

# How effective are graphical displays to communicate evidence?

## The impact of graph literacy

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University  
of Granada

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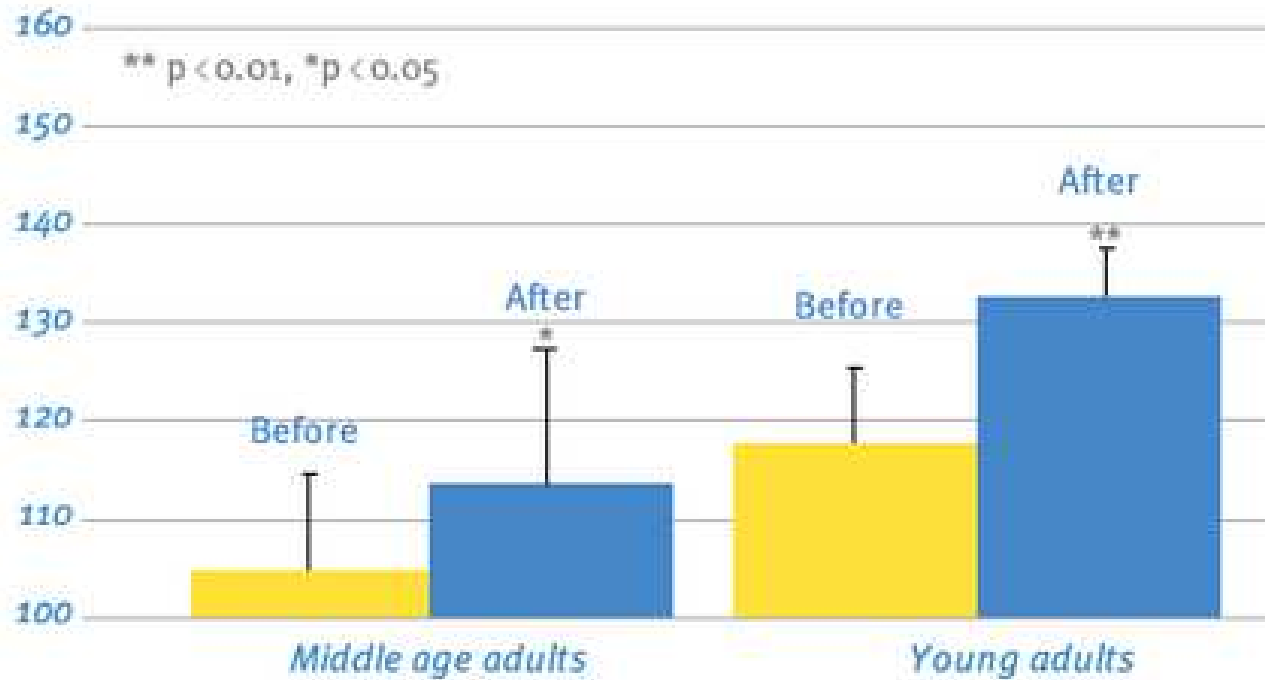
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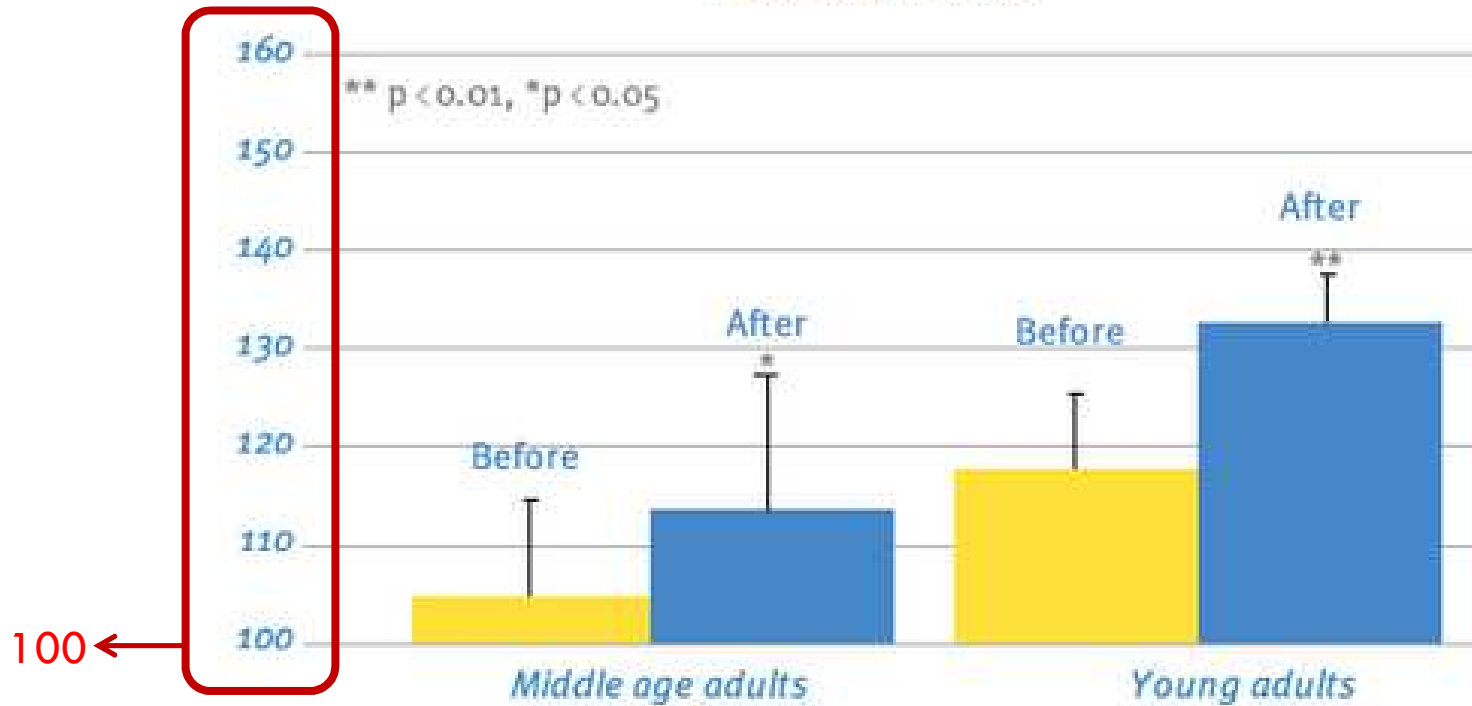
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## MEMORY QUOTIENT



Changes in memory quotients after two weeks of treatment

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Changes in memory quotients after two weeks of treatment

# The impact of graphs

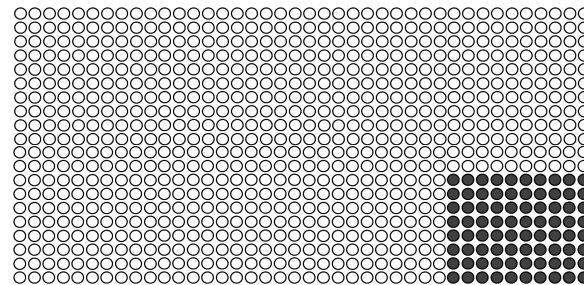
- Graphs are often used to communicate information (e.g., treatment effectiveness) that can affect important judgments and decisions.
- Increasing evidence that graphs can facilitate the communication of quantitative medical information. They contribute to overcome difficulties in grasping numerical concepts and systematic biases.
- Graphs available to the public (e.g., advertisements, newspapers) can also lead to judgment errors.
- Some individuals can be more susceptible to show errors than others.

# Graph literacy

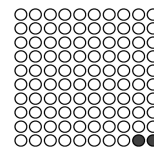
**Graph literacy:** The construct that describes the ability to understand graphically presented information (Galesic & Garcia-Retamero, 2011)

- Graph literacy can moderate the effectiveness of visual aids (icon arrays) in increasing accuracy of risk understanding

Without the drug



With the drug



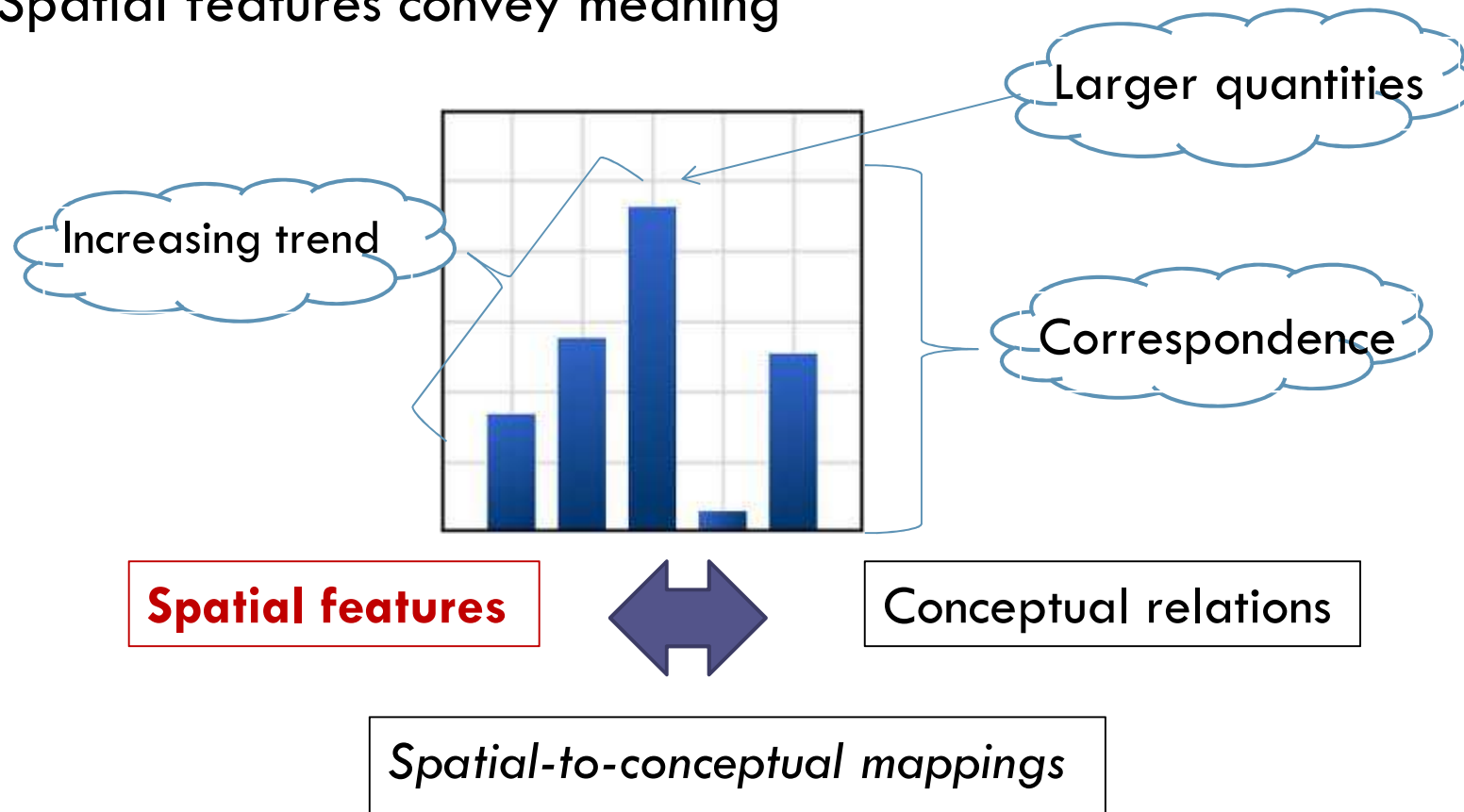


# Overview

1. What graph comprehension errors are more prominent among individuals with low graph literacy? **Study 1**
2. What cognitive processes underlie such errors? **Study 2**  
(Eye tracking)

# Study1. Background

- Spatial features convey meaning



# Study 1. Spatial features convey meaning

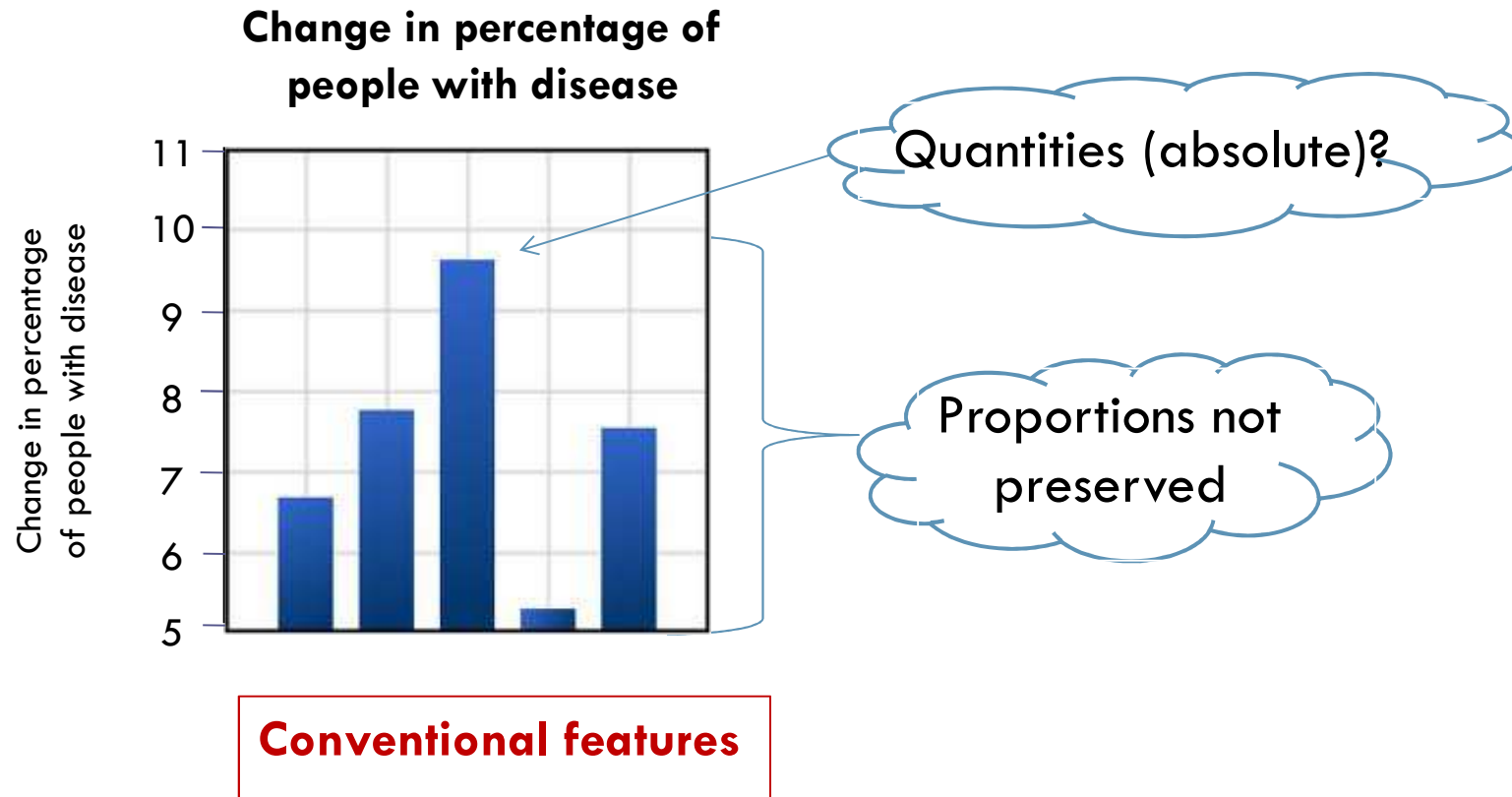
- Spatial-to-conceptual mappings are often rooted in viewers' experience with the physical environment



- “Natural correspondences” (Lakoff & Johnson, 1989; Tversky, 2001, 2009; Tversky, Kugelmass, & Winter, 1991)



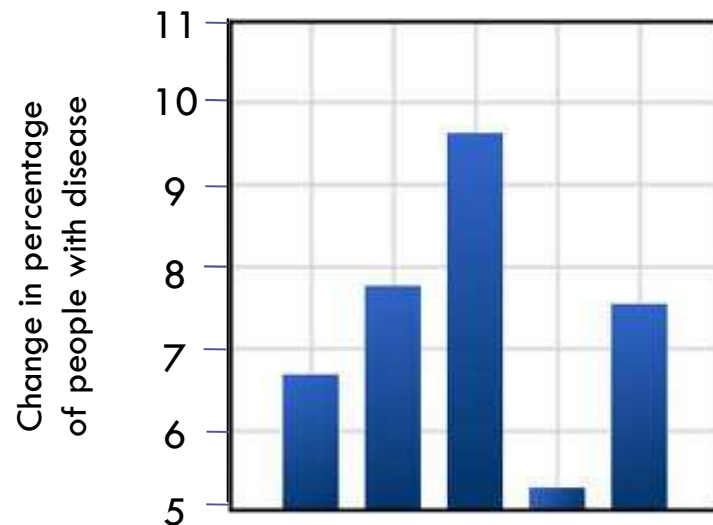
# Study 1. Conflicts in graphs



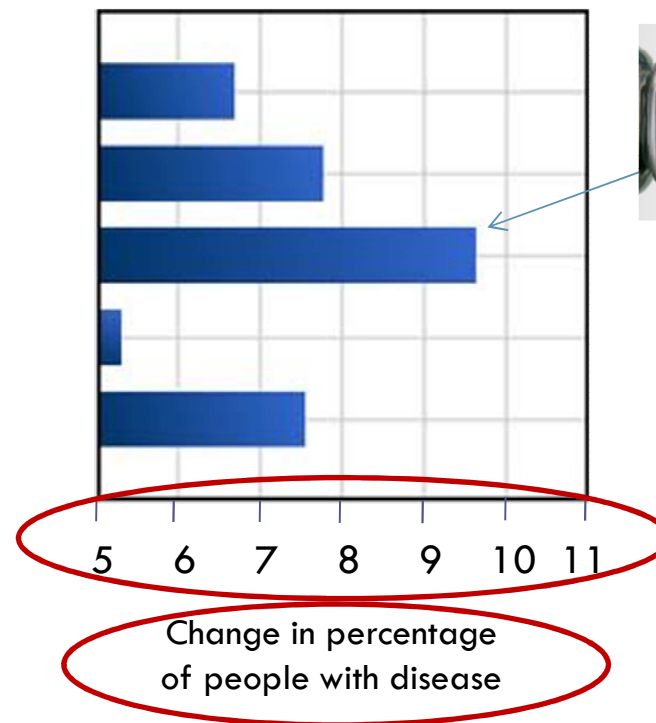
*Do not map onto viewers' experience with their environment*

# Study 1. The effect of orientation

Change in percentage of people with disease



Change in percentage of people with disease



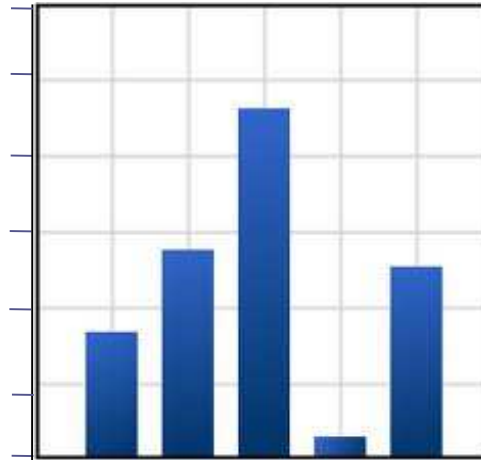
# Study 1: Research Questions

For graphs containing conflicts between spatial and conventional features...

- i. Do individuals with low graph literacy more often make erroneous interpretations corresponding to spatial-to-conceptual mappings?
- ii. Does the orientation of graphs affect interpretations?
  - a. If orientation of **bars** affects → less erroneous interpretations for all **horizontal graphs**
  - b. If orientation of **scales** affects → less erroneous interpretations for **horizontal graphs with key information in the scale**

# Study 1: Methods and Stimuli

Four graphs presenting medical information  
(containing conflicts)



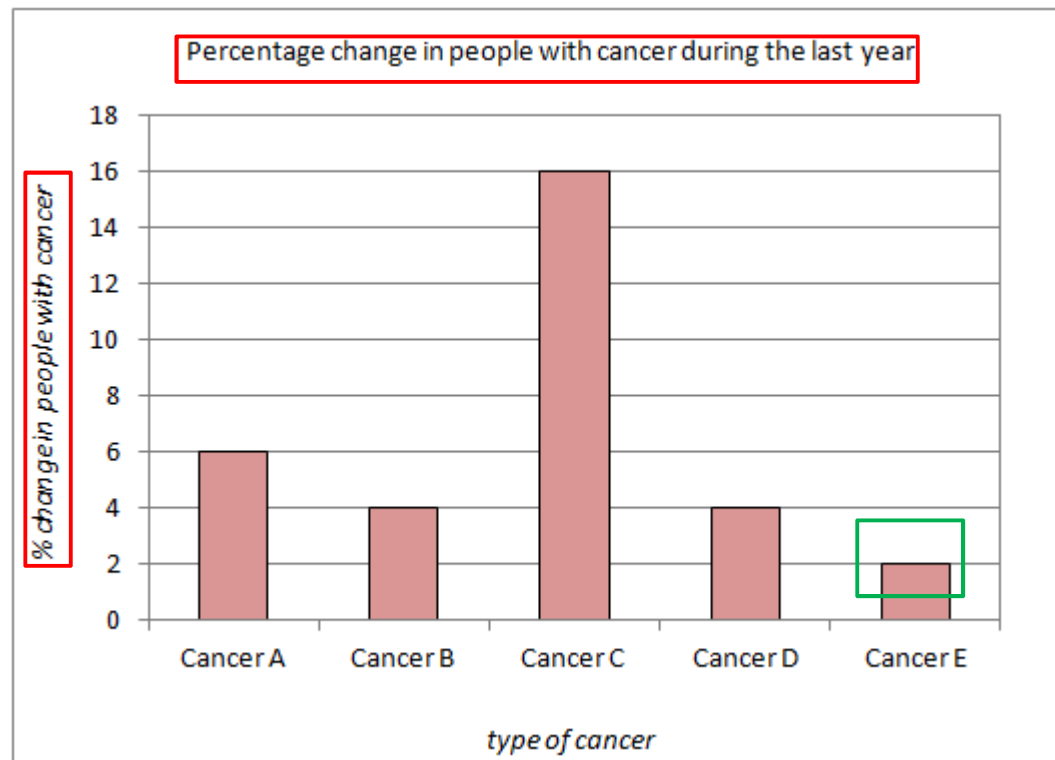
Web-based study  
(Amazon's Mechanical Turk)  
 $n = 182$ .

Interpretation questions

Measurement of graph literacy (Galesic & Garcia-Retamero, 2011)  
and numeracy (Lipkus et al., 2001)

# Study 1: Methods and Stimuli

Q: "What type of cancer affected the **smallest** percentage of people?"

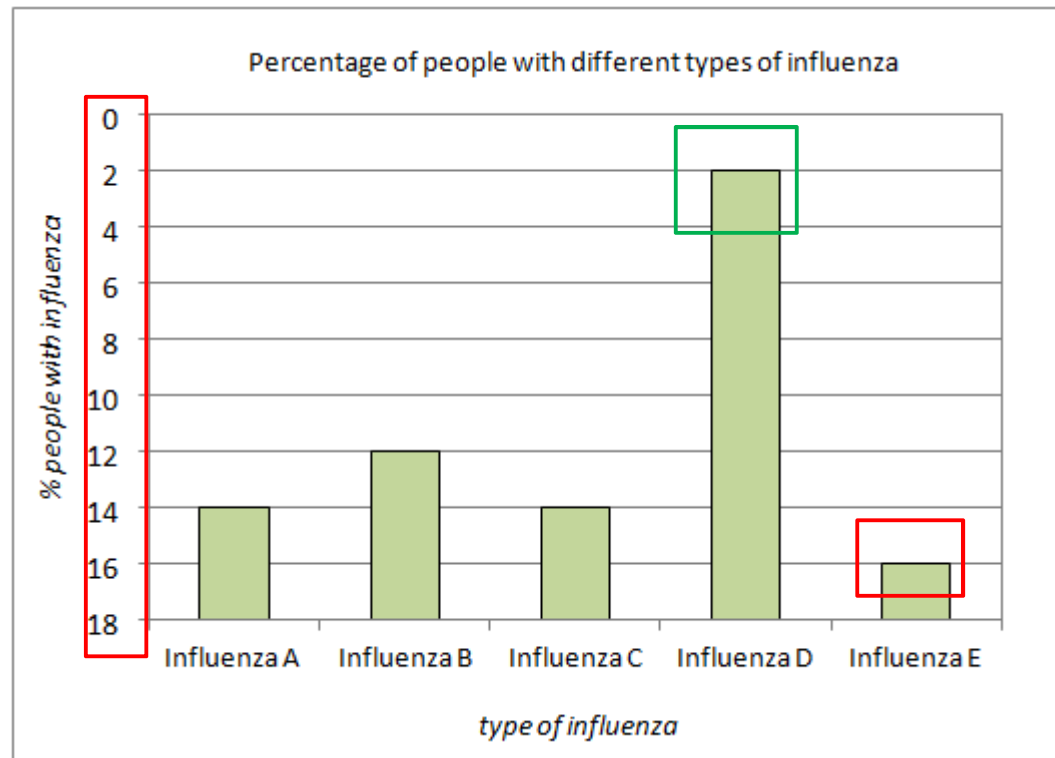


**Textual-Spatial  
conflict**  
(key information in  
title and labels)

2 graphs

# Study 1: Methods and Stimuli

Q: “What type of influenza affected the **largest** percentage of people?”

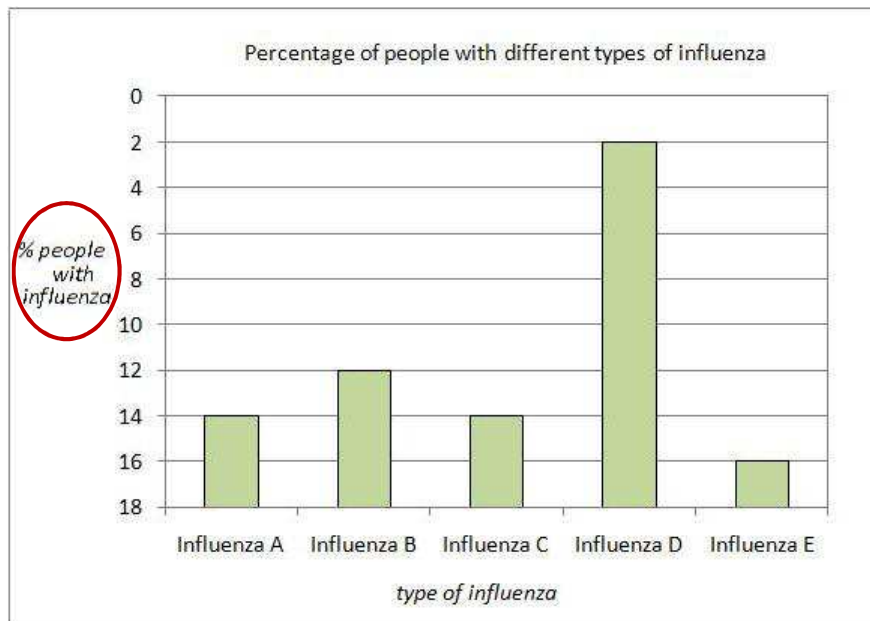


**Scale-Spatial conflict**  
(key information in  
numerical values on scale)

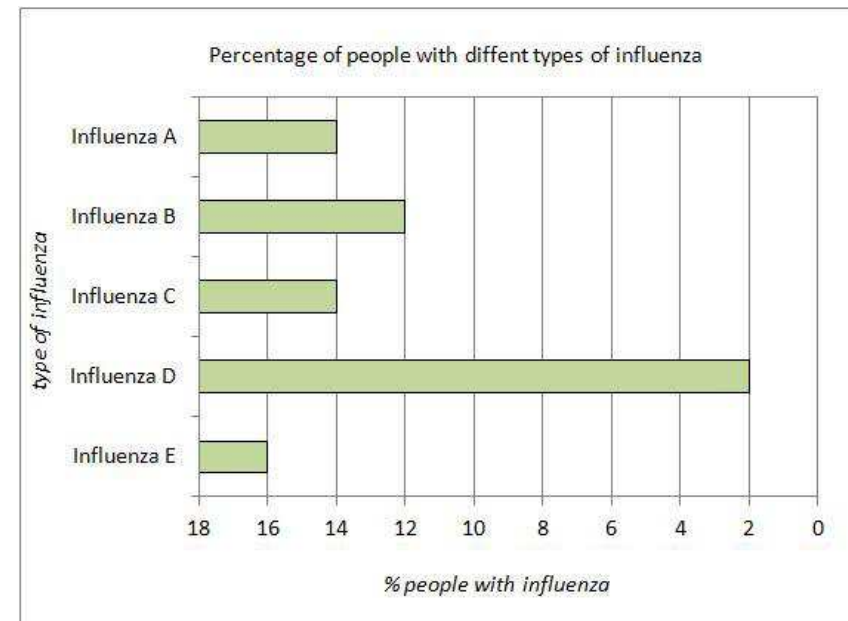
2 graphs

# Study 1: Methods and Stimuli

Vertical horizontal text



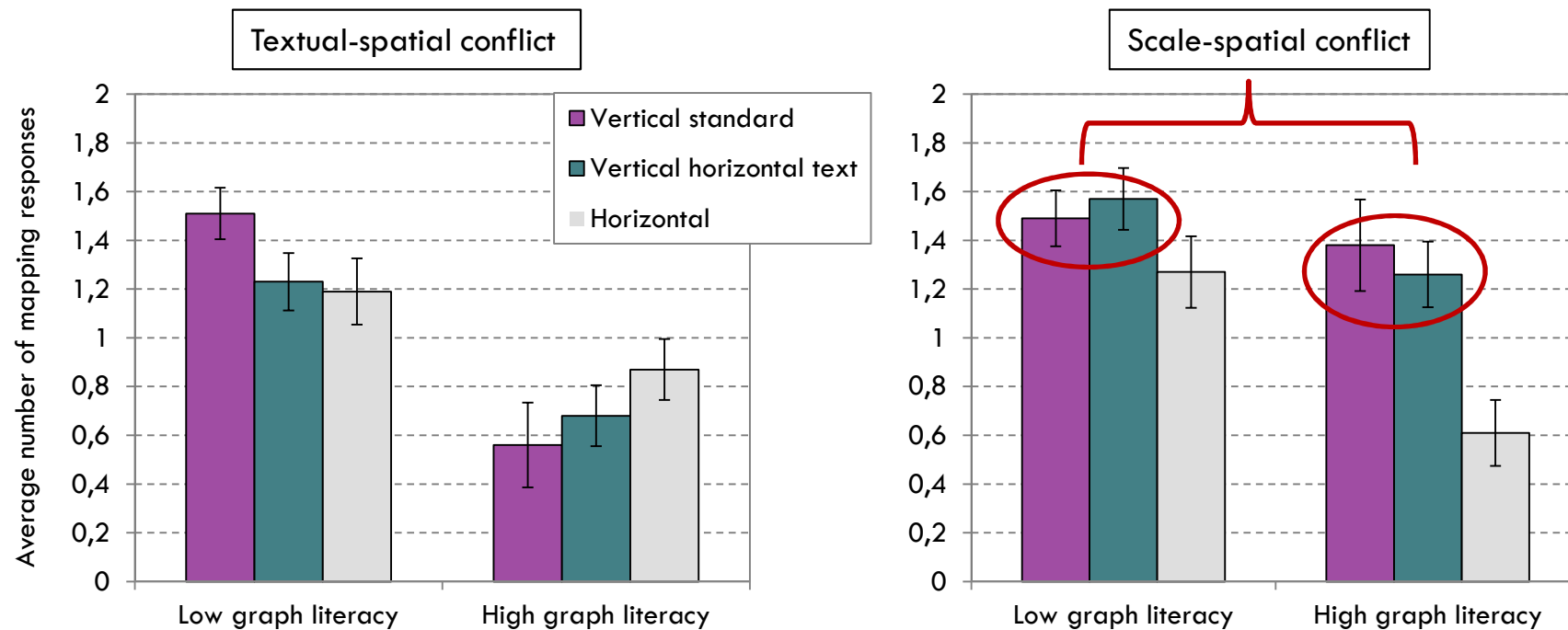
Horizontal



Orientation, manipulated between-subjects

# Study 1: Results

- i. Do individuals with low graph literacy more often make erroneous interpretations corresponding to spatial-to-conceptual mappings?



Error bars: +/- 1 SE

Graph literacy,  $F(1, 176) = 31.26, p = .001, \eta_p^2 = .151$

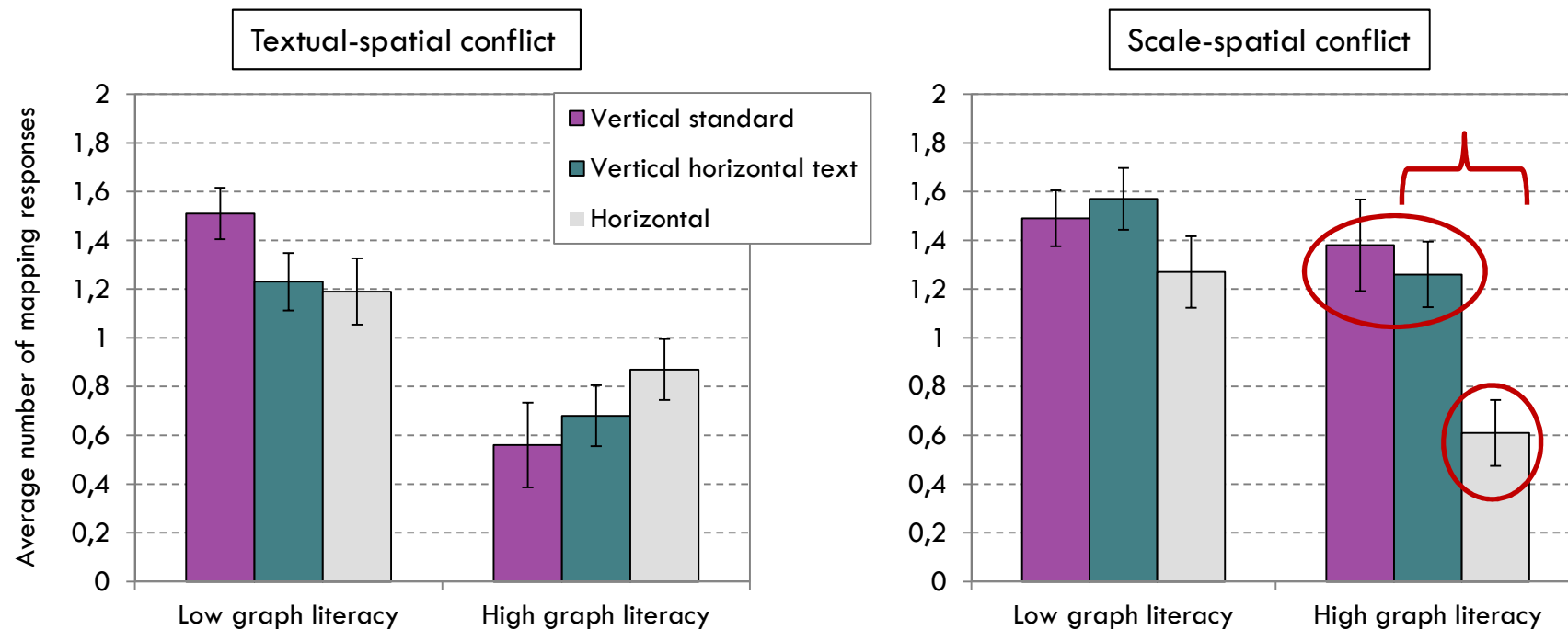
Type of conflict x orientation,  $F(2, 176) = 6.12, p = .003, \eta_p^2 = .065$ ; Graph literacy x type of conflict x orientation,  $F(2, 176) = 5.13, p = .007, \eta_p^2 = .055$

Okan, Y., Garcia-Retamero, R., Galesic, M., & Cokely, E. T. (2012). *Spatial Cognition and Computation*



# Study 1: Results

ii. Does the orientation of graphs affect interpretations?



Error bars: +/- 1 SE

Graph literacy,  $F(1, 176) = 31.26, p = .001, \eta_p^2 = .151$

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Okan, Y., Garcia-Retamero, R., Galesic, M., & Cokely, E. T. (2012). *Spatial Cognition and Computation*

# Study 1: Discussion

- ✓ Overall, individuals with low graph literacy more often make erroneous interpretations corresponding to spatial-to-conceptual mappings.
- ✓ Horizontal graphs are associated with fewer erroneous interpretations than vertical graphs. Linked to the orientation of the scale (easier to read). Only participants with high graph literacy benefit.

# Study 2: Research Questions

- i. Do individuals with low graph literacy spend **less time viewing** conventional features (attention and encoding)?
  
- ii. Is the effect of graph literacy on interpretations **mediated** by differences in the viewing time of conventional features?

# Study 2: Methods

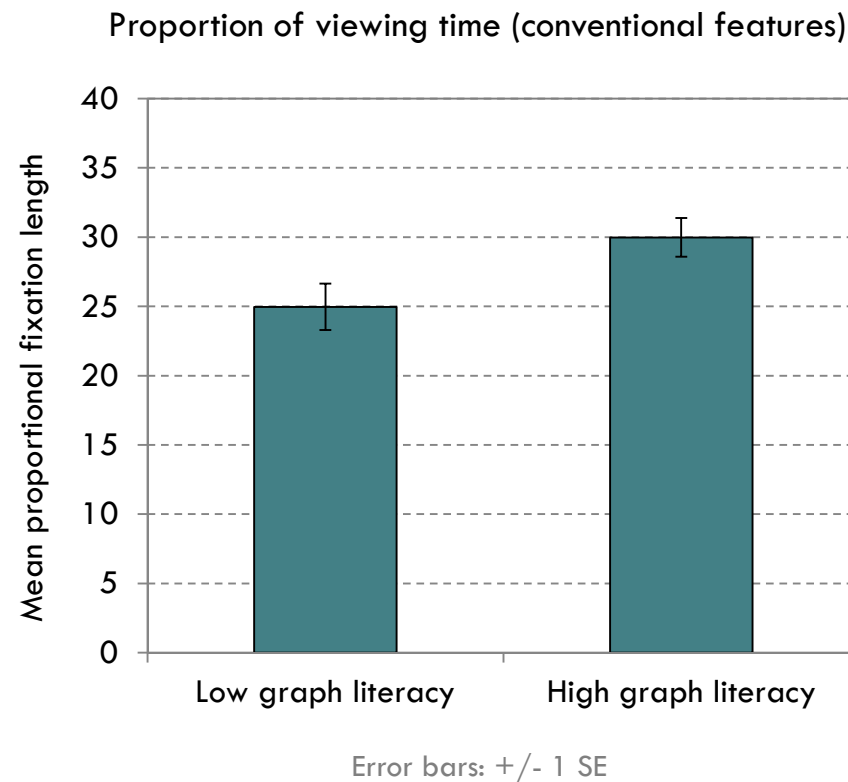


Tobii T120 Eye Tracker  
(n = 46)

Okan, Y., Galesic, M., & Garcia-Retamero, R. (under review). *Journal of Experimental Psychology: Learning, Memory and Cognition*

# Study 2: Results

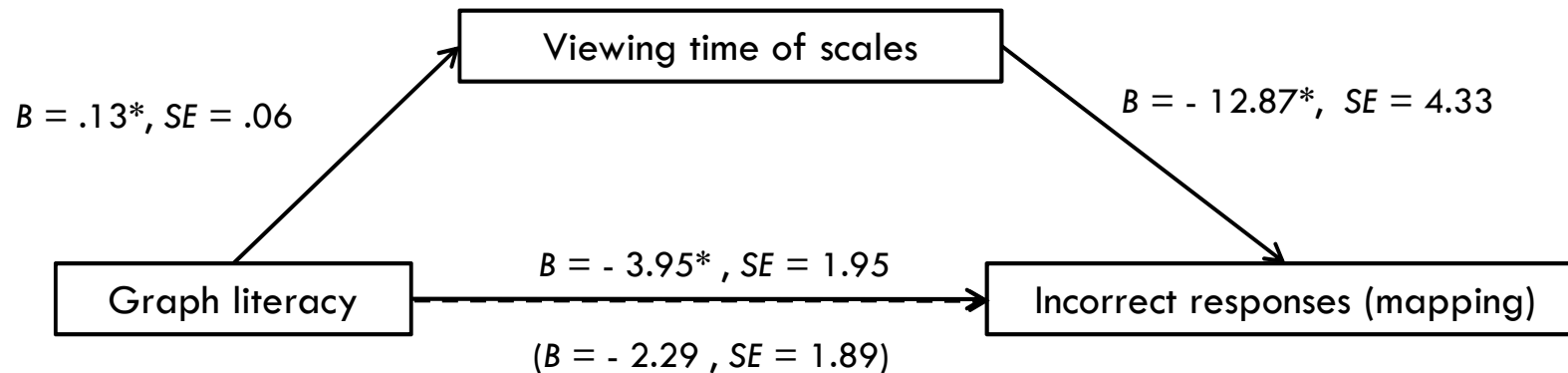
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Okan, Y., Galesic, M., & Garcia-Retamero, R. (under review). *Journal of Experimental Psychology: Learning, Memory and Cognition*

# Study 2: Results

- ii. Is any effect of graph literacy on accuracy of comprehension **mediated** by differences in the viewing time of conventional features?



$M = -1.66, 95\% CI: [-3.55, -.14]$

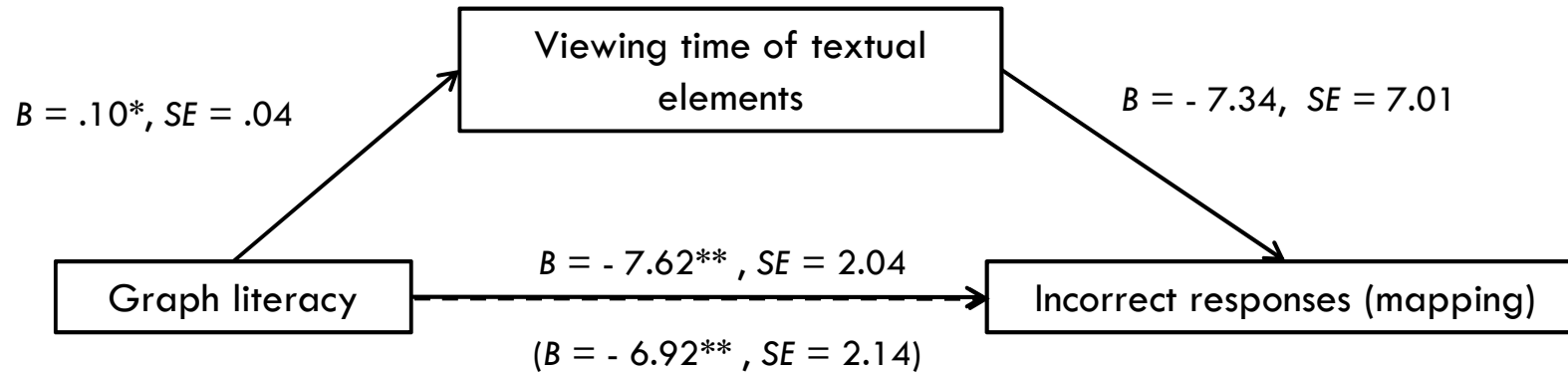
(Preacher & Hayes, 2004)

\* $p \leq .05$ , \*\* $p \leq .01$

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# Study 2: Results

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# Study 2: Discussion

- ✓ **For scale-spatial conflicts....**
  - ✓ The effect of graph literacy on accuracy can be accounted for partially by differences in attention to and encoding conventional features.
- ✓ **For textual-spatial conflicts...**
  - ✓ Other mediators? Different cognitive strategies used to operate on graphs and infer meanings? Not captured through eye tracking.



# General Discussion: Implications

- ✓ Graph literacy is related to differences in *which* information is processed (i.e., task-relevant information), not only *how*. Strategic differences in encoding (Cokely & Kelley, 2009; Haider and Frensch, 1999).
  
- ✓ **Practical implications:**
  - ✓ Misinterpretations can be frequent when natural correspondences are not preserved.
  - ✓ Graphs available to the public fail to preserve correspondences.
- ✓ **Interventions:**
  - ✓ Capitalize on viewers' experience with the environment: Evidence for significant improvement in performance.
  - ✓ Training methods for individuals with low graph literacy.
  - ✓ Custom-tailored designs, e.g. interactive displays.

Thank you for your attention!!



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