Data Visualization for Decision Making

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Visualization and Graphics Group (VIG)

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Imagine a circle that contains all of human knowledge.

By the time you finish elementary school, you know a little.

By the time you finish high school, you know a bit more.

With a bachelor's degree, you gain a specialty.

A master's degree deepens that specialty.

Reading research papers takes you to the edge of human knowledge.

Once you're at the boundary, you focus.

You push at the boundary
for a few years.

And, that dent you've made is called a Ph.D.

Ph.D

The world looks different
to you now.

But, don't forget the bigger picture.

KEEP PUSHING.

```
[c]);   }   return b; } function liczenie() {   for (var a = $("#User_logged").val(), a = replaceAll(",", " ",
a = a.replace(/ +(?= )/g, ""), a = a.split(" "), b = [], c = 0;c < a.length;c++) {     0 == use_array(a[c], b)
push(a[c]);   }   c = {};   c.words = a.length;   c.unique = b.length - 1;   return c; } function use_unique(
for (var b = [], c = 0;c < a.length;c++) {     0 == use_array(a[c], b) && b.push(a[c]);   }   return b.length;
function count_array_gen() {   var a = 0, b = $("#User_logged").val(), b = b.replace(/(\r\n|\n|\r)/gm, " "),
replaceAll(",", " ", b), b = b.replace(/ +(?= )/g, "");   inp_array = b.split(" ");   input_sum = inp_array.le
   for (var b = [], a = [], c = [], a = 0;a < inp_array.length;a++) {     0 == use_array(inp_array[a], c) &&
(inp_array[a]), b.push({word:inp_array[a], use_class:0}), b[b.length - 1].use_class = use_array(b[b.length -
, inp_array));   }   a = b;   input_words = a.length;   a.sort(dynamicSort("use_class"));   a.reverse();   b
indexOf_keyword(a, " ");   -1 < b && a.splice(b, 1);   b = indexOf_keyword(a, void 0);   -1 < b && a.splice(b
   b = indexOf_keyword(a, "");   -1 < b && a.splice(b, 1);   return a; } function replaceAll(a, b, c) {   ret
eplace(new RegExp(a, "g"), b); } function use_array(a, b) {   for (var c = 0, d = 0;d < b.length;d++) {     b
a && c++;   }   return c; } function czy_juz_array(a, b) {   for (var c = 0, c = 0;c < b.length && b[c].word
++) {   }   return 0; } function indexOf_keyword(a, b) {   for (var c = -1, d = 0;d < a.length;d++) {     if
word == b) {     c = d;     break;   }   }   return c; } function dynamicSort(a) {   var b = 1;   "-" =
&& (b = -1, a = a.substr(1));   return function(c, d) {     return(c[a] < d[a] ? -1 : c[a] > d[a] ? 1 : 0)
} function occurrences(a, b, c) {   a += "";   b += "";   if (0 >= b.length) {     return a.length + 1;   }
= 0, f = 0;   for (c = c ? 1 : b.length;;) {     if (f = a.indexOf(b, f), 0 <= f) {     d++, f += c;
     break;   }   }   return d; } ;     $("#go-button").click(function() {   var a = parseInt($("
limit_val").a()), a = Math.min(a, 200), a = Math.min(a, parseInt(h().unique));   limit_val = parseInt($("#l
```

Human-Computer Interaction (HCI)

Icons from the Noun Project

Icons from the Noun Project

Decision
Making
Human-Computer
Interaction
(HCI)

RED CHILI CHINESE FOOD

APPETIZERS

A1. Green Onion Pipe (paratha)	$ 1.99
A2 .Spring Rolls (6 PCS)	$ 2.99
A3. Fried Wonton (6PCS)	$ 3.99
A4.Chicken Satay	$ 4.99
A5.Garlic String Beans	$ 3.99

SOUPS

S1.Hot & Sour Soup (Single Serving)	$ 1.99
(Large Bowl)	$ 6.99
S2.Chicken Corn Soup (Single Serving)	$ 1.99
(Large Bowl)	$ 6.99

SEAFOOD DISHES

SE1 Kung pao Shrimp	$ 8.49
SE2 Salt & Pepper Shrimp	$ 9.99
SE3. Shrimp With Broccoli	$ 8.49
SE4. Shrimp With Mixed Vegetables	$ 8.49
SE5. Shrimp With Cashew Nuts	$ 8.49
SE6. Shrimp With Hot Pepper Sauce	$ 8.49
SE7. Sweet & Sour Shrimp	$ 8.49
SE8. Garlic Shrimp	$ 8.49
SE9. Black Pepper Shrimp	$ 8.49
SE10. Sliced Fish With Spicy Sauce	$ 8.49

BEEF DISHES

B1. Kung Pao Beef	$ 7.49
B2. Mongolian Beef	$ 7.49
B3. Beef With Green Onions	$ 7.49
B4. Beef With Broccoli	$ 7.49
B5. Beef With Spicy Sauce	$ 7.49
B6. Beef With Bell Pepper	$ 7.49
B7. Beef With Vegetables	$ 7.49
B8. Black Pepper Beef	$ 7.49

CHICKEN DISHES

C1. Salt & Pepper Chicken	$ 8.49
C2. Kung Pao Chicken	$ 7.49
C3. Chicken With cashew Nuts	$ 7.49
C4. Chicken With Jalapeno	$ 7.49
C5. Sweet & Sour Chicken	$ 7.49
C6. Chicken With Spicy Sauce	$ 7.49
C7. Chicken With Broccoli	$ 7.49
C8. Black Pepper Chicken	$ 7.49
C9. Orange Chicken	$ 7.49
C10. Chicken With Mixed Vegetables	$ 7.49

NOODLES

N1. Three Flavor Chow Mein	$ 8.99
N2. Chicken Chow Mein	$ 7.49
N3. Shrimp Chow Mein	$ 7.49
N4. Beef Chow Mein	$ 7.49
N5. Veggie Chow Mein	$ 4.99

RICE DISHES

R1. Steamed Rice	$ 1.99
R2. Egg Fried Rice	$ 2.99
R3. Chicken Fried Rice	$ 6.99
R4. Beef Fried Rice	$ 6.99
R5. Shrimp Fried Rice	$ 7.99
R6. Combination Fried Rice (Shrimp Chicken & Beef)	$ 8.99
R7. Vegetable Fried Rice	$ 4.99

RED CHILI FAST FOOD

APPETIZERS

Buffalo Wings (8 PCS)	$ 5.99
Asian Style Chicken Tenders (10 PCS)	$ 5.99
Fries (Regular Or Curly)	$ 2.99

BURGERS

Cheese Burger (Beef Or Chicken)	$ 2.99
Chicken Tikka Burger	$ 4.49
Santa Fe Burger	$ 4.49
Red Chilli Monster	$ 4.[illegible]
Teriyaki Pineapple Burger	$ 3[illegible]
Mushroom Burger	$[illegible]

SANDWICHES

Philly Steak Sandwich
Chicken Steak Sandwich
Chicken Melt Sandwich
Veggie Melt Sandwich

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Decision Making
Human-Computer Interaction (HCI)

	1	
	X	Y
	10.0	8.04
	8.0	6.95
	13.0	7.58
	9.0	8.81
	11.0	8.33
	14.0	9.96
	6.0	7.24
	4.0	4.26
	12.0	10.84
	7.0	4.82
	5.0	5.68
Mean	9.0	7.5
Variance	10.0	3.75
Correlation	0.816	

Anscombe, Francis J. "Graphs in statistical analysis." *The American Statistician* 27.1 (1973): 17-21.

Vision Science
Decision Making
Human-Computer Interaction (HCI)

How many 3s do you count?

Turn on you microphone and shout the number of 3s!

How many **3**'s do you count?

2 1 7 6 5 8 6 2 1 5 2 8 2 7 3 8 5 8 5 9 4 5 9 7 4 6 0 5 4 0 8 4 7 4 6
0 9 8 7 6 8 9 6 5 2 6 2 7 0 9 8 9 9 2 4 5 1 6 7 8 0 9 8 5 8 2 6 9 3 8
5 9 2 8 3 6 2 8 4 5 4 6 4 9 8 7 6 7 6 1 2 8 2 7 4 9 7 2 9 7 2 2 9 2 8
8 7 0 8 2 8 7 5 9 7 1 2 9 7 9 7 5 0 5 4 2 7 3 8 6 2 1 2 1 9 8 6 9 7 8

Ware, Information Visualization using Vision to Think

How many **3**'s do you count?

2 1 7 6 5 8 6 2 1 5 2 8 2 7 **3** 8 5 8 5 9 4 5 9 7 4 6 0 5 4 0 8 4 7 4 6
0 9 8 7 6 8 9 6 5 2 6 2 7 0 9 8 9 9 2 4 5 1 6 7 8 0 9 8 5 8 2 6 9 **3** 8
5 9 2 8 **3** 6 2 8 4 5 4 6 4 9 8 7 6 7 6 1 2 8 2 7 4 9 7 2 9 7 2 2 9 2 8
8 7 0 8 2 8 7 5 9 7 1 2 9 7 9 7 5 0 5 4 2 7 **3** 8 6 2 1 2 1 9 8 6 9 7 8

Ware, Information Visualization using Vision to Think

Pre-attentive processing

Some stimuli can be perceived without the need for focused attention (generally within 200-250 ms)

Find if there is a red circle

Turn on you microphone and shout “**YES**” or “**NO**”.

Find if there is a red circle

Hue

Yes, can be done preattentively!

Healey, 2012, Attention and Visual Memory in Visualization and Computer Graphics

Find if there is a red circle

Turn on you microphone and shout “**YES**” or “**NO**”.

Find if there is a red circle

Shape
Yes, can be also done preattentively!

Healey, 2012, Attention and Visual Memory in Visualization and Computer Graphics

Find if there is a red circle

Turn on you microphone and shout “**YES**” or “**NO**”.

Find if there is a red circle

Hue & Shape
No, cannot be done preattentively. Need to search!

Healey, 2012, Attention and Visual Memory in Visualization and Computer Graphics

Which visual variables for which data?

more accurate

less accurate

Quantitative	Ordinal	Categorical
Position	Position	Position
Length	Density	Hue
Angle	Saturation	Density
Slope	Hue	Saturation
Area	Length	Shape
Density	Angle	Length
Saturation	Slope	Angle
Hue	Area	Slope
Shape	Shape	Area

Jacques Bertin refined by Cleveland & McGill then by Card & Mackinlay

vision science

cognitive psychology ?

economics ?

decision theory ?

how to design technology that helps people make **unbiased** and **data-informed** decisions?

how to design technology that helps people make **unbiased** and **data-informed** decisions?

Cognitive biases & Data Visualization

Dimara E., Franconeri S., Plaisant C., Bezerianos A., and Dragicevic P. **A Task-based Taxonomy of Cognitive Biases for Information Visualization**
IEEE Transactions on Visualization and Computer Graphics (TVCG/VIS '19). 2019

Flugspuren
Zeitliche Entwicklung
Räumliche Aggregation
Schallimmissionen
Darstellungsoptionen
Übernehmen
Reset
Filter nach Uhrzeit (MEZ)
Filter nach Regionen
Filter nach Landerichtung
Filter nach Regelverstößen
Details
Google

What is a cognitive bias?

Which president would you vote for?

trade-off decision

dominated alternative

Attraction Effect

trade-off
decision

dominated alternative

Cognitive Bias

- deviates from a norm

regularity

dominance

invariance

Cognitive Bias

deviates from a norm

- deviates involuntarily

Cognitive Bias

deviates from a norm

deviates involuntarily

- hard, almost impossible to avoid

Cognitive Bias

deviates from a norm

deviates involuntarily

hard, almost impossible to avoid

- ≠ perceptual bias

Do cognitive biases exist in visualizations?

Debate in decision making research

The Attraction Effect applies only to

numerical tables

[Frederick et al, 2014]

[Yang and Lynn, 2014]

	A	B	C
attribute 1	2	5	5
attribute 2	5	2	1

Debate in decision making research

The Attraction Effect applies only to **numerical tables**

[Frederick et al, 2014]
[Yang and Lynn, 2014]

VS.

The Attraction Effect is **robust**

[Huber et al, 2014]
[Simonson, 2015]

Debate in decision making research

consumer

products

[Simonson &Tversky, 1992]

Debate in decision making research

consumer products

[Simonson &Tversky, 1992]

job candidates

[Highhouse , 1996]

Debate in decision making research

consumer products

[Simonson &Tversky, 1992]

job candidates

[Highhouse , 1996]

real gambles

[Herne, 1999]

Debate in decision making research

consumer products

[Simonson &Tversky, 1992]

job candidates

[Highhouse , 1996]

real gambles

[Herne, 1999]

animals

e.g. bees, amoebae

[Shafir et al, 2002]

[Latty & Beekman, 2002]

Can the attraction effect occur in visualizations?

Can the attraction effect occur in visualizations?

The attraction effect may be limited to **numbers**
and does not apply to "**perceptual**" representations.

[Frederick et al, 2014]

The Attraction Effect in Visualizations

Dimara, Bezerianos & Dragicevic @InfoVis 2017

The Attraction Effect in Visualizations

Dimara, Bezerianos & Dragicevic @InfoVis 2017

1st Experiment: "Choose a **gym**"

[Malkoc et al,2013]

cleanliness

vs.

1st Experiment: "Choose a gym"

better in **variety**

	A	B
variety	5	2
cleanliness	2	5

1st Experiment: "Choose a gym"

better in **cleanliness**

	A	B
variety	5	2
cleanliness	2	5

1st Experiment: "Choose a gym"

	A	B
variety	5	2
cleanliness	2	5

decoy

C
1
5

1st Experiment: "Choose a gym"

1st Experiment: "Choose a gym"

replication of the attraction effect design in **tables** [Malkoc et al,2013]

1st Experiment: "Choose a gym"

Can the attraction effect occur in visualizations?

1st Experiment: "Choose a gym"

	A	B
variety	5	2
cleanliness	2	5

1st Experiment: "Choose a gym"

	A	B
variety	5	2
cleanliness	2	5

1st Experiment: "Choose a gym"

	A	B
variety	5	2
cleanliness	2	5

	A	B	C
variety	5	5	2
cleanliness	1	2	5

1st Experiment: "Choose a gym"

	A	B
variety	5	2
cleanliness	2	5

	A	B	C
variety	5	5	2
cleanliness	1	2	5

	A	B	C
variety	5	2	1
cleanliness	2	5	5

Can the attraction effect occur in visualizations?

Can the attraction effect occur in visualizations?

*** all error bars in this talk are 95% confidence intervals

Does the attraction effect extend to larger datasets?

Does the attraction effect extend to larger datasets?

The attraction effect requires asymmetric dominance relationships to be "**perceptual in nature**" and "**easy to access**" . The bias should be eliminated as the number of pairwise comparisons increases.
[Bettman et al, 2014]

2nd Experiment: "Choose a **lottery ticket**" [Wedell, 1991]

probability

vs.

prize

2nd Experiment: "Choose a **lottery ticket**" [Wedell, 1991]

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Does the attraction effect extend to larger datasets?

73 crowdsourced participants

2nd Experiment: "Choose a **lottery ticket**" [Wedell, 1991]

Does the attraction effect extend to larger datasets?

extension of a within-subjects study

73 crowdsourced participants

2nd Experiment: "Choose a **lottery ticket**"

real choice !

2nd Experiment: "Choose a **lottery ticket**"

2nd Experiment: "Choose a **lottery ticket**"

2nd Experiment: "Choose a **lottery ticket**"

2nd Experiment: "Choose a **lottery ticket**"

2nd Experiment: "Choose a **lottery ticket**"

2nd Experiment: "Choose a **lottery ticket**"

2nd Experiment: "Choose a **lottery ticket**"

2nd Experiment: "Choose a **lottery ticket**"

2nd Experiment: "Choose a **lottery ticket**"

Does the addition of decoys increase the attractiveness of the target?

Does the addition of decoys increase the attractiveness of the target?

Does the addition of decoys increase the attractiveness of the target?

Implications of the attraction effect

TAKE AWAY MESSAGE

People understood the data!

Dimara E., Bezerianos A., and Dragicevic P. **The Attraction Effect in Information Visualization**
IEEE Transactions on Visualization and Computer Graphics. 2017

DATA UNTERSTANDING

=

GOOD DECISION ?

How can we “debias" a scatterplot?

WHAT WOULD YOU DO?

Dimara E., Bailly G., Bezerianos A., and Franconeri S. **Mitigating the Attraction Effect with Visualizations**
IEEE Transactions on Visualization and Computer Graphics (TVCG/VIS '18). 2019, 25(1).

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Summary of current debiasing methods

debias the judge

rely less on the judge

debias the environment instead of the judge

Dimara E., Bailly G., Bezerianos A., and Franconeri S. **Mitigating the Attraction Effect with Visualizations**
IEEE Transactions on Visualization and Computer Graphics (TVCG/VIS '18). 2019, 25(1).

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How can we “debias" a scatterplot?

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How can we “debias" a scatterplot?

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How do people make decisions?

satisficing

weighted additive

elimination by aspects

perhaps reduces trade-off aversion

Dimara E., Bailly G., Bezerianos A., and Franconeri S. **Mitigating the Attraction Effect with Visualizations**
IEEE Transactions on Visualization and Computer Graphics (TVCG/VIS '18). 2019, 25(1).

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How can we “debias" a scatterplot?

Approach C:

Change the way users interact with the data!

Dimara E., Bailly G., Bezerianos A., and Franconeri S. **Mitigating the Attraction Effect with Visualizations**
IEEE Transactions on Visualization and Computer Graphics (TVCG/VIS '18). 2019, 25(1).

Delete the datapoints that you do not want.

Select a datapoint.

Dimara E., Bailly G., Bezerianos A., and Franconeri S. **Mitigating the Attraction Effect with Visualizations**
IEEE Transactions on Visualization and Computer Graphics (TVCG/VIS '18). 2019, 25(1).

Conclusion

following the "elimination by aspects" decision strategy while interacting with a scatterplot reduces the attraction effect

visualisations that allow removing inappropriately salient or distracting data may lead to more rational decisions

Take-away

the importance of interaction
in visualised decision-support

communicate that interactive visualizations
can contribute to cognitive bias alleviation

Cognitive biases & Data Visualization

lack of evidence
debates
cognitive bias papers = lonely islands
pop science
poor connections
cognitive psychology
decision theory
social psychology
consumer research
conflicts
economics
medical research
no comprehensive listings / unified theory

all cognitive biases
in wikipedia

all cognitive biases
in wikipedia
bias
tasks
bias
similarities
psychology
articles
relevance
visualization
articles

all cognitive biases
in wikipedia
ESTIMATION
DECISION
HYPOTHESIS ASSESSMENT
CAUSAL ATTRIBUTION
RECALL
OPINION REPORTING
OTHER
relevance
bias
tasks
bias
similarities
psychology
articles
visualization
articles

all cognitive biases
in wikipedia
ASSOCIATION
BASELINE
INERTIA
OUTCOME
SELF PERSPECTIVE
relevance
bias
tasks
bias
similarities
psychology
articles
visualization
articles

all cognitive biases
in wikipedia
original
empirical study
bias
tasks
bias
similarities
psychology
articles
relevance
visualization
articles

all cognitive biases
in wikipedia
bias
tasks
bias
similarities
psychology
articles
alleviate
detect
relevance
study
discuss
visualization
articles

all cognitive biases
in wikipedia
bias
tasks
bias
similarities
psychology
articles
relevance
visualization
articles

all cognitive biases
in wikipedia
bias
tasks
bias
similarities
psychology
articles
relevance
visualization
articles

#	Flavor	Cognitive bias	Ref	Relevance to fake/fib	Short description
TASK: ESTIMATION					
1	Anecdotes	Availability bias	[1]	0.7	Stories more prominent if easy to remember
2		Availability cascade	[2]	0.7	Specific outcomes more probable than general
3		Neglect of probability	[3]	0.8	Ignoring probability when making decisions under uncertainty
4		Subadditivity effect	[4]	0.8	Overestimate risks not to cover disjunctive events
5		Subjective validation	[5]	0.8	Perceive something true if a belief or hypothesis seems true
6		Base rate fallacy	[6]	0.8	Ignore base rate probabilities or general prevalence
7		Bandwagon effect	[7]	0.8	Adopt a belief or behavior because many other people have adopted it
8	Baseline	Conjunction fallacy	[8]	0.8	Assume that a more frequent will be less frequent in future
9		Gambler's fallacy	[9]	0.8	Expect a random process to change because of past events
10		Hot-hand fallacy	[10]	0.8	Expect a random process to keep because of past events
11		Negativity bias	[11]	0.8	Overestimate bad probabilities, underestimate rare ones
12		Negativity effect	[12]	0.8	Judge ambiguous stimuli as likely more negative than positive
13		Optimism bias	[13]	0.8	Overestimate good things happening to oneself
14		Pessimistic bias	[14]	0.8	Overestimate bad things happening to oneself
15	Inertia	Ostrich effect	[15]	0.8	Ignore an ongoing negative situation
16		Reactance	[16]	0.8	Doing something to be perceived based on intuition and emotions
17		Reactance effect	[17]	0.8	Increase the perceived value of something you can't have
18	Optimism	Optimism bias	[18]	0.8	Overestimate desirable events and underestimate undesirable events
19		Pollyanna effect	[19]	0.8	Focus on the positive aspects of everything even the bad
20		Reactance bias	[20]	0.8	Overestimate of ability to resist temptation
21		Wishful thinking	[21]	0.8	Form beliefs based on what one hopes is true, not what is true
22	Self-perspective	False consensus effect	[22]	0.8	Overestimate the agreement of others with one's own opinions
23		False uniqueness effect	[23]	0.8	Overestimate the agreement of others with one's own opinions
24		False visibility effect	[24]	0.8	Overestimate how others can see one's current state
25		Illusion of transparency	[25]	0.8	Overestimate weight of others over one's current state and vice versa
26		Illusion of validity	[26]	0.8	Overestimate ability to predict events correctly even after the fact
27		Optimism bias	[27]	0.8	Positive outcomes more probable for themself than others
28		Self-serving bias	[28]	0.8	Overestimate responsibility for success and underestimate responsibility for failure
29		Self-relevance effect	[29]	0.8	Process information better if it is related to oneself
30		Spotlight effect	[30]	0.8	Overestimate how others are thinking about one's own appearance, behavior
31		Sleeper effect	[31]	0.8	Underestimate over-authoritarian sources to attract ill-defined leads
TASK: DECISION					
32		Ambiguity effect	[32]	0.8	Choose affected by their association with authentic authority
33		Authority bias	[33]	0.8	Choose affected by their association with authentic authority
34		Bandwagon effect	[34]	0.8	Choose affected by their association with a popular or trendy option
35		Choice-supportive bias	[35]	0.8	Choose affected by whether alternatives are presented as good or bad
36		Conformity	[36]	0.8	Choose affected by their association with a group
37	Anecdotes	Identifiable victim effect	[37]	0.8	Decision choose affected by whether victims are identifiable
38		Loss aversion	[38]	0.8	Choose affected by whether the loss amount value for another currency falls
39		Negativity effect	[39]	0.8	Choose affected by stronger of a positive or negative
40		Negativity effect	[40]	0.8	Choose affected by stronger of a positive or negative
41		Peak-end rule	[41]	0.8	Choose affected by memories of an experience and its intensity
42		Prospect theory	[42]	0.8	Choose affected by whether the loss amount value for another currency falls
43		Reactance	[43]	0.8	Choose affected by their association with a group
44		Reactance effect	[44]	0.8	Choose affected by whether people are in a group
45		Status quo bias	[45]	0.8	Choose affected by their association with a group
46		Omission effect	[46]	0.8	Choose affected by whether the loss amount value for another currency falls
47		Ostrich effect	[47]	0.8	Choose affected by whether the loss amount value for another currency falls
48		Outcomes bias	[48]	0.8	Choose affected by how many are the alternatives
49		Overjustification effect	[49]	0.8	Choose affected by their association with a group
50		Status quo bias	[50]	0.8	Choose affected by minimal monetary value
51		Sunk cost effect	[51]	0.8	Choose affected by their association with a group
52		Reactance	[52]	0.8	Choose affected by overcoming of obstacles
53		Reactance effect	[53]	0.8	Choose affected by whether people are in a group
54		Functional fixedness	[54]	0.8	Choose affected by their association with a conventional concept
55		Functional fixedness	[55]	0.8	Choose of object was affected by the traditional way of use
56	Inertia	Mere exposure effect	[56]	0.8	Choose affected by their association with a group
57		Semmelweis effect	[57]	0.8	Choose of social practice affected by a norm or established norms
58		Status quo bias	[58]	0.8	Choose affected by their association with a group
59		Sunk cost effect	[59]	0.8	Choose affected by the urge to avoid a change, even when better conditions exist
60	Optimism	Ostrich effect	[60]	0.8	Choose affected by the urge to avoid a change, even when better conditions exist
61		Pleasure principle	[61]	0.8	Choose affected by the urge to be rewarded or what pleasure urge to be rewarded
TASK: OUTCOMES ASSESSMENT					
62	Anecdotes	Illusory truth effect	[62]	0.8	Statement considered true after repeated exposure to it
63		Illusory truth effect	[63]	0.8	Statement considered true after repeated exposure
64		Recency effect	[64]	0.8	High recency effect in a list of items presented sequentially
65		Reminiscence bump	[65]	0.8	Remember more events from ages 10–30 than other ages
66		Clustering illusion	[66]	0.8	Seeing patterns in some, e.g., clusters in a dot field
67		Confirmation bias	[67]	0.8	Interpret information in a way that confirms one's preexisting beliefs
68		Congruence bias	[68]	0.8	Testing a hypothesis at a minimum by looking for evidence of its truth
69		Illusory correlation	[69]	0.8	Perceive a relationship between variables even when no such relationship exists
70		Illusory correlation	[70]	0.8	Perceive an association between variables when there is none
71		Pareidolia	[71]	0.8	Seeing faces in clouds, e.g. in the moon
TASK: CAUSAL ATTRIBUTION					
72		Actor–observer bias	[72]	0.8	Group traits extrapolated to an individual member
73	Optimism	Group attribution error	[73]	0.8	Overgeneralizing traits of a group
74		Hostile attribution bias	[74]	0.8	Interpret ambiguous behavior as intentional and hostile
75		Just-world hypothesis	[75]	0.8	Bad people deserve bad things, and good people deserve good things
76		Ultimate attribution error	[76]	0.8	Attribute a desirable behavior to an internal cause and an undesirable behavior due to situation
77		Attribution asymmetry hypothesis	[77]	0.8	Choose of whether attributing to self or others, with the actor
78		Dunning–Kruger effect	[78]	0.8	Incompetent people think that they are smarter than others
79	Self-perspective	Fundamental attribution error	[79]	0.8	Attribute of others due to behavior or personality, even behavior due to situation
80		Illusion of control	[80]	0.8	Overestimate the degree to which one's actions can influence events
81		Self-serving bias	[81]	0.8	Use a self-serving attribution to protect self-esteem
82		Self-serving bias	[82]	0.8	Use a self-serving attribution to protect self-esteem
TASK: RECALL					
83		Childhood amnesia	[83]	0.8	Hardly recall event details before certain age
84		Confabulation	[84]	0.8	Memory intrusion into remembrance, recalled e.g. autobiographical plagiarism
85		Cue dependent forgetting	[85]	0.8	Failure to recall unstimulated without retrieval cues
86		Cryptomnesia	[86]	0.8	Memory intrusion into remembrance, recalled e.g. unknowing plagiarism
87		Fading affect bias	[87]	0.8	Forgetting negative emotions faster than positive ones
88		Forgetting curve	[88]	0.8	Forgetting information at a rate depending on time
89		Hindsight bias	[89]	0.8	Easier to recall memories before
90		Hindsight bias	[90]	0.8	Easier to recall memories before
91		Leveling and sharpening	[91]	0.8	Forgetting details and remembering central elements
92		Levels of processing effect	[92]	0.8	Easier to recall words at deep level encoding
93		Mandela effect	[93]	0.8	Shared false memory of a specific event
94		Metamemory	[94]	0.8	Easier to recall than judgments of memory
95		Mood congruent memory	[95]	0.8	Easier to recall events that are congruent to current mood
96	Anecdotes	Negative memory	[96]	0.8	Easier to recall than positive memories
97		Peak-end rule	[97]	0.8	Easier to recall memories at their most intense and at the end
98		Persistence	[98]	0.8	Easier to recall memories that are unfulfilled
99		Primacy effect	[99]	0.8	Easier to recall first items in a series
100		Recency effect	[100]	0.8	Easier to recall last items in a series
101		Reminiscence bump	[101]	0.8	Remember more events from ages 10–30 than other ages
102		Serial position effect	[102]	0.8	Easier to recall first and last items in a series
103		Spacing effect	[103]	0.8	Easier to recall information learnt spaced than massed repetition
104		Suggestibility	[104]	0.8	Easier to recall false memories suggested by others
105		Suggestibility	[105]	0.8	Easier suggestible to a particular standard for interpersonal
106		Testing effect	[106]	0.8	Easier to recall information after retrieval
107		Testing effect	[107]	0.8	Recall more but to better memory than recognition tests
108		Tip-of-the-tongue phenomenon	[108]	0.8	Recall partial information but not whole
109		Verbatim effect	[109]	0.8	Easier to recall gist than verbatim
110		Von Restorff effect	[110]	0.8	Easier to recall unique items than common
111	Baseline	Leveling effect	[111]	0.8	Easier to recall items from longer lists
112		Serial position effect	[112]	0.8	Easier to recall first and last items, forgetting middle items
113	Inertia	Zeigarnik effect	[113]	0.8	Recall unfinished tasks better than completed ones
114		Choice-supportive bias	[114]	0.8	Recall good choices as better than they were
115	Optimism	Rosy retrospection	[115]	0.8	Recall good old days as better than they were, forgetting the unknown
116		Rosy retrospection	[116]	0.8	Recall good old days as better than they were
117	Self-perspective	Self-generation effect	[117]	0.8	Self-generated content is easier to recall than if simply read
118		Self-generation effect	[118]	0.8	Self-generated content is easier to recall than if simply read
TASK: OPINION REVISING					
119	Anecdotes	Belief perseverance	[119]	0.8	Persistence of a belief even after being presented with evidence against it
120		Belief perseverance effect	[120]	0.8	Persistence of a belief even after being presented with evidence against it
121		Belief revision effect	[121]	0.8	Revision of a belief based on new information
122	Baseline	Anchoring bias	[122]	0.8	Rely too heavily on first piece of information offered (the "anchor")
123		Anchoring effect	[123]	0.8	Rely too heavily on first piece of information offered (the "anchor")
124	Inertia	Attitude bias	[124]	0.8	Attitude affected by whether the factor is or due to incentive
125		Attitude bias	[125]	0.8	Attitude affected by whether the factor is or due to incentive
126		Belief bias	[126]	0.8	Belief affected by its plausibility and how it feels
127	Optimism	Belief bias	[127]	0.8	Belief affected by its plausibility and how it feels
128		Stereotyping	[128]	0.8	Attributing characteristics of group members
129		Belief perseverance effect	[129]	0.8	Persistence of a belief even after being presented with evidence against it
130		Belief revision effect	[130]	0.8	Revision of a belief based on new information
131		Dunning–Kruger effect	[131]	0.8	Incompetent people think that they are smarter than others
132		Illusion of validity	[132]	0.8	Overestimate ability to predict events correctly even after the fact
133	Self-perspective	Illusion of validity	[133]	0.8	Overestimate ability to predict events correctly even after the fact
134		Illusion of validity	[134]	0.8	Overestimate ability to predict events correctly even after the fact
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TASK: OTHER					
201	Anecdotes	Illusion of truth	[201]	0.8	Hard to believe a common information in a complicated manner
202		Illusion of truth effect	[202]	0.8	Hard to believe a common information in a complicated manner
203	Baseline	Ostrich effect	[203]	0.8	Ignore an ongoing negative situation, e.g. ignoring a bad investment
204		Ostrich effect	[204]	0.8	Ignore an ongoing negative situation, e.g. ignoring a bad investment
205		Reactance	[205]	0.8	Doing something based on intuition and emotions
206		Reactance effect	[206]	0.8	Increase the perceived value of something you can't have

all cognitive biases
in wikipedia
WHY
Vs.
WHAT
bias
tasks
bias
similarities
psychology
articles
relevance
visualization
articles

all cognitive biases
in wikipedia
DECISION
Experimental Procedure
The goal of the experiment was to measure the effect of adding an asymmetrically dominated decoy. Within that classification, it was to gauge the effect of the four decoy placement strategies. In the light of comments by Einhorn and Hogarth (1981), distinguishing within- and between-subject analyses, it was felt that the effects should be established both ways. To accomplish the between-subjects analysis, 153 students in graduate and undergraduate business classes were asked to make a series of choices from among six product categories. Each product class had three choices, a target, a competitor and a decoy. As a parity check verifying its dominated character, the decoy was chosen 2% of
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ESTIMATION

DECISION

HYPOTHESIS ASSESSMENT

CAUSAL ATTRIBUTION

RECALL

OPINION REPORTING

OTHER

find the original bias

find relevant visualization works

identify opportunities for future research

reflect on our own research practices

Decision task

select one over several alternative options

Decision task

uncertainty

framing

inertia

Decision task

- **identifiable victim effect**

Decision task

- **identifiable victim effect**

Boy et al. 2017

Decision task

- **attraction effect**

- **compromise effect**

Decision task

- **attraction effect**

Conceptual and Methodological Issues in Evaluating Multidimensional Visualizations for Decision Support

Evanthia Dimara, Anastasia Bezerianos, and Pierre Dragicevic

Fig. 1: The visualizations we evaluated: Parallel Coordinates (PC), Scatterplot Matrix (SM) and Tabular Visualization (TV)

Estimation task

assess the value of a quantity

Estimation task

probability estimation

frequency estimation

time estimation

quantity estimation

performance estimation

Estimation task

probability estimation

frequency estimation

time estimation

quantity estimation

performance estimation

Recall task

recall or recognise previous material

Recall task

shape vs text vs audio

self-generated content

effort

Recall task

Hypothesis testing

investigate whether one or more hypotheses are true or false

HYPOTHESIS ASSESSMENT

Causal Attribution

assess the cause of an event

Causal Attribution

joined achievements

stereotyping

overgeneralisation

CAUSAL ATTRIBUTION

"Why are there more mass killings in the US than other countries?"

"What caused the recent decrease in road fatalities in France?"

ESTIMATION

DECISION

HYPC

CAUS

RECA

OPINION REPORTING

OTHER

MANY OTHER S

Automation bias

Manzey, et al. 2012

group decision making?

group related biases

polarization

conformity

transparent decision process

WHAT IS DATA VISUALISATION?

Garden of Eden: air pollution data

Thorsten Kiesl, Harald Moser, and Timm-Oliver Wilks Garden of Eden. 2007.

Ambient Airport Visualizations : weather & air traffic data

Left: eCLOUD is an airport installation at the San Jose International Airport created by Dan Goods, Nik Hafermaas, and Aaron Koblin.

Right: airFIELD created by the same team two years later. Hartsfield-Jackson Atlanta International Airport.

Dynamic Composite Physicalizations with wheeled micro-robots

Le Goc et al. Dynamic composite data physicalization using wheeled micro-robots
IEEE transactions on visualization and computer graphics 25.1 (2018): 737-747

REMEMBER ME?