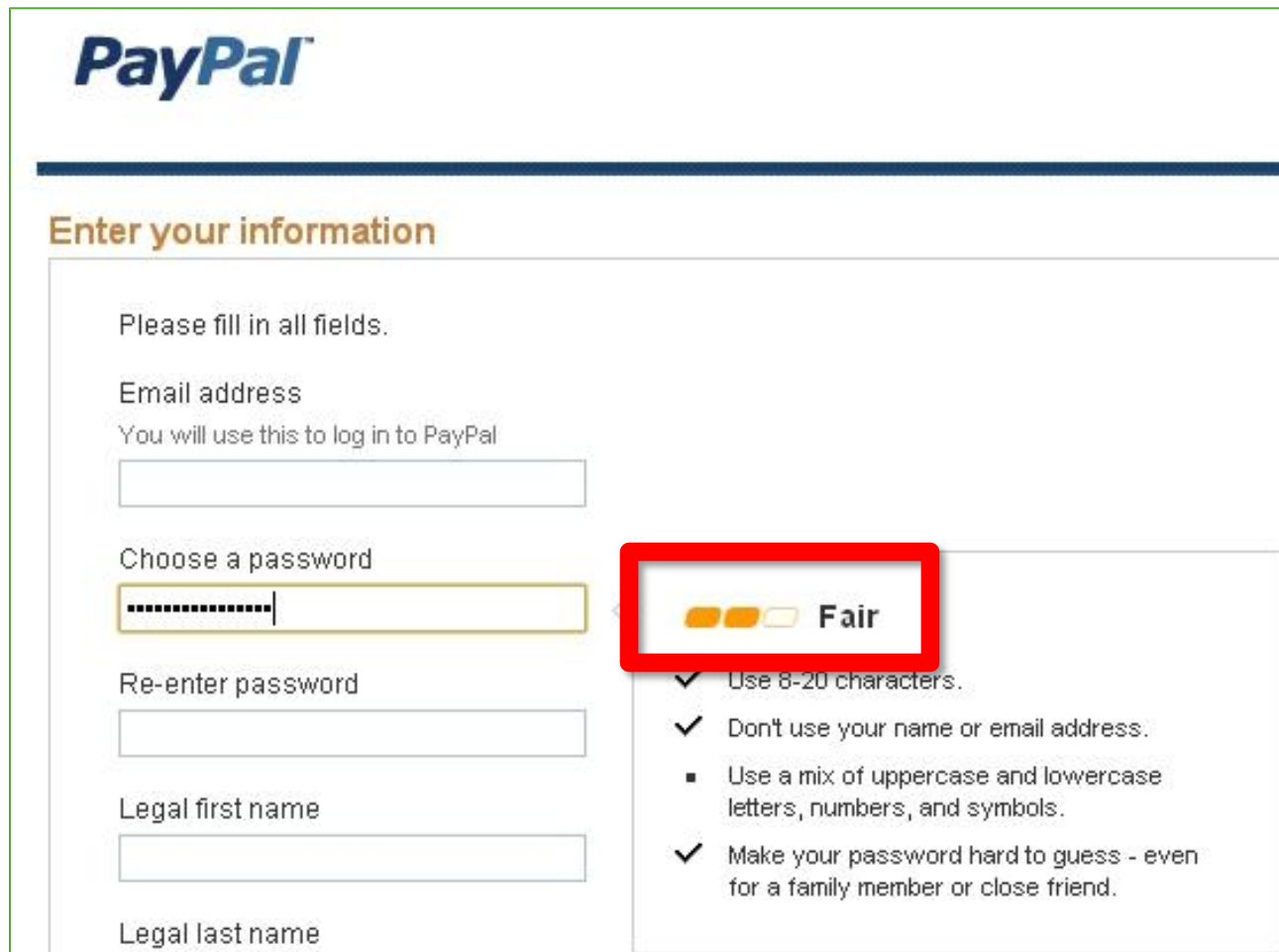
Make my password expire every 72 days.

Blase Ur, Patrick Gage Kelley, Saranga Komanduri, Joel Lee, Michael Maass, Michelle L. Mazurek, Timothy Passaro, Richard Shay, Timothy Vidas, Lujo Bauer, Nicolas Christin, Lorrie Faith Cranor

Carnegie Mellon

Password Meters

- Feedback of password strength at creation time
 - Encourage users to create “stronger” passwords



PayPal

Enter your information

Please fill in all fields.

Email address
You will use this to log in to PayPal

Choose a password

Re-enter password

Legal first name

Legal last name

Fair

- ✓ Use 8-20 characters.
- ✓ Don't use your name or email address.
 - Use a mix of uppercase and lowercase letters, numbers, and symbols.
- ✓ Make your password hard to guess - even for a family member or close friend.

Password Meters

- Widely used


Google

collaborate, discover, and create. See
Google products from Gmail to Google+ to
YouTube, view your search history, all with
one username and password, all backed up
all the time and easy to find at (you
guess

Choose your username

Create a password

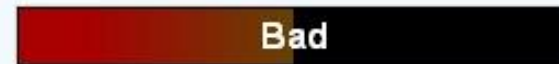
Confirm your password

Password strength: Weak


Use at least 8 characters. Don't use a password from another site, or something too obvious like your pet's name. Why?

WordPress

Great passwords use upper and lower case characters, numbers and symbols like !"£\$%^&().



USENIX

Password

Passwords match: yes

Confirm password

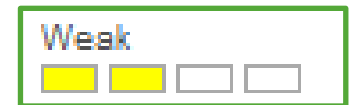
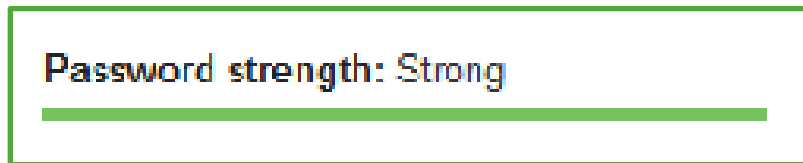
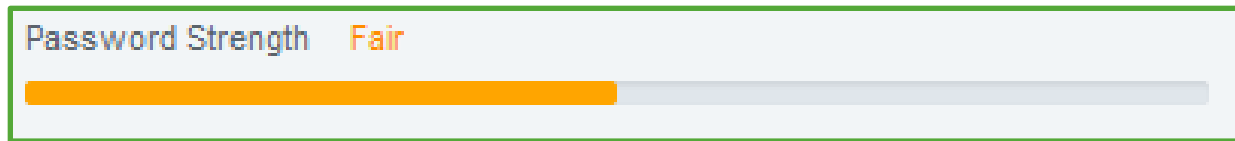
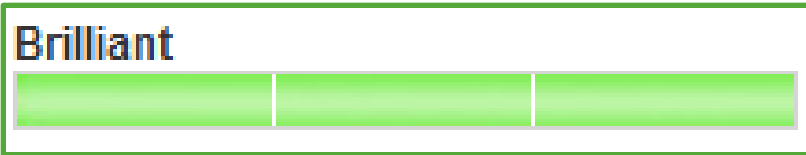
To make your password stronger:

- Add uppercase letters
- Add numbers
- Add punctuation

Password strength: Fair


Password Meters

- Come in all shapes and sizes



Primary Research Questions

1. How do password meters affect ...?

- Composition
- Guessability
- Creation process
- Memorability
- User sentiment

2. What elements of meter design are important?

We present the first large-scale experiment on how the visual and scoring aspects of meters affect password properties

Methodology

- 2,931-participant online study
- Between-subjects design
 - 15 conditions: no meter + 14 different meters
- 2-part study, 2+ days apart
 - Compensated \$0.55 and \$0.70, respectively

Methodology

- Part 1: Create a password and answer a survey about its creation
 - Scenario: Main email provider is requiring you to change your password
 - Only requirement: 8+ characters
- Part 2: Emailed to return, re-enter password, and answer a survey about remembering password

Overview of Conditions

- **Control** conditions
- **Visual** differences
- **Scoring** differences
- Both **visual & scoring** differences

Control Conditions

- Conditions to which all others were compared:
 - **No meter:** No feedback on strength
 - **Baseline meter:** Standard password meter

Baseline Password Meter

- Based on meters used “in the wild”
 - 8 lowercase letters would fill 1/3rd of the meter
- Higher scores possible from:
 - Longer passwords, e.g., *passwordpassword*
 - More character classes, e.g., *Pa\$5worD*

Baseline Password Meter



LiveMail

Create a password

Account Password

A strong password helps prevent unauthorized access to your email account.

Type new password:

8-character minimum; case sensitive

Password strength: Please enter a password in the box above.



Retype new password:

Make my password expire every 72 days.

Save

Baseline Password Meter



LiveMail

Create a password

Account Password

A strong password helps prevent unauthorized access to your email account.

Type new password:

8-character minimum; case sensitive

Password strength: Bad. Consider adding an uppercase letter or making your password longer.



Retype new password:

Make my password expire every 72 days.

Save

Non-segmented bar

Baseline Password Meter



LiveMail

Create a password

Account Password

A strong password helps prevent unauthorized access to your email account.

Type new password:

8-character minimum; case sensitive

Password strength: **Bad.** Consider adding an uppercase letter or making your password longer.

Retype new password:

Make my password expire every 72 days.

Save

Bad ⇨ Poor ⇨ Fair ⇨ Good ⇨ Excellent

Baseline Password Meter



LiveMail

Create a password

Account Password

A strong password helps prevent unauthorized access to your email account.

Type new password:

8-character minimum; case sensitive

Password strength: Bad Consider adding an uppercase letter or making your password longer.

Retype new password:

Make my password expire every 72 days.

Save

Provides a suggestion

Baseline Password Meter



LiveMail

Create a password

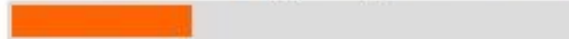
Account Password

A strong password helps prevent unauthorized access to your email account.

Type new password:

Your password is in our dictionary of common passwords.

Password strength: Bad. Consider adding an uppercase letter or making your password longer.



Retype new password:

Make my password expire every 72 days.

Save

Checks against OpenWall cracking dictionary

Baseline Password Meter



LiveMail

Create a password

Account Password

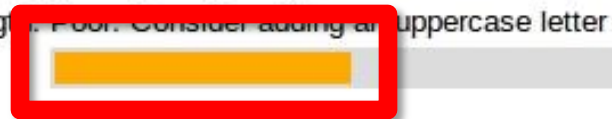
A strong password helps prevent unauthorized access to your email account.

Type new password:

8-character minimum; case sensitive

Your password is in our dictionary of common passwords.

Password strength: **Poor.** Consider adding an uppercase letter or making your password longer.



Retype new password:

Make my password expire every 72 days.

Save

Changes color: red ⇒ orange/yellow ⇒ green

Baseline Password Meter



LiveMail

Create a password

Account Password

A strong password helps prevent unauthorized access to your email account.

Type new password:

8-character minimum; case sensitive

Password strength: Good. Consider adding a digit or making your password longer.



Retype new password:

Make my password expire every 72 days.

Save

Baseline Password Meter



LiveMail

Create a password

Account Password

A strong password helps prevent unauthorized access to your email account.

Type new password:

8-character minimum; case sensitive

Password strength: Excellent!



Retype new password:

Make my password expire every 72 days.

Save

Overview of Conditions

- Control conditions (2)
- **Visual** differences (7)
- **Scoring** differences (4)
- Both **visual & scoring** differences (2)

Conditions with Visual Differences

Type new password:

8-character minimum; case sensitive

Baseline meter

Bad. Consider adding a digit or making your password longer.



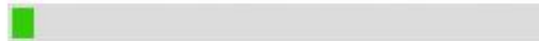
Three-segment

Bad. Consider adding a digit or making your password longer.



Green

Bad. Consider adding a digit or making your password longer.



Tiny

Bad. Consider adding a digit or making your password longer.



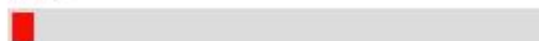
Huge

Bad. Consider adding a digit or making your password longer.



No suggestions

Bad.



Text-only

Bad. Consider adding a digit or making your password longer.

Conditions with Visual Differences

Type new password:

8-character minimum; case sensitive

Baseline meter

Bad. Consider adding a digit or making your password longer.



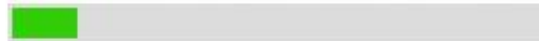
Three-segment

Bad. Consider adding a digit or making your password longer.



Green

Bad. Consider adding a digit or making your password longer.



Tiny

Bad. Consider adding a digit or making your password longer.



Huge

Bad. Consider adding a digit or making your password longer.



No suggestions

Bad.



Text-only

Bad. Consider adding a digit or making your password longer.

Conditions with Visual Differences

Type new password:

8-character minimum; case sensitive

Baseline meter

Bad. Consider adding a digit or making your password longer.



Three-segment

Bad. Consider adding a digit or making your password longer.



Green

Bad. Consider adding a digit or making your password longer.



Tiny

Bad. Consider adding a digit or making your password longer.



Huge

Bad. Consider adding a digit or making your password longer.



No suggestions

Bad.



Text-only

Bad. Consider adding a digit or making your password longer.

Conditions with Visual Differences

Type new password:

8-character minimum; case sensitive

Baseline meter

Fair. Consider adding a digit or making your password longer.



Three-segment

Fair. Consider adding a digit or making your password longer.



Green

Fair. Consider adding a digit or making your password longer.



Tiny

Fair. Consider adding a digit or making your password longer.



Huge

Fair. Consider adding a digit or making your password longer.



No suggestions

Fair.



Text-only

Fair. Consider adding a digit or making your password longer.

Conditions with Visual Differences

Type new password:

8-character minimum; case sensitive

Baseline meter

Good. Consider adding a digit or making your password longer.



Three-segment

Good. Consider adding a digit or making your password longer.



Green

Good. Consider adding a digit or making your password longer.



Tiny

Good. Consider adding a digit or making your password longer.



Huge

Good. Consider adding a digit or making your password longer.



No suggestions

Good.



Text-only

Good. Consider adding a digit or making your password longer.

Conditions with Visual Differences

Type new password:

8-character minimum; case sensitive

Baseline meter

Excellent!



Three-segment

Excellent!



Green

Excellent!



Tiny

Excellent!



Huge

Excellent!



No suggestions

Excellent!



Text-only

Excellent!

Bunny Condition

A strong password helps prevent unauthorized access to your email account.
The stronger your password, the faster Bugs Bunny dances!

Type new password:

8-character minimum; case sensitive

Password strength: Please enter a password in the box above.



Retype new password:

Make my password expire every 72 days.

Save

Conditions with Scoring Differences

Type new password:

8-character minimum; case sensitive

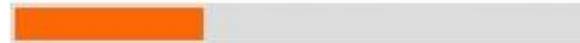
Baseline meter

Fair. Consider adding a digit or making your password longer.



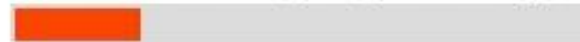
Half-score

Bad. Consider adding a digit or making your password longer.



One-third-score

Bad. Consider adding a digit or making your password longer.



Nudge-16

Bad. Consider making your password longer.



Nudge-Comp8

Fair. Consider adding a digit or making your password longer.



Conditions with Scoring Differences

Type new password:

8-character minimum; case sensitive

Baseline meter

Excellent!



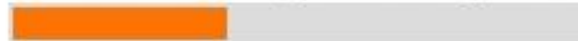
Half-score

Poor. Consider adding a different symbol or making your password longer.



One-third-score

Bad. Consider adding a different symbol or making your password longer.



Nudge-16

Poor. Consider making your password longer.



Nudge-Comp8

Excellent!



Conditions with Scoring Differences

Type new password:

8-character minimum; case sensitive

Baseline meter

Excellent!



Half-score

Fair. Consider adding a different symbol or making your password longer.



One-third-score

Poor. Consider adding a different symbol or making your password longer.



Nudge-16

Good. Consider making your password longer.



Nudge-Comp8

Excellent!



Conditions with Scoring Differences

Type new password:

8-character minimum; case sensitive

Baseline meter

Excellent!



Half-score

Good. Consider adding a different symbol or making your password longer.



One-third-score

Poor. Consider adding a different symbol or making your password longer.



Nudge-16

Excellent.



Nudge-Comp8

Excellent!



Conditions with Scoring Differences

Type new password:

usernIXse5WHYismyP4\$\$word99

8-character minimum; case sensitive

Baseline meter

Excellent!



Half-score

Excellent!



One-third-score

Fair. Consider adding a different symbol or making your password longer.



Nudge-16

Excellent.



Nudge-Comp8

Excellent!



Conditions with Scoring Differences

Type new password:

usernX\$e5WHYismyP4\$\$word99notGOOD|

8-character minimum; case sensitive

Baseline meter

Excellent!



Half-score

Excellent!



One-third-score

Fair. Consider making your password longer.



Nudge-16

Excellent.



Nudge-Comp8

Excellent!



Conditions with Scoring Differences

Type new password:

usernIXse5WHYismyP4\$\$word99notGOODenough?

8-character minimum; case sensitive

Baseline meter

Excellent!



Half-score

Excellent!



One-third-score

Excellent!



Nudge-16

Excellent.



Nudge-Comp8

Excellent!



Conditions with Visual & Scoring Diff.

Type new password:

8-character minimum; case sensitive

Baseline meter

Fair. Consider adding a digit or making your password longer.



Text-only-half

Bad. Consider adding a digit or making your password longer.

Bold text-only-half

Bad. Consider adding a digit or making your password longer.

Conditions with Visual & Scoring Diff.

Type new password:

8-character minimum; case sensitive

Baseline meter

Excellent!



Text-only-half

Poor. Consider adding a different digit or making your password longer.

Bold text-only-half

Poor. Consider adding a different digit or making your password longer.

Conditions with Visual & Scoring Diff.

Type new password:

8-character minimum; case sensitive

Baseline meter

Excellent!



Text-only-half

Fair. Consider adding a different symbol or making your password longer.

Bold text-only-half

Fair. Consider adding a different symbol or making your password longer.

Conditions with Visual & Scoring Diff.

Type new password:

8-character minimum; case sensitive

Baseline meter

Excellent!



Text-only-half

Fair. Consider adding a different digit or making your password longer.

Bold text-only-half

Fair. Consider adding a different digit or making your password longer.

Conditions with Visual & Scoring Diff.

Type new password:

8-character minimum; case sensitive

Baseline meter

Excellent!



Text-only-half

Good. Consider adding a different symbol or making your password longer.

Bold text-only-half

Good. Consider adding a different symbol or making your password longer.

Conditions with Visual & Scoring Diff.

Type new password:

8-character minimum; case sensitive

Baseline meter

Excellent!



Text-only-half

Excellent!

Bold text-only-half

Excellent!

Stringent Meters

- Those with more *stringent* scoring:
 - Half-score
 - One-third-score
 - Text-only-half
 - Bold text-only-half

Participants

- 2,931 participants
 - Recruited on Amazon's Mechanical Turk
- 63% male, 37% female
- 40% technical (degree/job)
- 18 to 74 years old
- 96 countries
 - 42% from India
 - 32% from U.S.

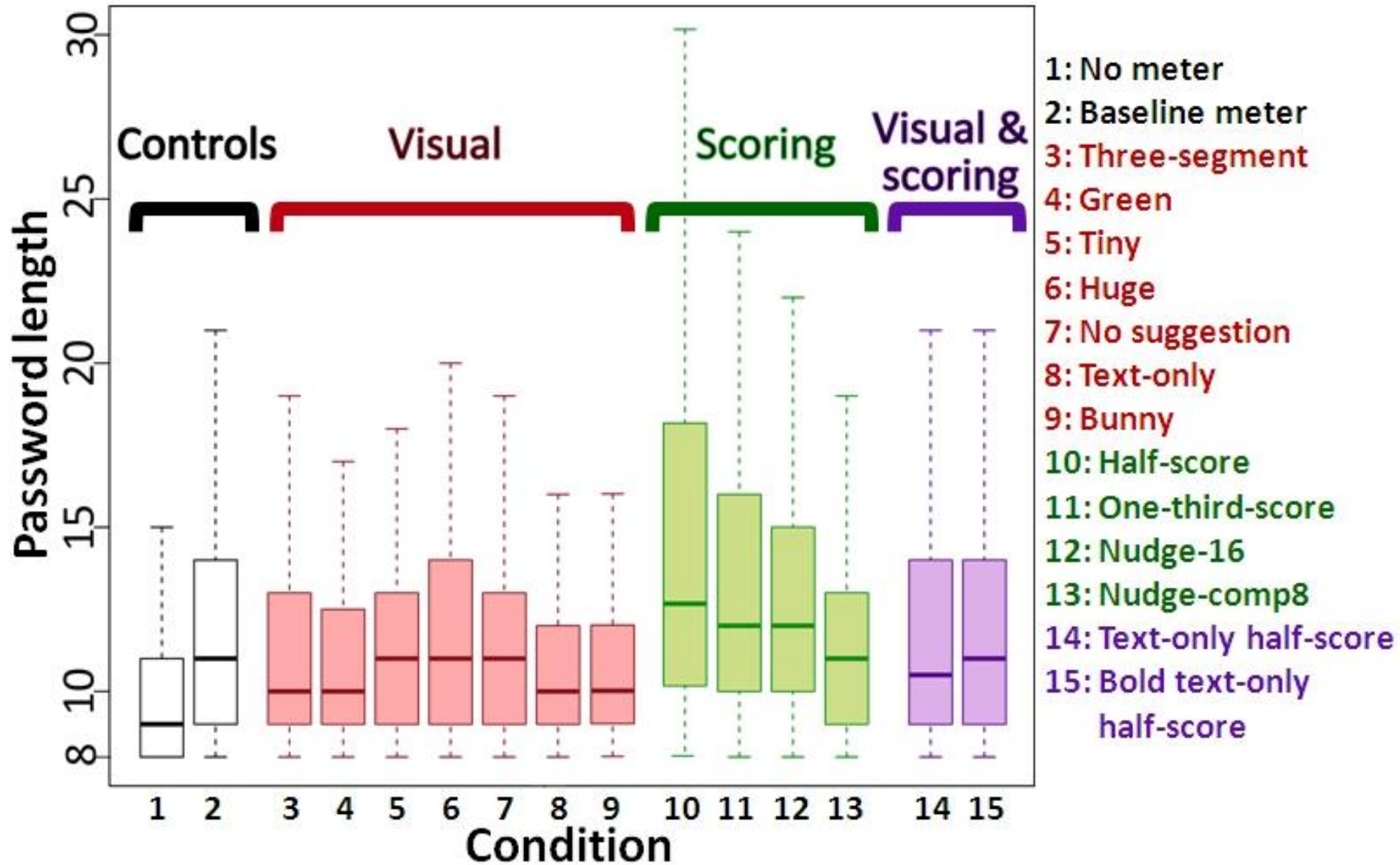
Metrics for Results

- Composition
- Guessability
- Creation process
- Memorability
- Sentiment

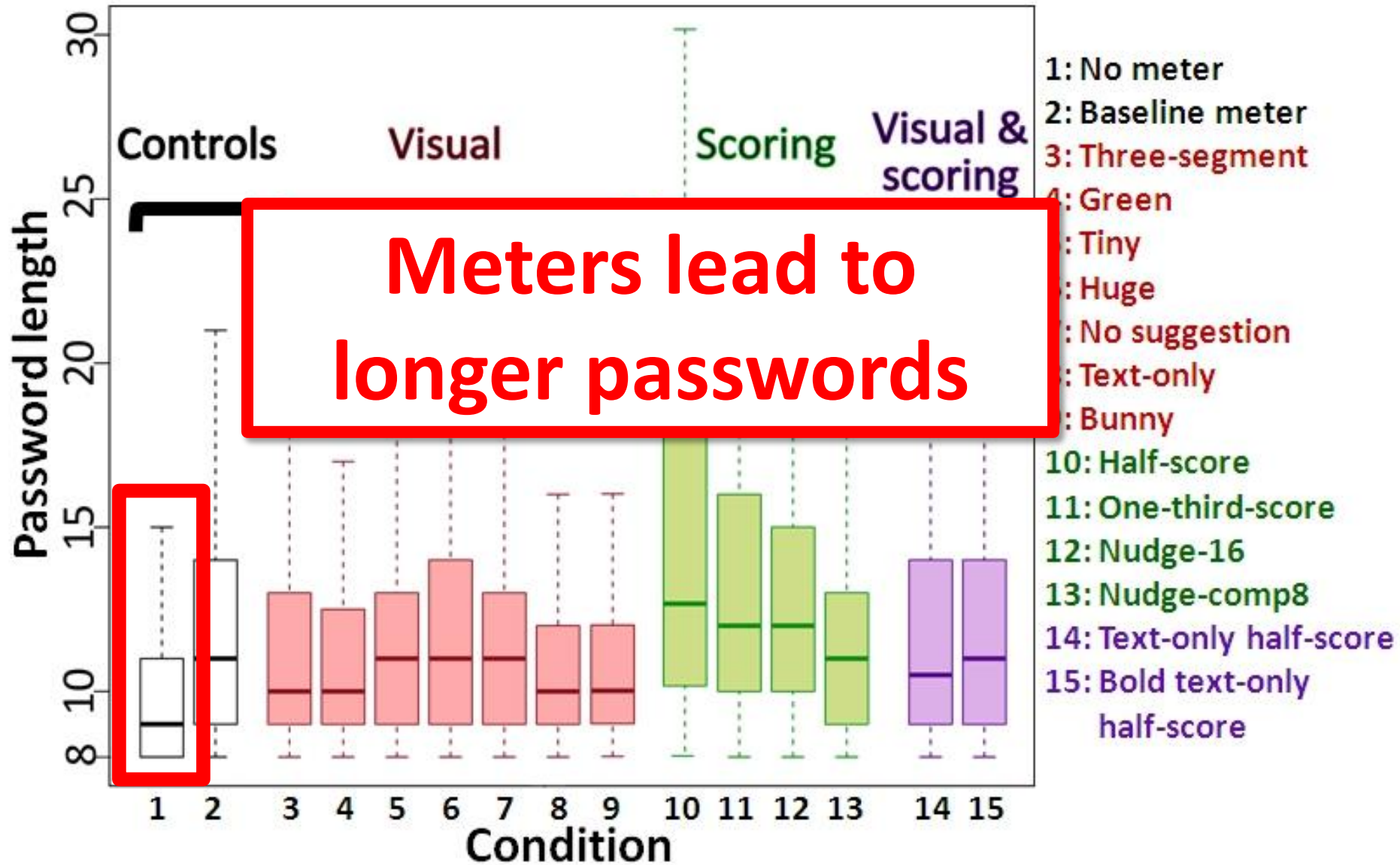
Metric – Password Composition

- Password length

Password Length



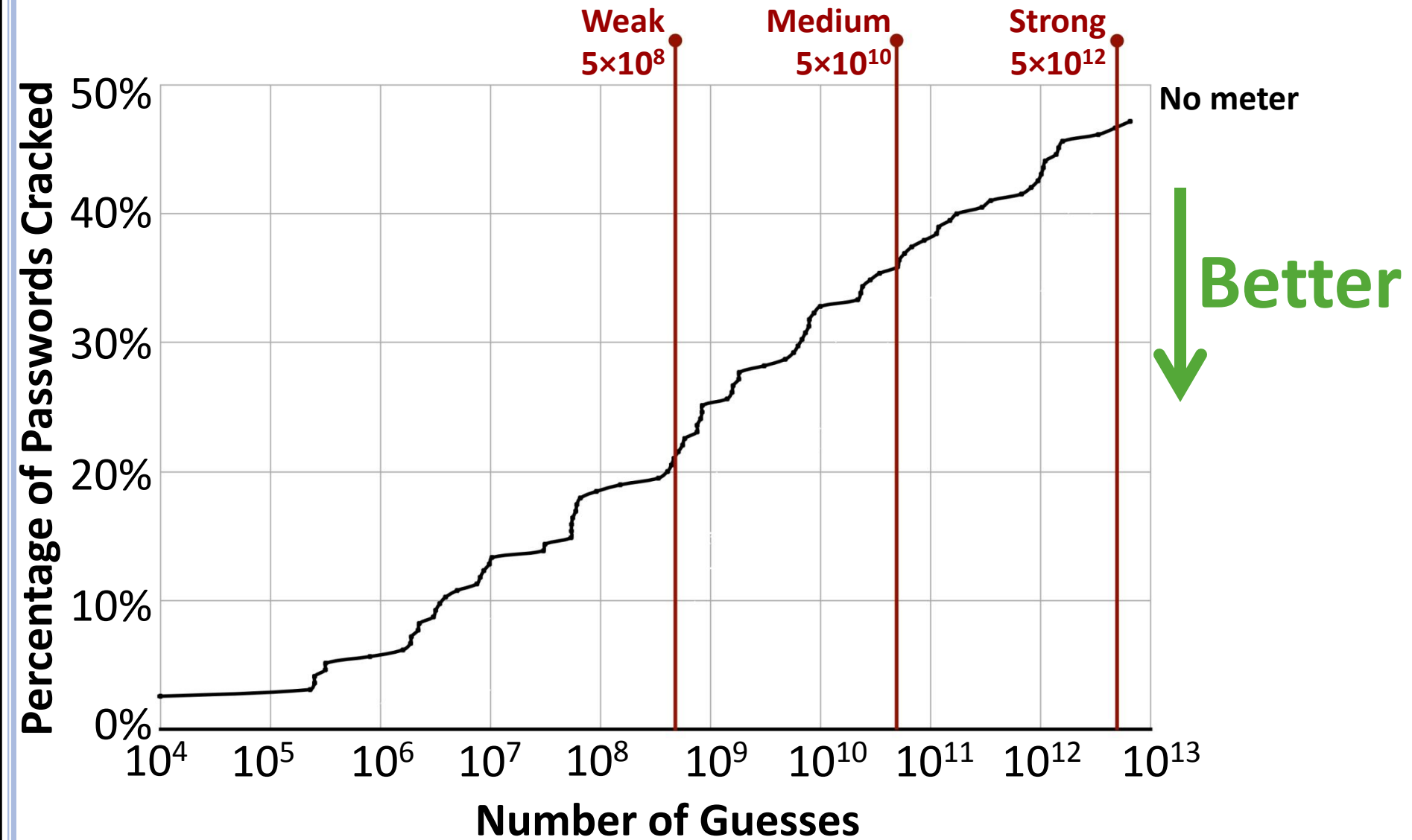
Password Length



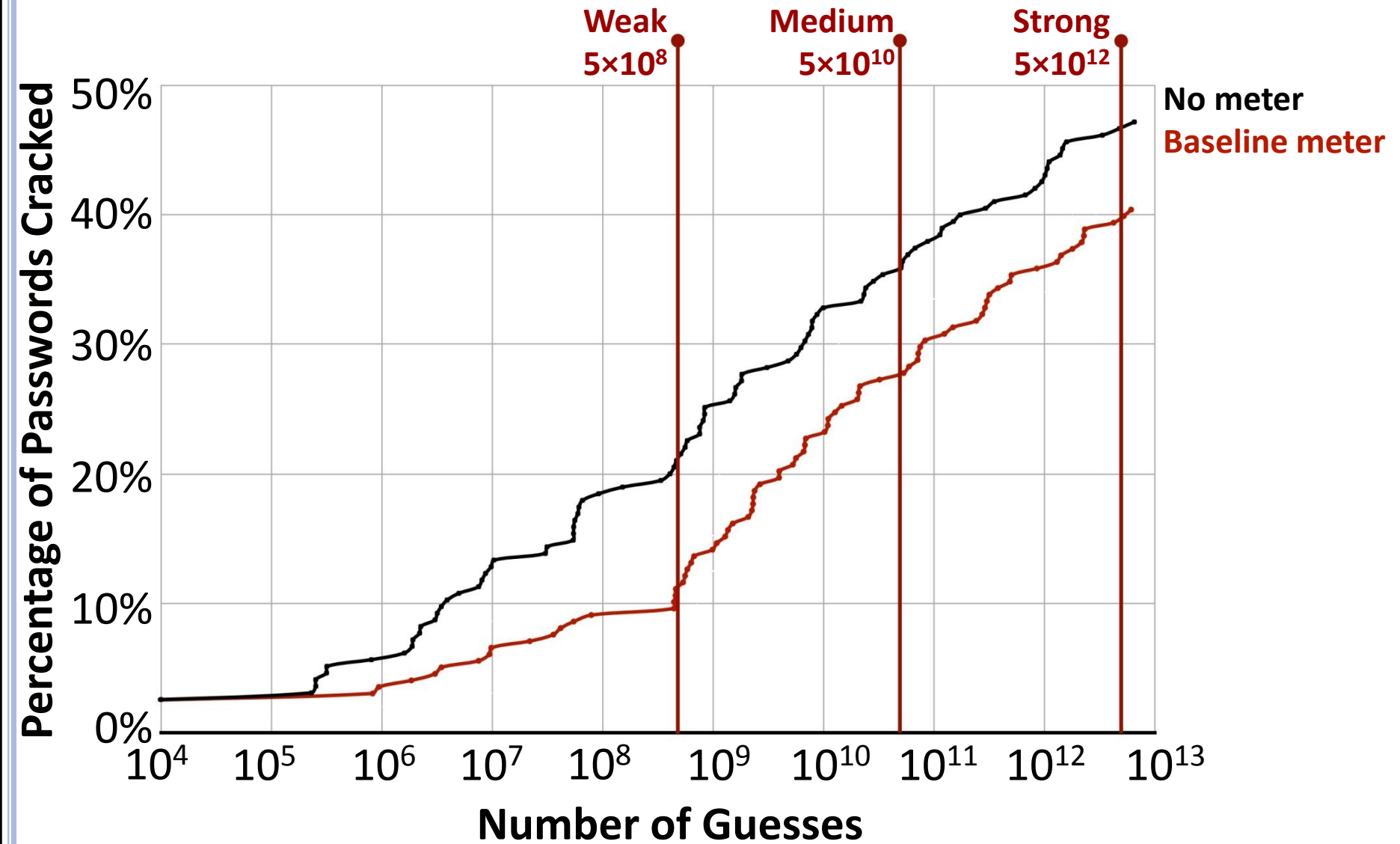
Metric – Guessability

- Guessability – how many guesses to crack?
 - Threat model: offline attack
 - Brute-force first guesses: *aaaaaaaaa, aaaaaaab*
 - Better first guesses: *12345678, password*
 - Cracking algorithm: Weir et al. (Oakland '09)
 - Guess calculator: Kelley et al. (Oakland '12)
 - Weak adversary: 500 million guesses (5×10^8)
 - Medium adversary: 50 billion guesses (5×10^{10})
 - Strong adversary: 5 trillion guesses (5×10^{12})

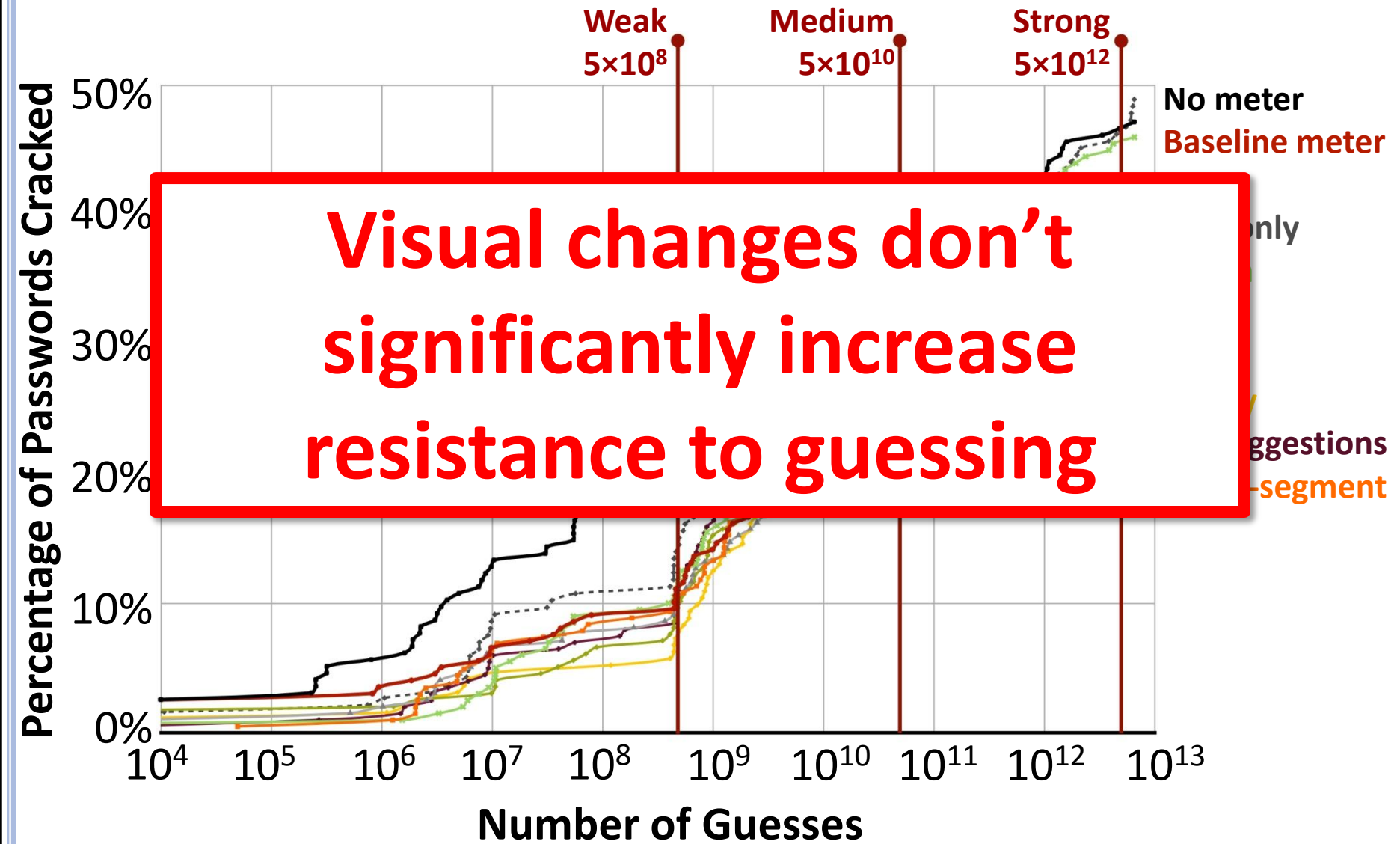
Results – Guessability (No meter)



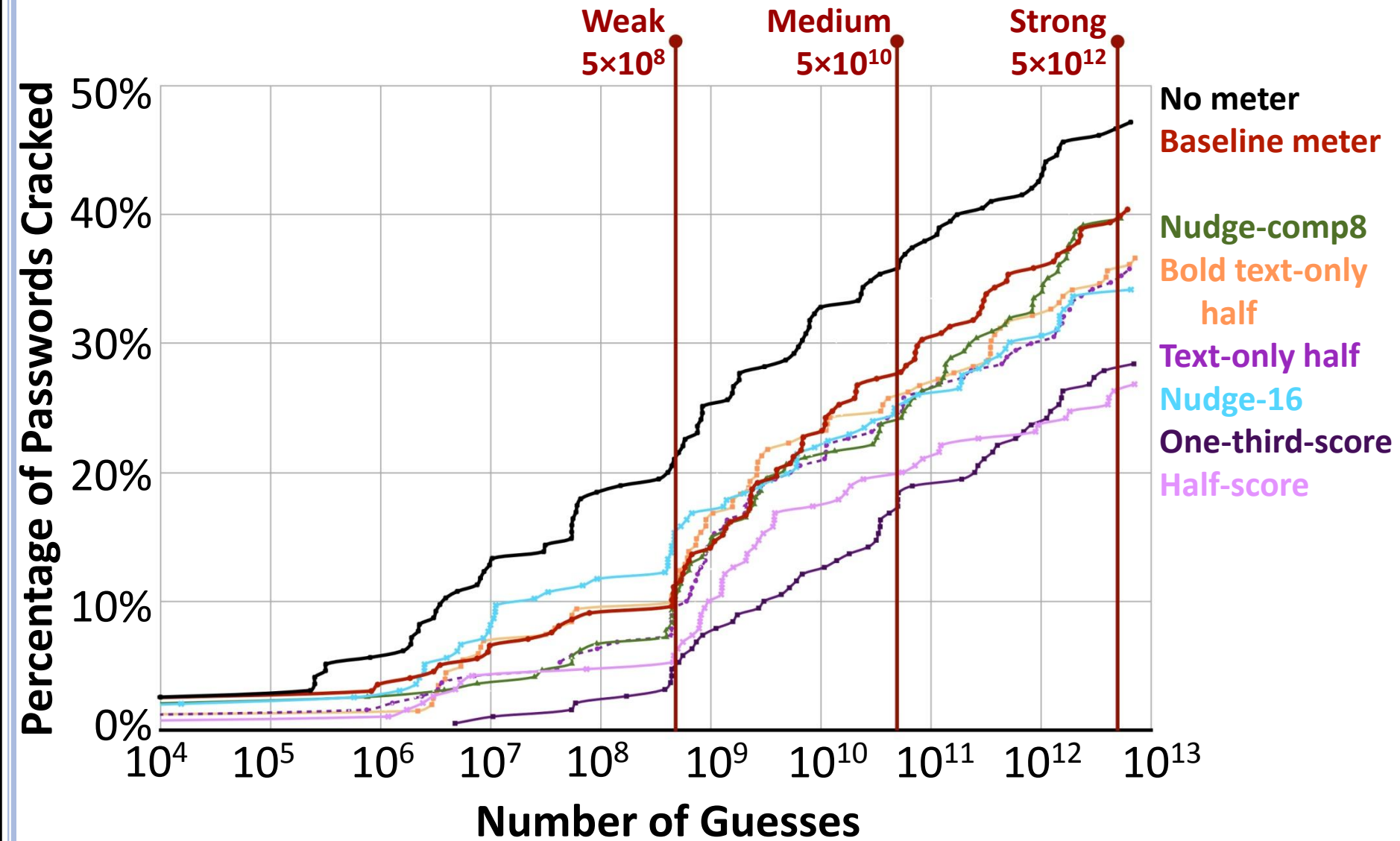
Results – Guessability (Controls)



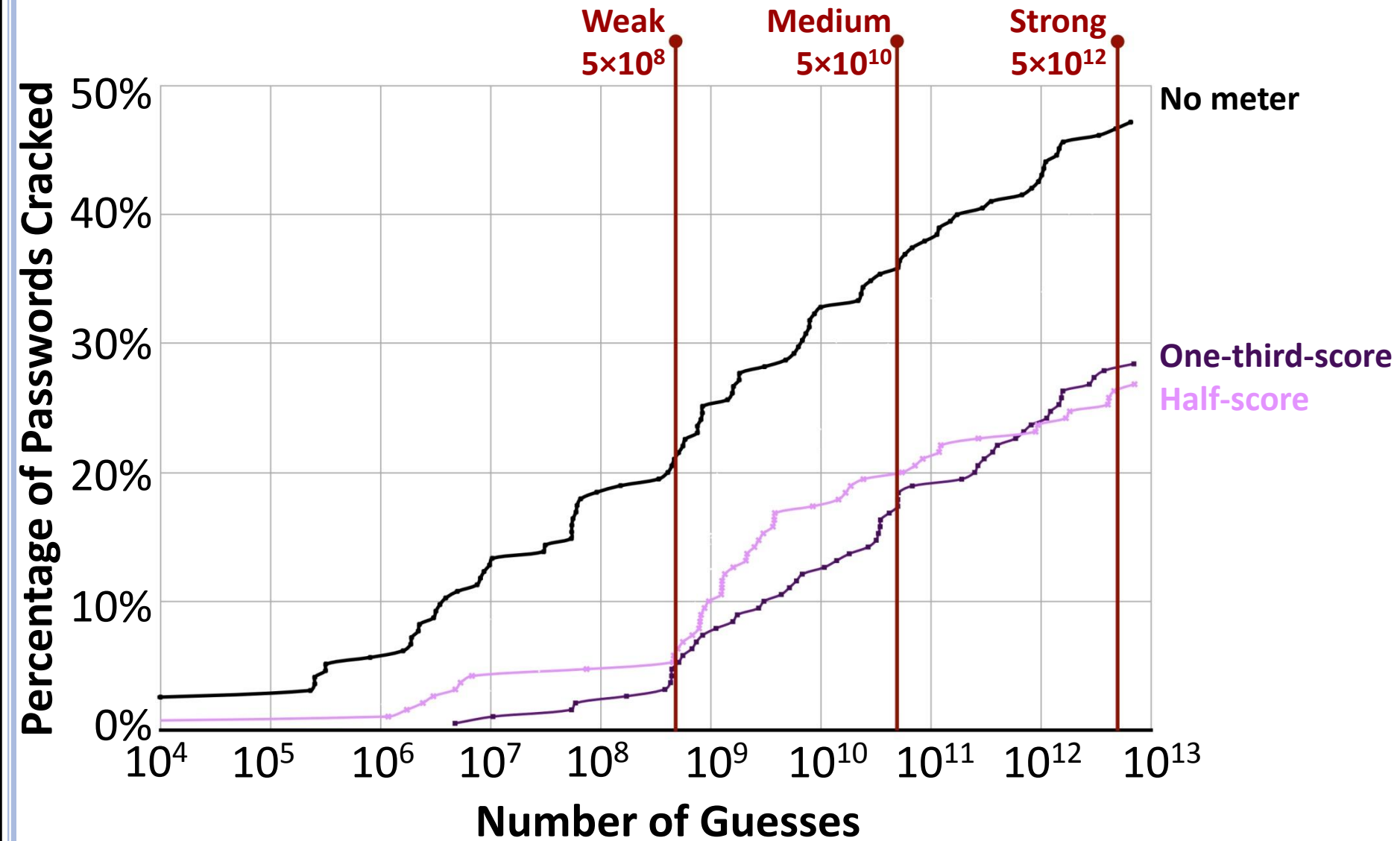
Results – Guessability (Visual)



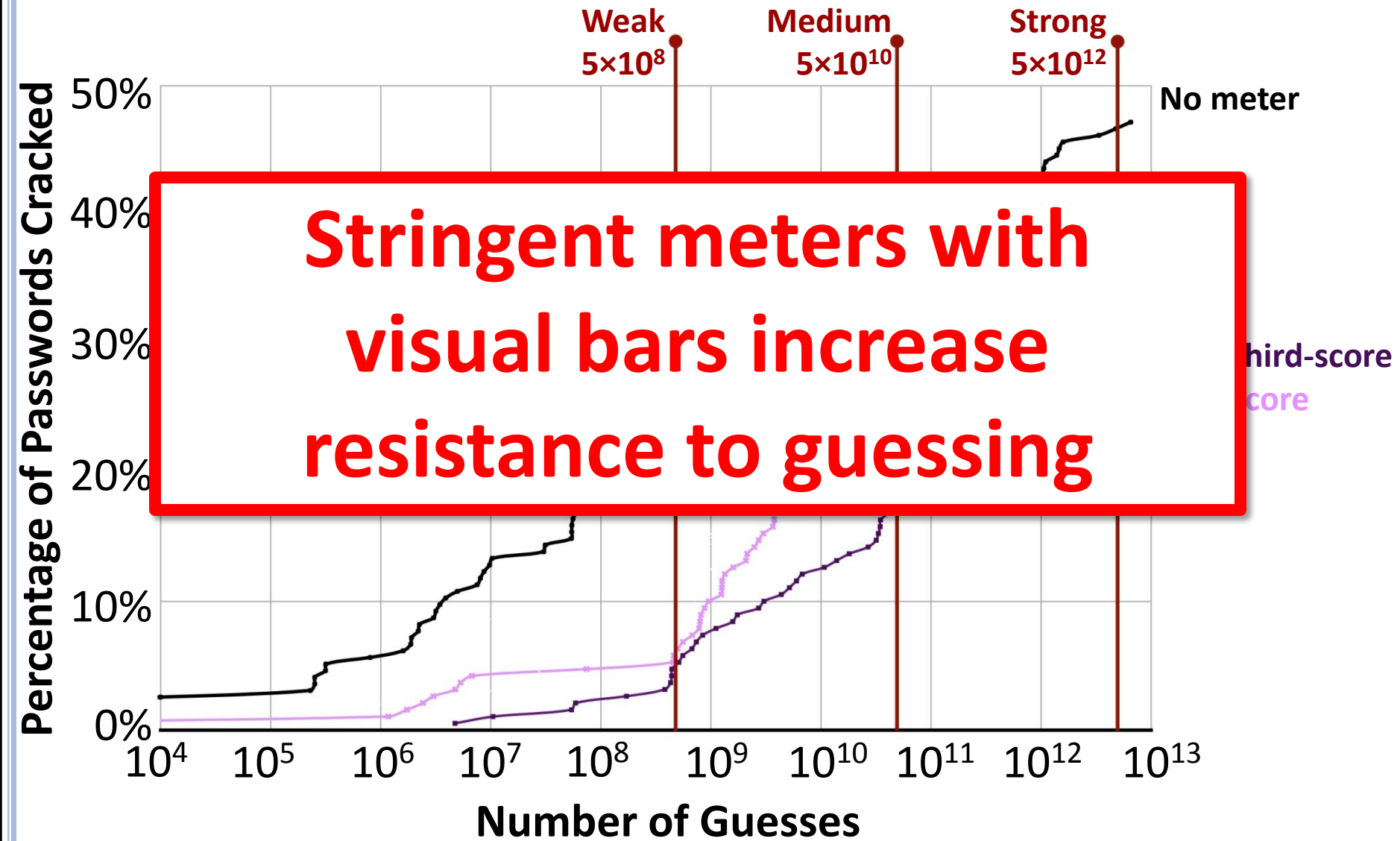
Results – Guessability (Scoring)



Results – Guessability (Significant)



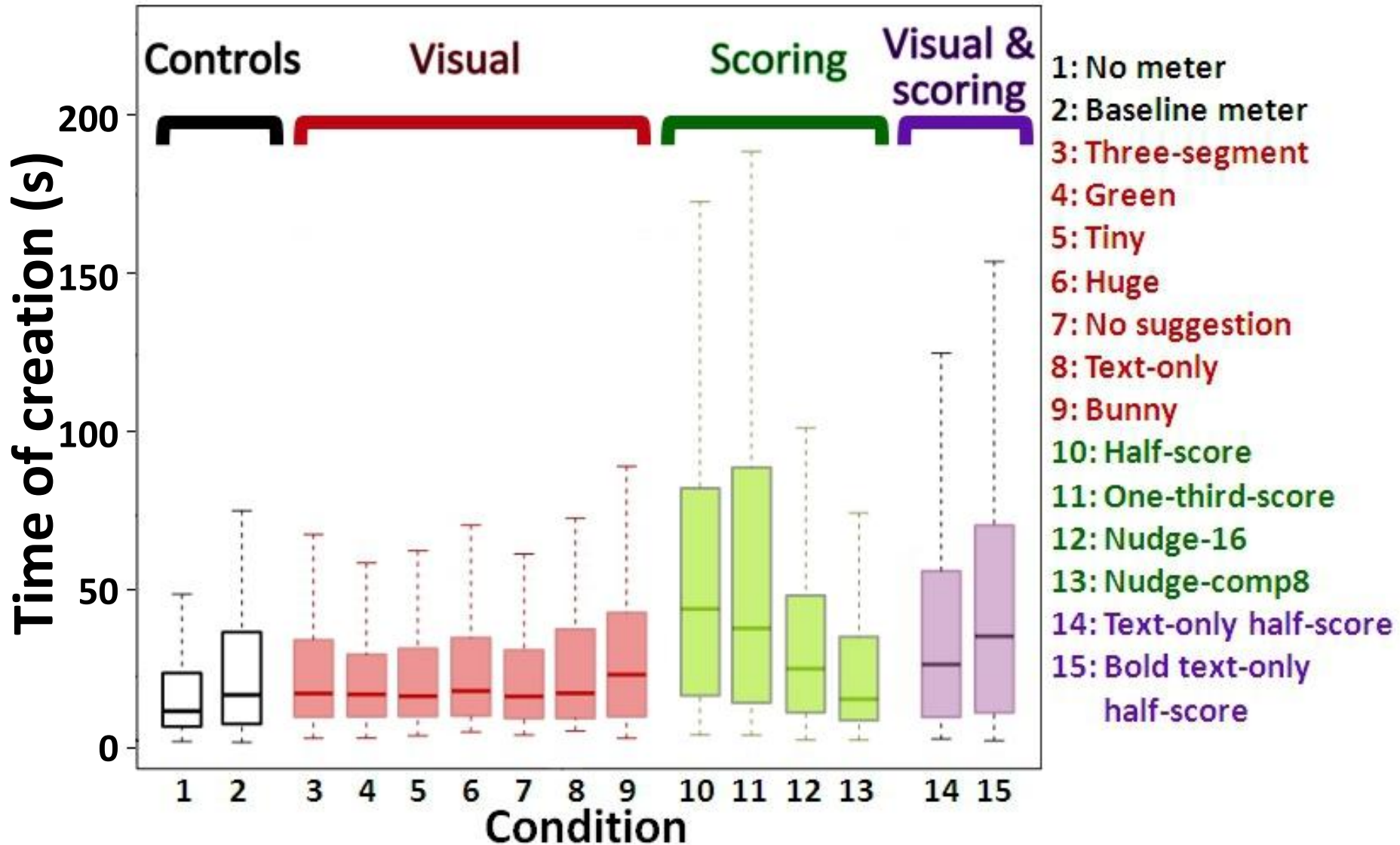
Results – Guessability (Significant)



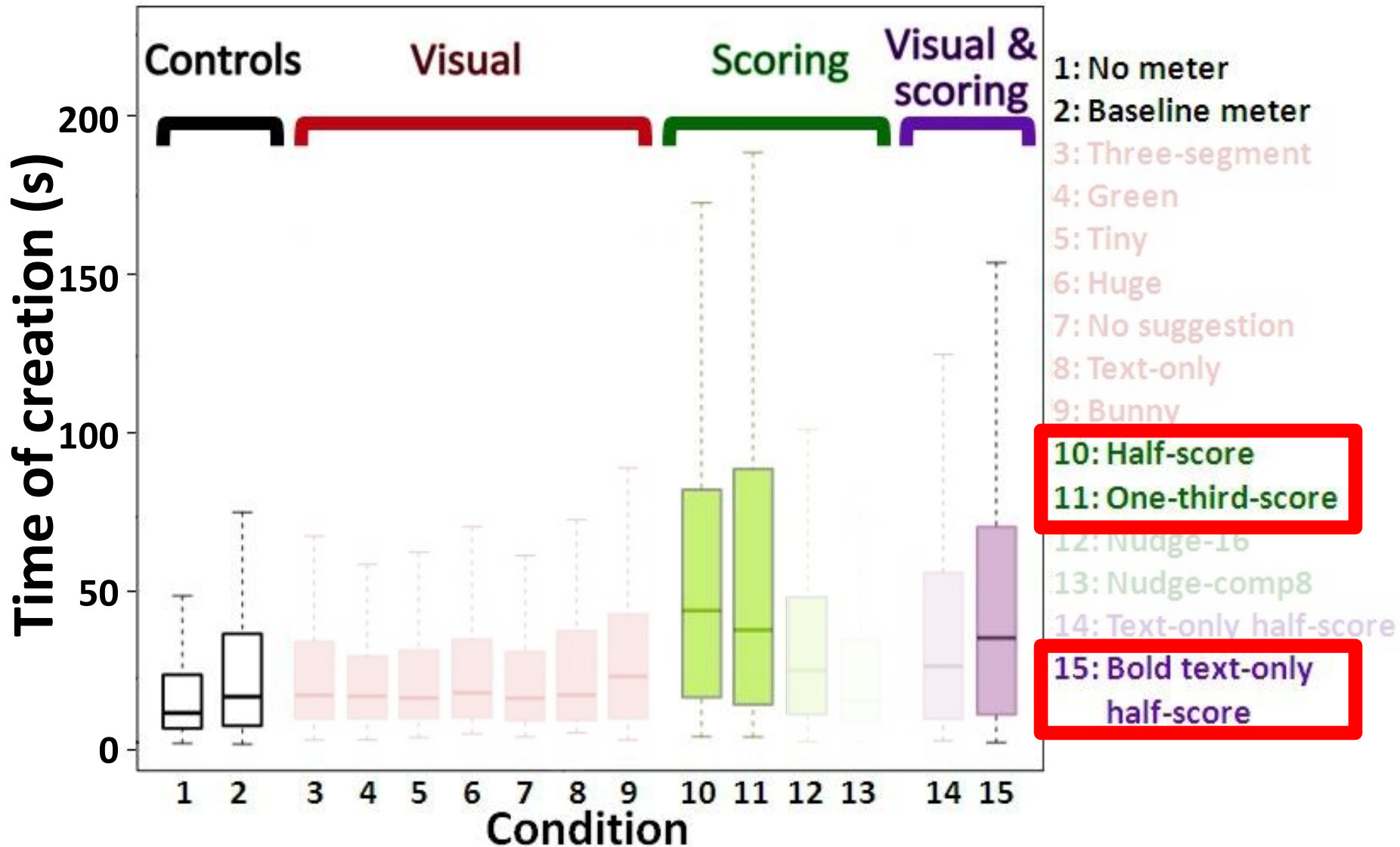
Creation Process

- Time to create password
- Changed their mind during creation

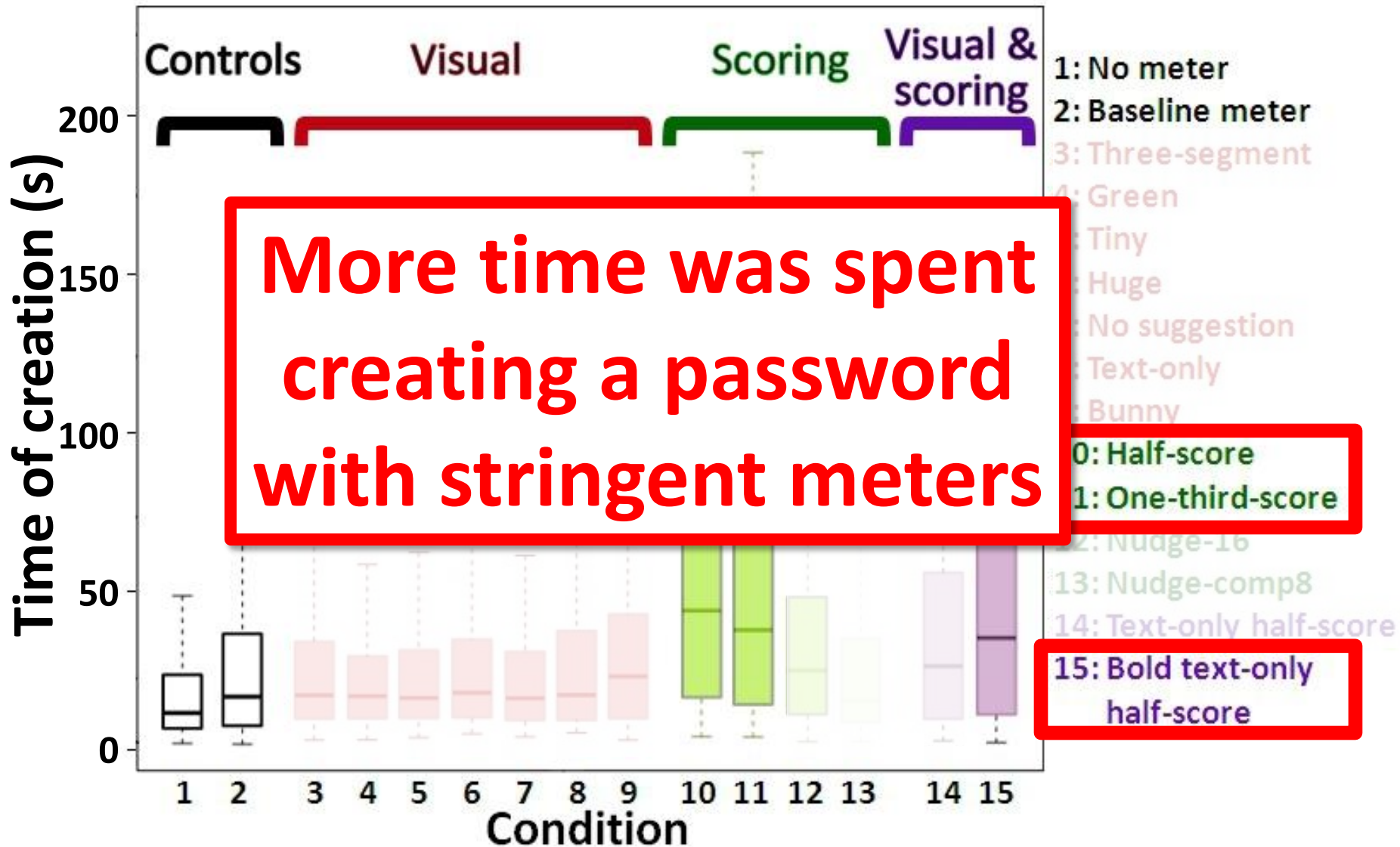
Results – Password Time of Creation



Results – Password Time of Creation



Results – Password Time of Creation



Results – Changed Their Mind

- Changed their mind during password creation

- Typed 8+ character password

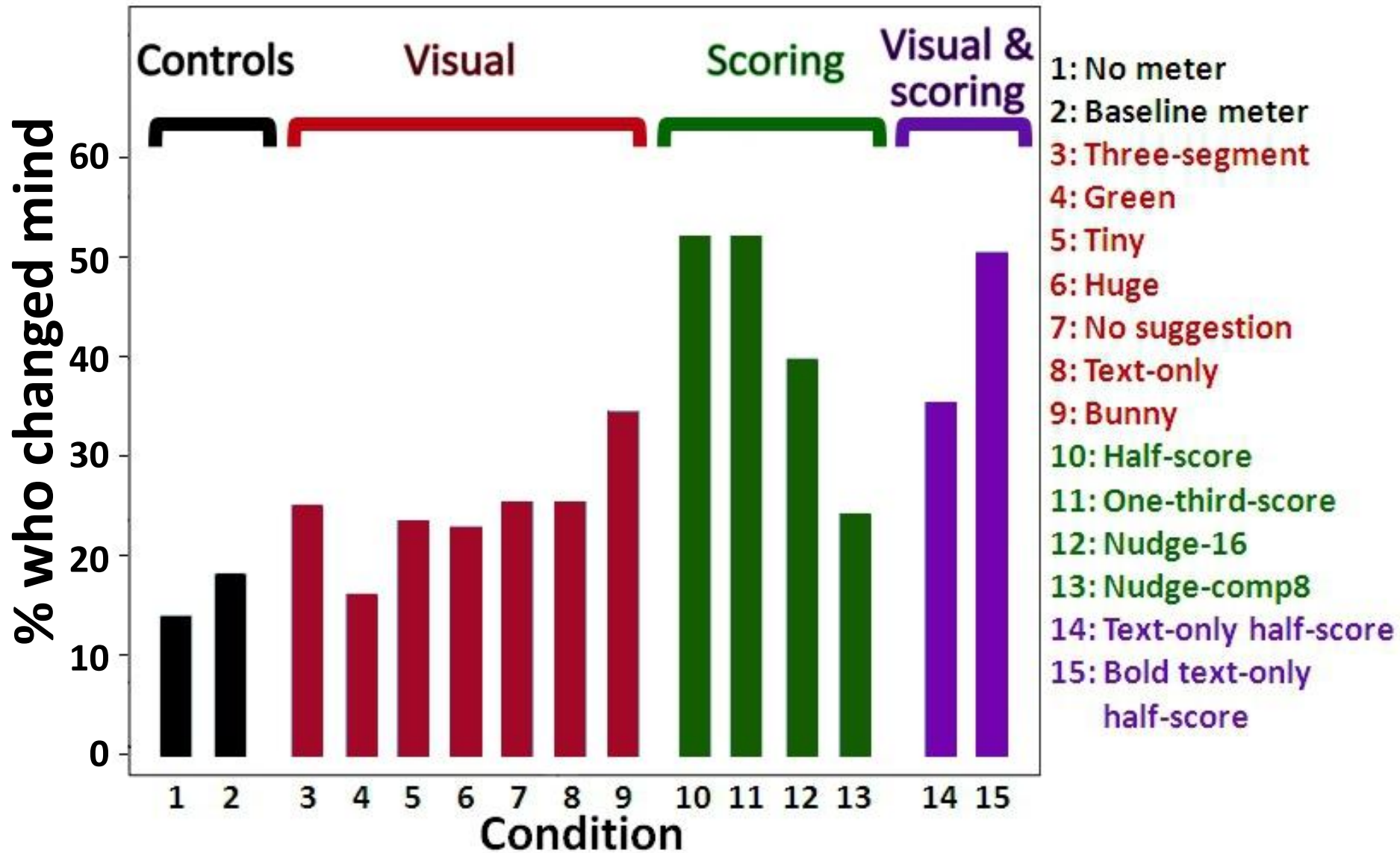
usenixsec

- Completely erased it

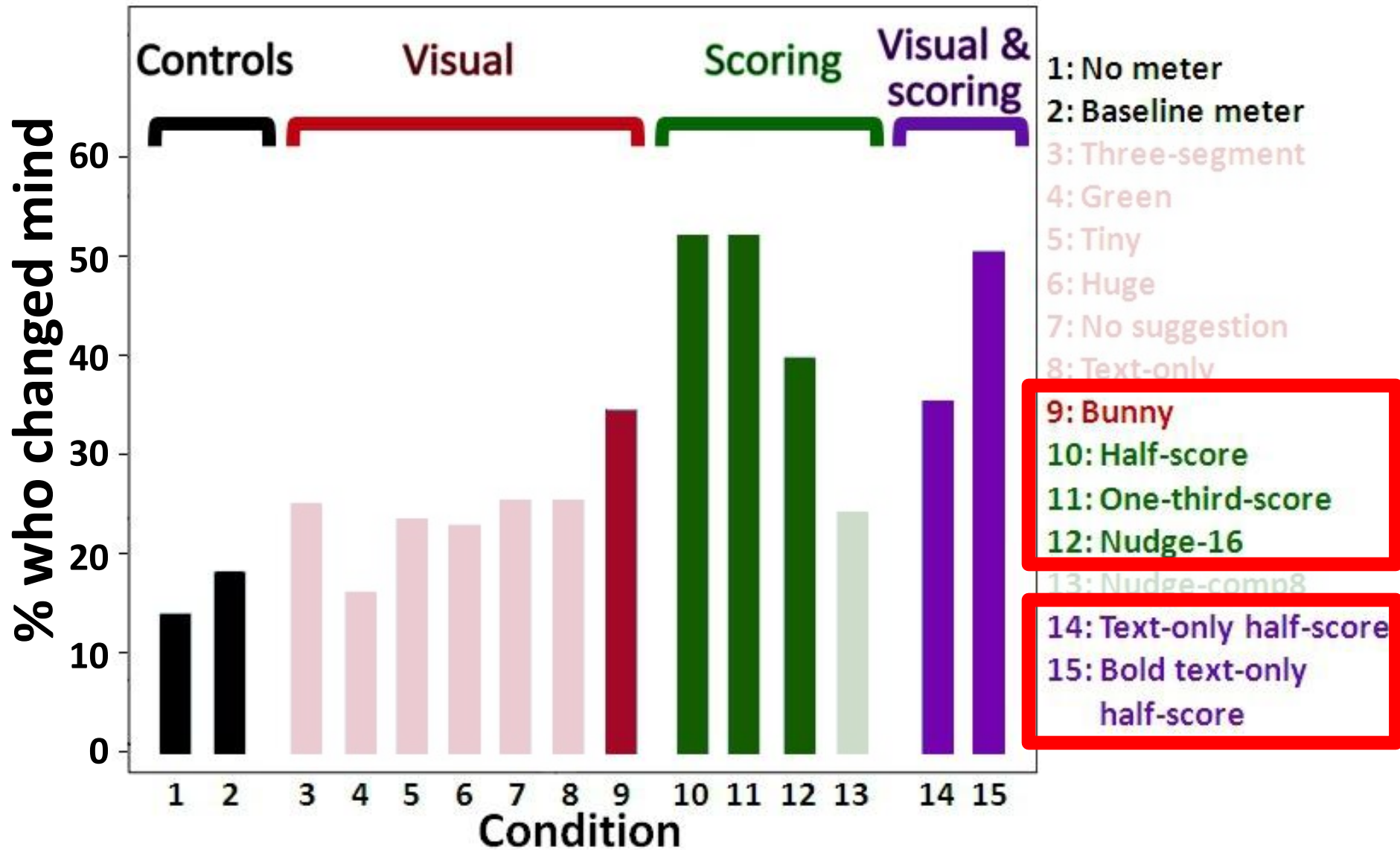
- Saved a different password

iLIKEbunnies

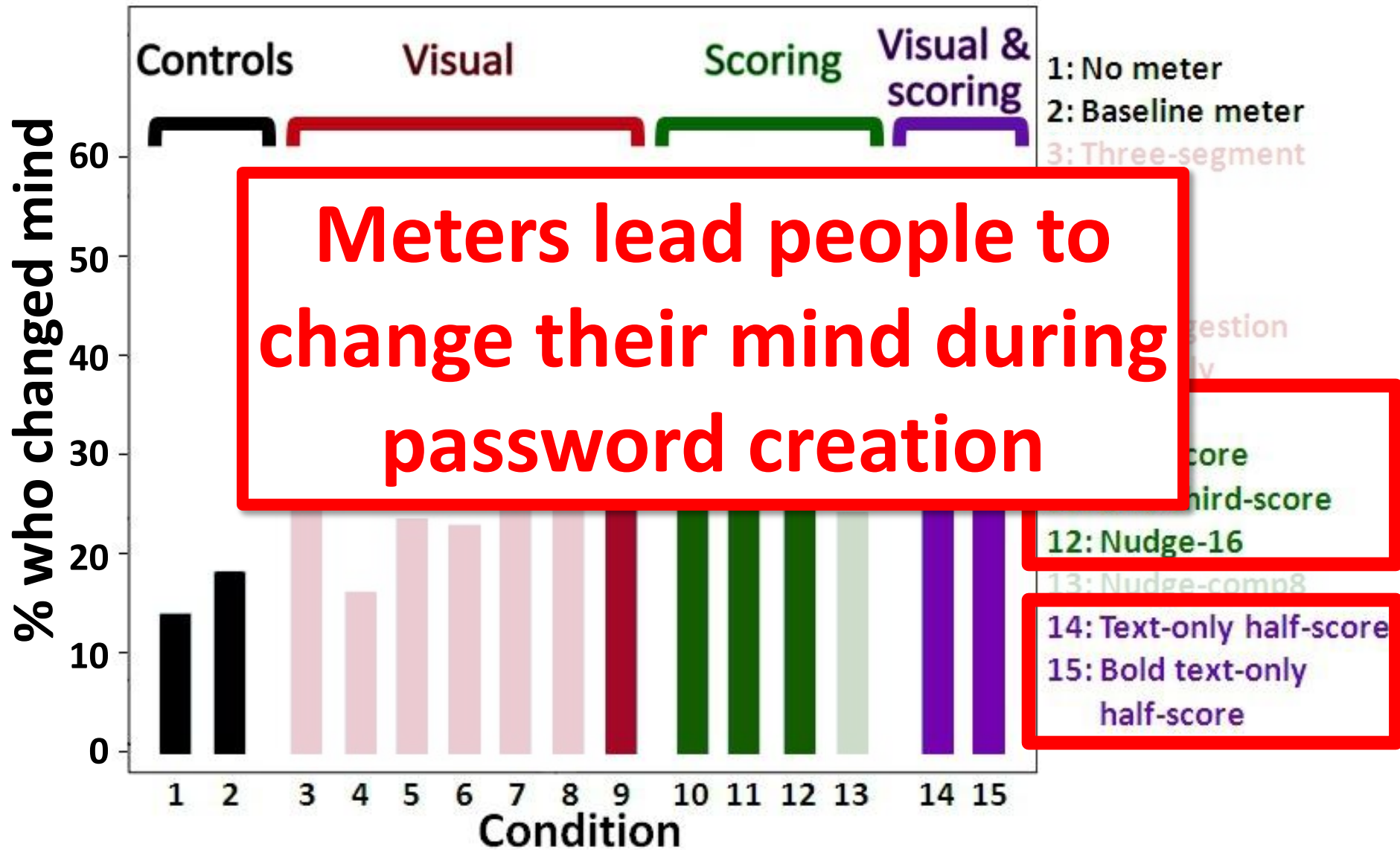
Results – Changed Their Mind



Results – Changed Their Mind



Results – Changed Their Mind



Metric – Memorability

- Successful login about 5 minutes later and 2+ days later
- Return rate
- Wrote password down, stored it, or pasted it
- **No significant differences across conditions for any of these metrics**

Metric – Sentiment

- Level of agreement with 14 statements
 - Password creation (e.g., fun, difficult, annoying)
 - Password meter (e.g., incorrect, high score important)

6. The password strength meter was annoying. *

Strongly disagree

Disagree

Neutral

Agree

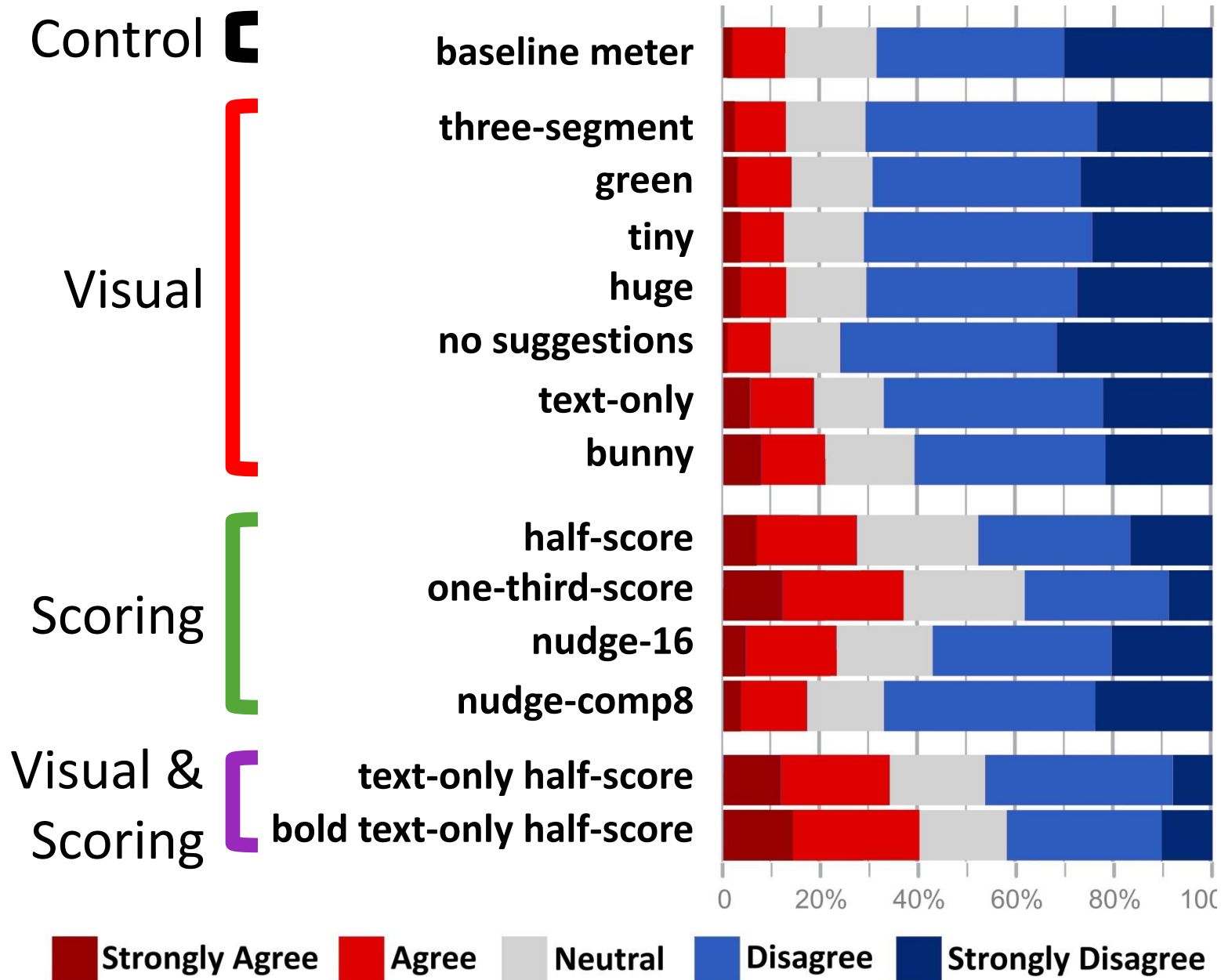
Strongly agree

Not Applicable

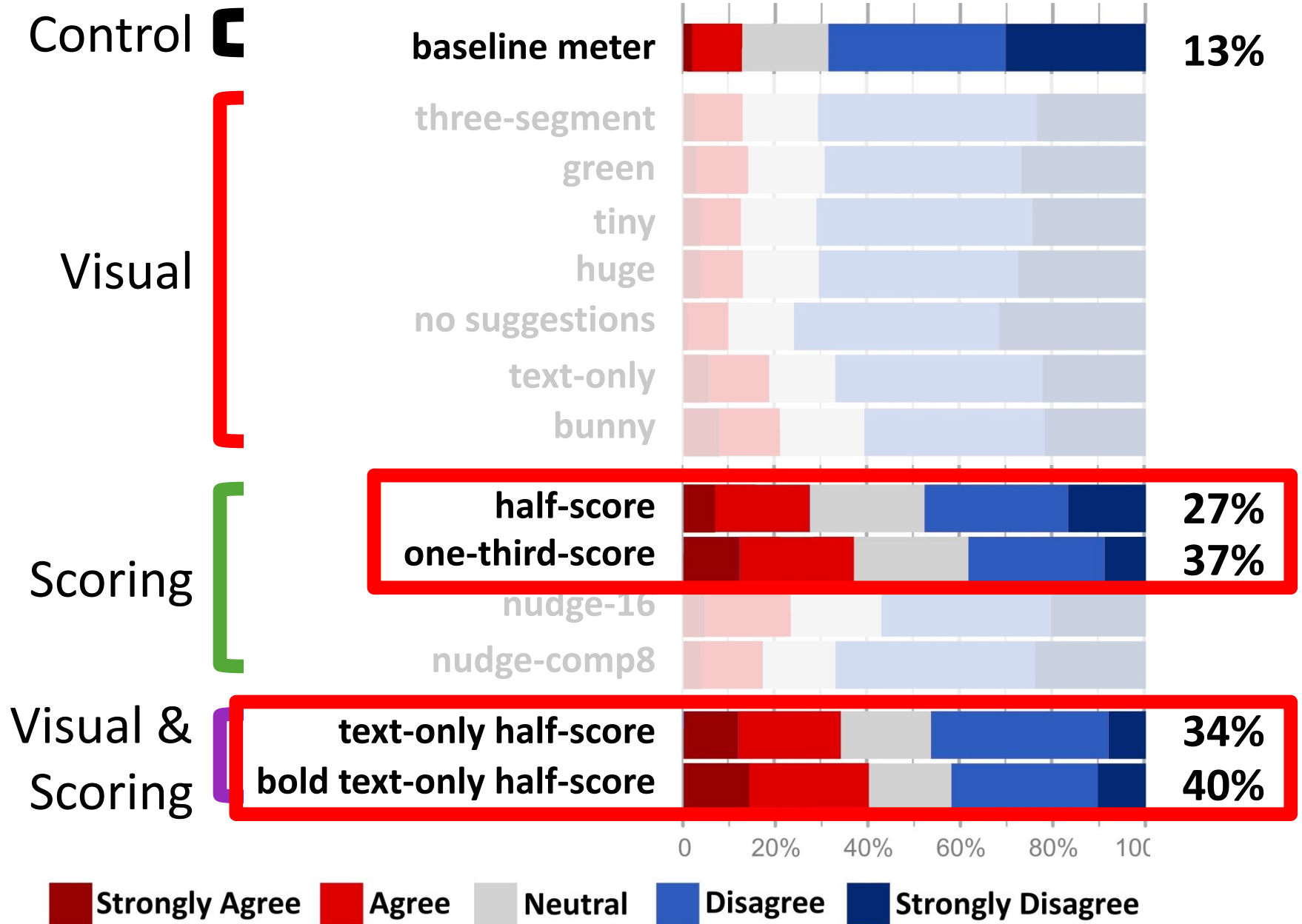
Results – Sentiment

- Stringent meters a bit more annoying
- Stringent meters violated expectations

The Password Strength Meter Was Annoying



The Password Strength Meter Was Annoying



Takeaway: Meters Matter

- Meters lead to longer passwords
- Stringent meters reduce guessability
- Meters don't affect memorability
- Overly stringent meters don't add benefits
 - May even backfire

Takeaway: What Makes Meters Matter

- Important features
 - Scoring stringency
 - Having a visual component
- Less important features
 - Color
 - Segmentation
 - Size
 - Bunyness



Takeaway: What Makes Meters Matter

- Important features
 - Scoring stringency
 - Having a visual component
- Less important features
 - Color
 - Segmentation
 - Size
 - Bunyness



Thank You!

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Joel Lee, Michael Maass,
Michelle L. Mazurek, Timothy Passaro,
Richard Shay, Timothy Vidas, Lujo Bauer,
Nicolas Christin, Lorrie Faith Cranor

Carnegie Mellon