Science Communication & Narrative Medical Visualization

Turning Complex Medical Science into Meaningful Stories

Introduction

Science Communication Involves

1 SCIENTIFIC RESULTS

Communicate the **findings** and **evidence**

- Blood tests for early cancer detection
- Key data and measurements
- What the results show

2 SCIENTIFIC PROCESS

Explain **how** the discovery was made

- Characterization of the discovery
- Scientists and their work
- Historical, societal context
- Measurement and research process

3 IMPLICATIONS

Communicate **why it matters** and what comes next

- Benefits and risks
- Potential applications
- Impact on society and new technologies (e.g., nano-technology)

Introduction

Effective science communication **bridges the gap** between complex research and everyday understanding.

Science Communication: Goal and Definition

GOAL

Aims at creating **shared meanings**, deeply connected to the nature of modern societies.

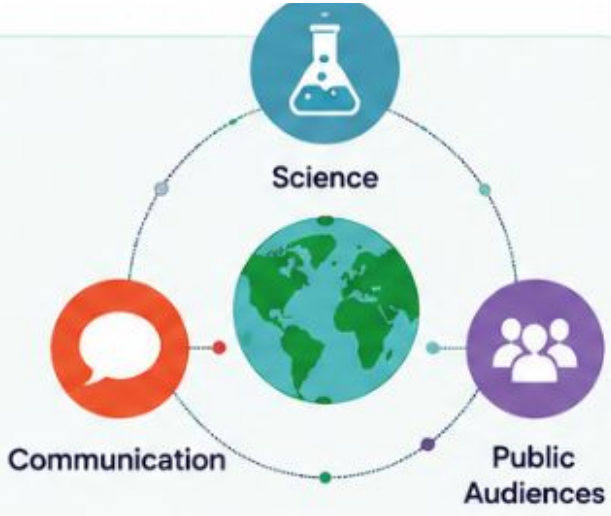
(Davies, 2019)

DEFINITION

Science communication is the science of **developing**, **testing** and **teaching strategies** to convey science to children, students and the general public.

- Involves an understanding of **Science**, of **Communication** and of **public audiences**.

(Davies, 2019)



Science Communication: Foundation

FOUNDATION

Theoretical models based on visual literacy, numeracy and text comprehension as well as empirical research based on:

Numeracy
(Various Studies)

Text Comprehension
(Various Studies)

Astronomy
(Clough, 2011)

Biology
(Morais, 2019)

Chemistry
(Morais, 2019)

Assessing Science Communication

Criteria for assessing Science Communication

(Davies, 2019)

Comprehension

How well the message is understood.

Attitude towards science

Fostering positive perceptions and trust in science.

Curiosity

Sparking interest and a desire to learn more.

Entertaining

Making content engaging and enjoyable.

Credibility

Ensuring accuracy, reliability and trust in the information.

Motivation to study science (for pupils)

Encouraging learners to explore and pursue science.

Boredom

Avoiding dull or unengaging presentations.

Confusion

Presenting information clearly to avoid misunderstanding.

Frustration (too difficult, "not for us")

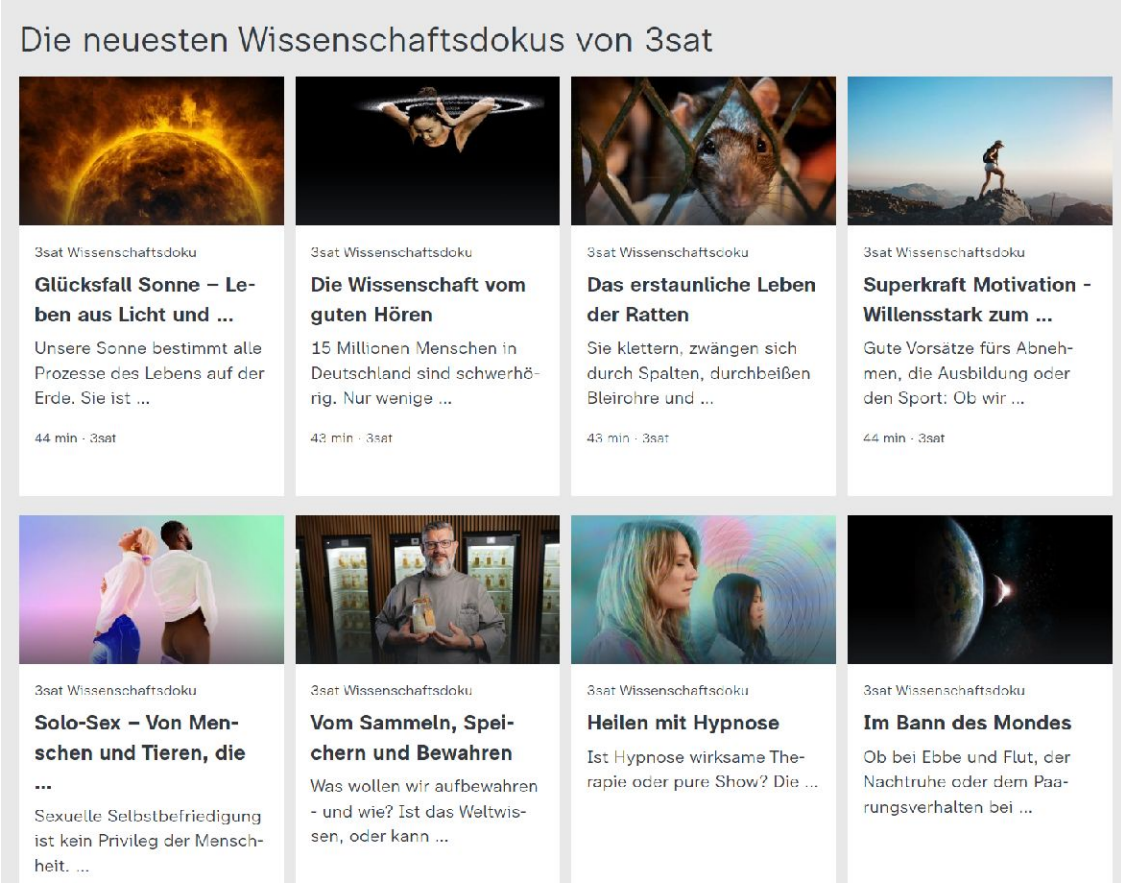
Avoiding overly complex experiences that may overwhelm and cause people to give up.

Forms of Science Communication

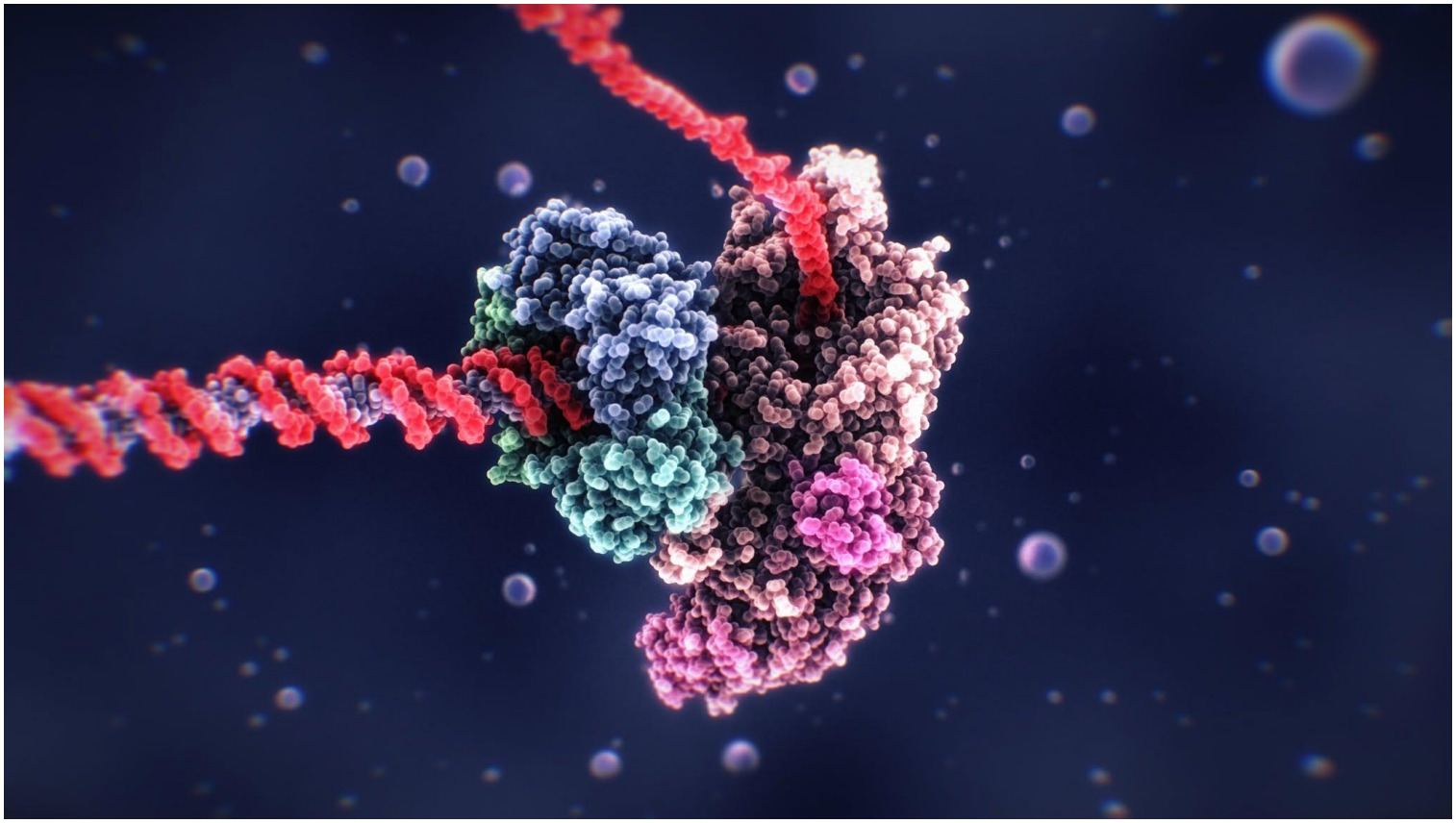
(Davies, 2019)

Science communication takes **many forms** and reaches audiences through diverse platforms and experiences.

- Science-TV, Science books, Science Fiction, Science Museums, Science cafés, Media campaigns, Science Film Festivals, Science in journals, such as New York Times, Washington Post, Scientific American, ...

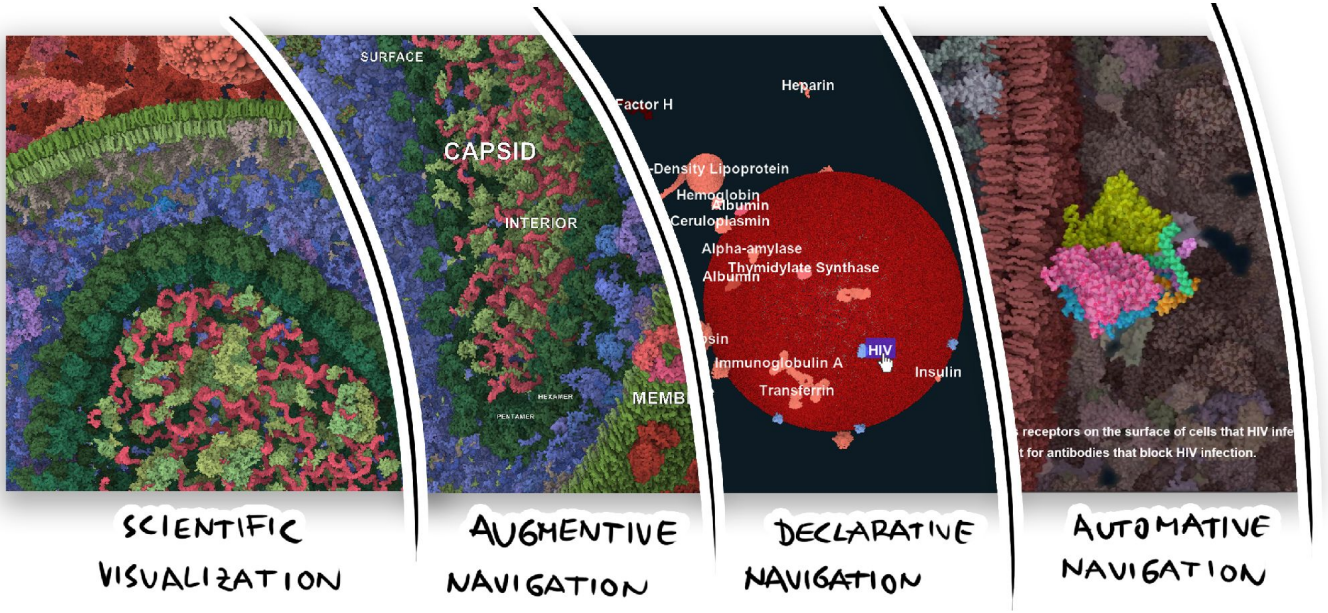


Science Communication at TU Vienna



Excellent visual communication by NanoGraphics (Peter Mindek)

Science Communication at TU Vienna



Phd Thesis David Kouril, *„Interactive Visualization of Dense and Multi-Scale Data for Science Outreach“*, 2021

Narrative Formats

Storytelling with Intents Beyond Entertainment

Serious storytelling (Lugmayer, 2016) → Stories for Science Communication

WHY STORIES FOR SCIENCE?

Stories (serious storytelling) help communicate science with **purpose and impact**.

> Narratives offer increased **comprehension, interest,** and **engagement.**

> Narratives ... offers science communicators tactics for **persuading** otherwise **resistant audiences,** although such use also raises **ethical considerations.**

(Dahlström, Michael 2014: "Using narratives and storytelling to communicate science with nonexpert audiences." *Proc. of the national academy of sciences*)

Narrative Formats

NARRATIVE FORMATS FOR SCIENCE COMMUNICATION (Dahlström, 2014)

PERSONAL STORIES

Humanize science by sharing real experiences and personal journeys.

CASE STUDIES

Illustrate scientific concepts through real-world examples.

HERO'S JOURNEY

Structure stories around challenges, discoveries and transformation.

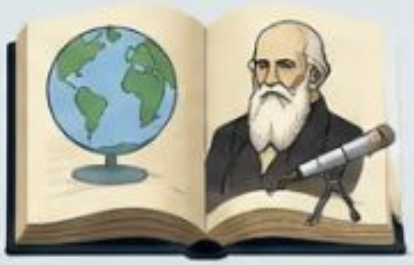
Narrative Formats

NARRATIVE FORMATS FOR SCIENCE COMMUNICATION (Dahlström, 2014)

CONFLICT & RESOLUTION

Show the problem, the scientific approach and the solution.

HISTORICAL NARRATIVES



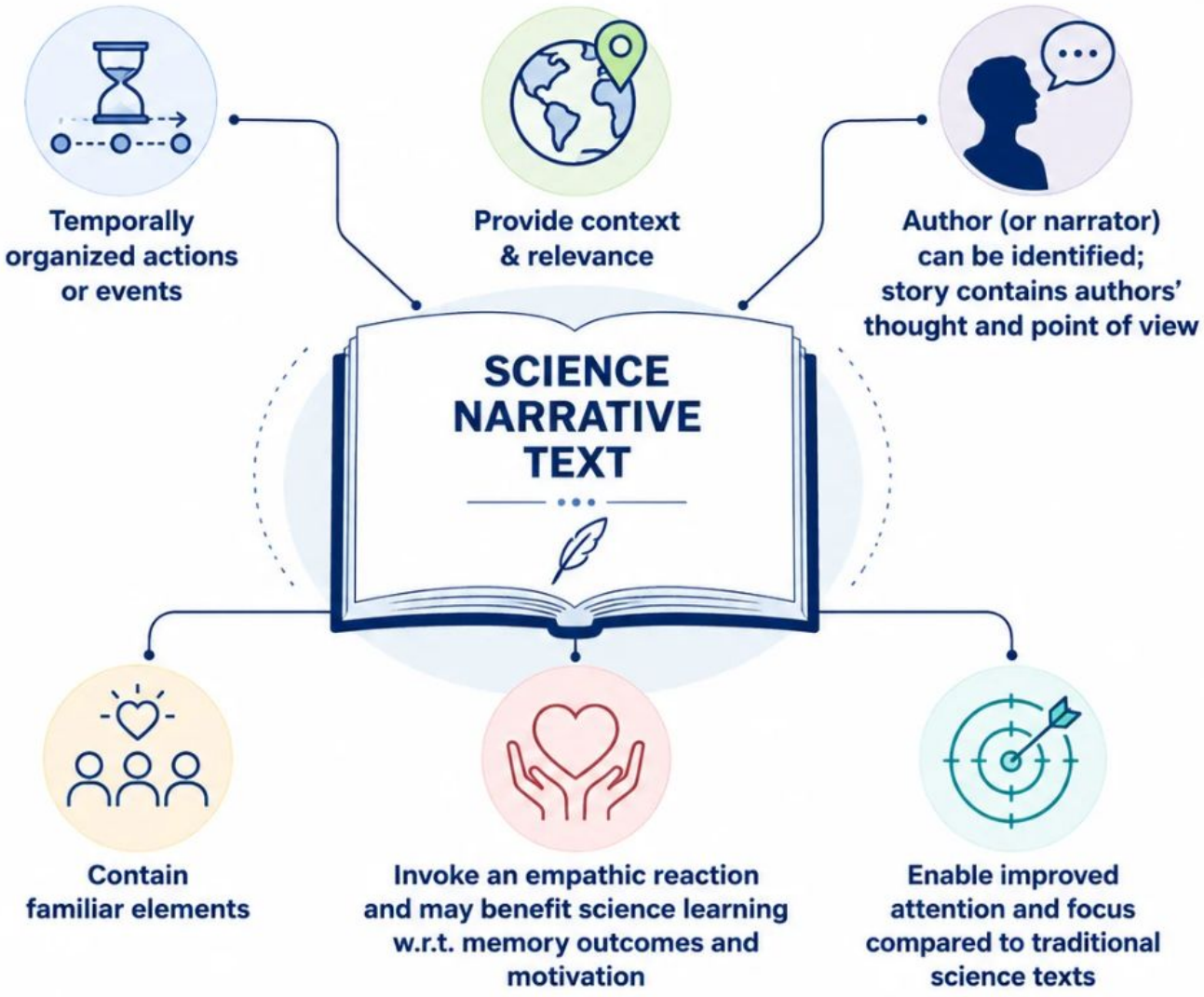
Bring the history of discoveries and scientists to life.

FUTURE SCENARIOS

Use stories to explore possibilities and inspire informed action.

When used responsibly, storytelling transforms complex science into meaningful, memorable experiences that **inform**, **engage** and **inspire action**.

Science Narrative Texts



(Ameseder, 2018; Soares, 2023; Solomon, 2002; Morais, 2019)

Visualization in Science Stories

Visualizations in science stories (Solomon, 2002)

Pictures valuable
(picture superiority effect)

Images help people understand, remember and connect with scientific information more effectively.

Larger capacity for focussing on moving objects

Video and acting will be "doubly valuable."

Animated cartoons may be valuable and evoke empathy

Characters and storylines help audiences feel connected and care more.

Visualization in Science Stories

Why Visualization Matters in Science Stories

Enhances Understanding

Captures Attention

Improves Memory

Builds Empathy & Connection

Supports Communication

Increases Motivation to Learn

InfoGraphics for Science Communication

- **Scientific results** communicated via scientific publications (journals, conference papers, book chapters, preprints)

- **(Textual) Abstracts** summarize content

- **Explosion of scientific literature** makes it difficult to get an overview of relevant work, e.g., for a specialized physician

- **Recent trend**: Visual summaries (graphical abstracts) to ease the perception of summarizing information

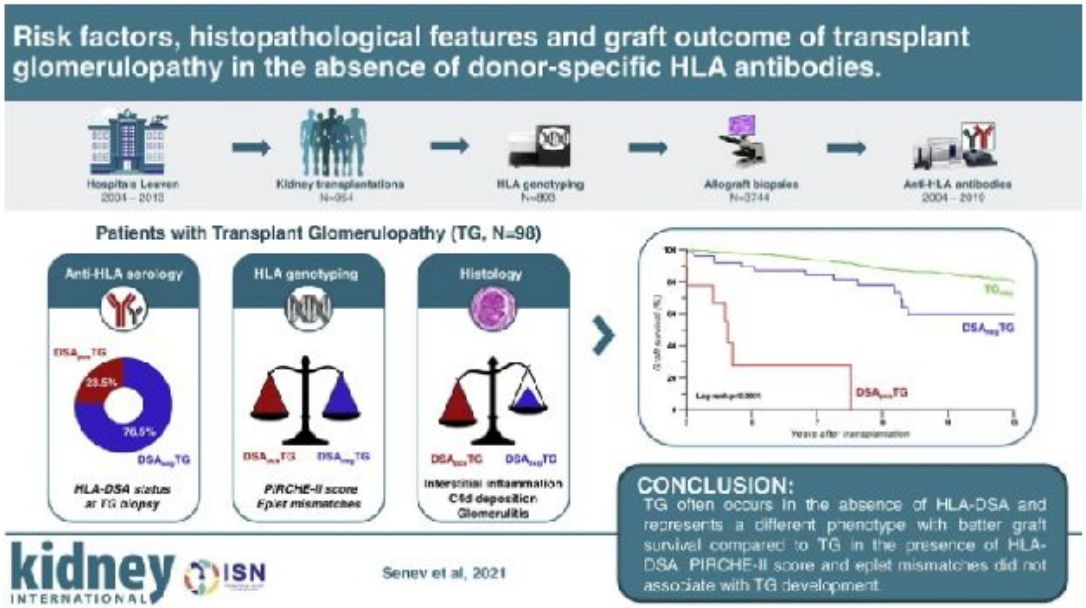
- **Components**: minimal amount of text, diagrams, symbols, e.g., to convey study design and results

- **Introduced** in 1976 in a chemistry journal, widespread use started about 2015, e.g., Annals of surgery (2016).

Why it matters: Graphical abstracts use visuals to convey the essence of research **quickly** and **clearly**—improving **discoverability**, **understanding**, and **impact**.

Visual Abstracts

- Compared to traditional textual abstracts, better perception on digital media
- Currently: Generative AI often employed to create compelling diagrams



Risk factors, histopathological features, and graft outcome of transplant glomerulopathy in the absence of donor specific HLA antibodies

A recommended graphical abstract *(From: Graphical abstract in Elsevier journals).*

Visual Abstracts

Role of infographics in summarizing research *(Martin, 2019)*

Visual abstracts in medical journals are part of a **broader communication strategy** that also involves social media, podcasts and blogs to **increase visibility and impact** of the published research.

PROS

Infographics characterized as "easy to perceive" and easier to remember

(cognitive load theory, dual coding theory)

- Enhances understanding and recall
- Facilitates quick grasp of key messages
- Increases engagement and shareability

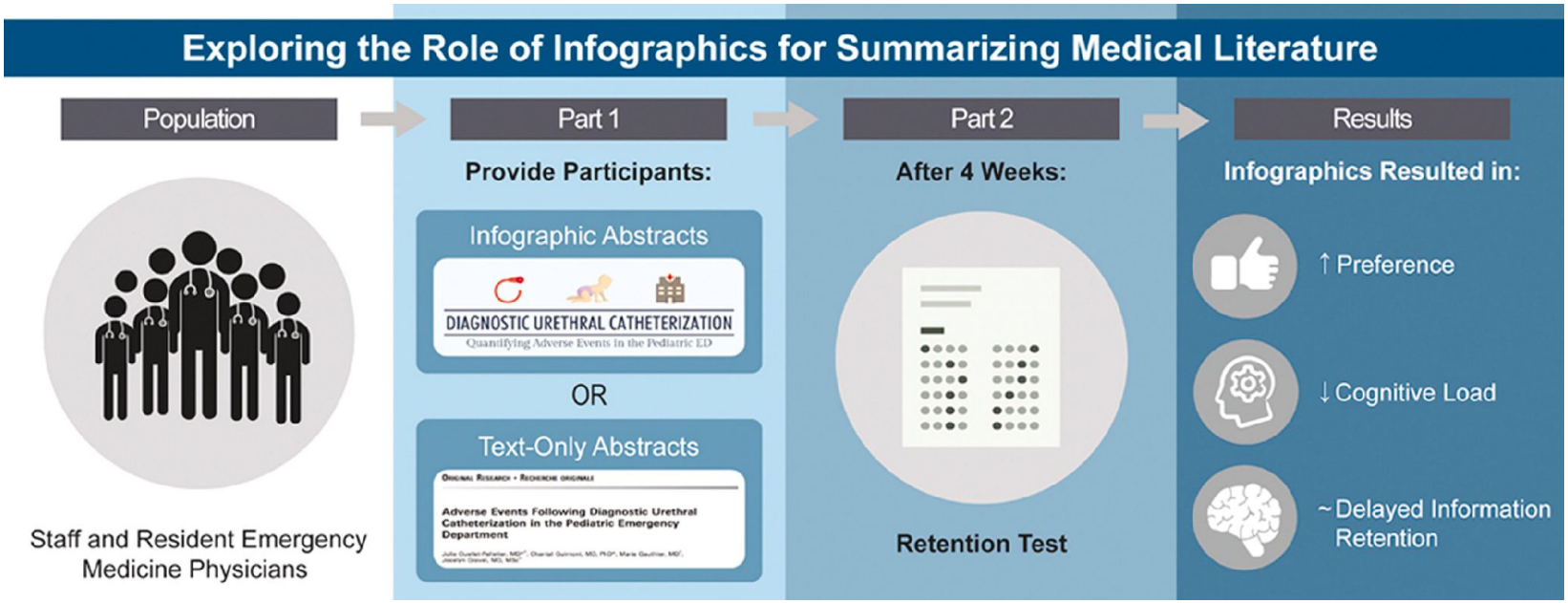
CONS

Time, effort, money to create and publish **high quality visual abstracts**

- Requires specialized skills and design expertise
- May involve additional resources and costs
- Needs careful planning to ensure clarity and accuracy

Takeaway: Visual abstracts leverage the power of visuals to **communicate science more effectively**, but creating high-quality ones **requires investment**.

Visual Abstracts



How effective are visual abstracts? (From: Martin, 2019)

Visual Abstracts

Role of infographics in summarizing research *(Martin, 2019):*

EVALUATION CRITERIA

- Assess reader preference
- Assess perceived mental effort

STUDY DESIGN

- **Participants:** 112 Canadian emergency physicians
- **Stimuli:** 4 infographics (visual abstracts) & 4 text-only summaries
- **Infographics** created by experienced designer with medical experts

RESULTS

PROS

Physicians clearly preferred visual abstracts
(8x „strongly preferred" visual compared to textual)

8x more likely to strongly prefer

PROS

Physicians clearly consider visual abstracts
cognitively easier

CONS

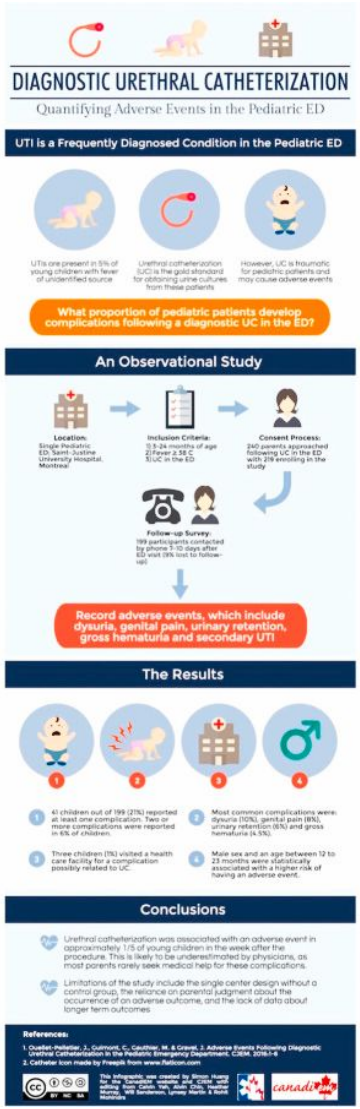
Delayed retention very similar
between abstracts and visual abstracts

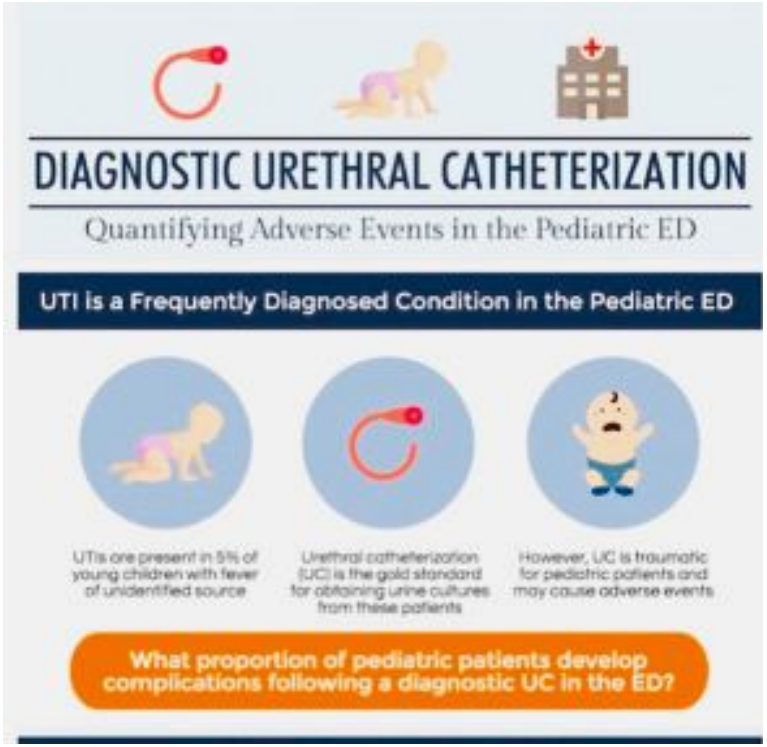
No significant difference in delayed retention

TAKEAWAY

Visual abstracts are **preferred** and perceived as **easier to process**, without compromising retention.

Visual Abstracts





Example of a visual abstract (Martin et al., 2019).

Visual abstracts with QR-codes pointing to full article.

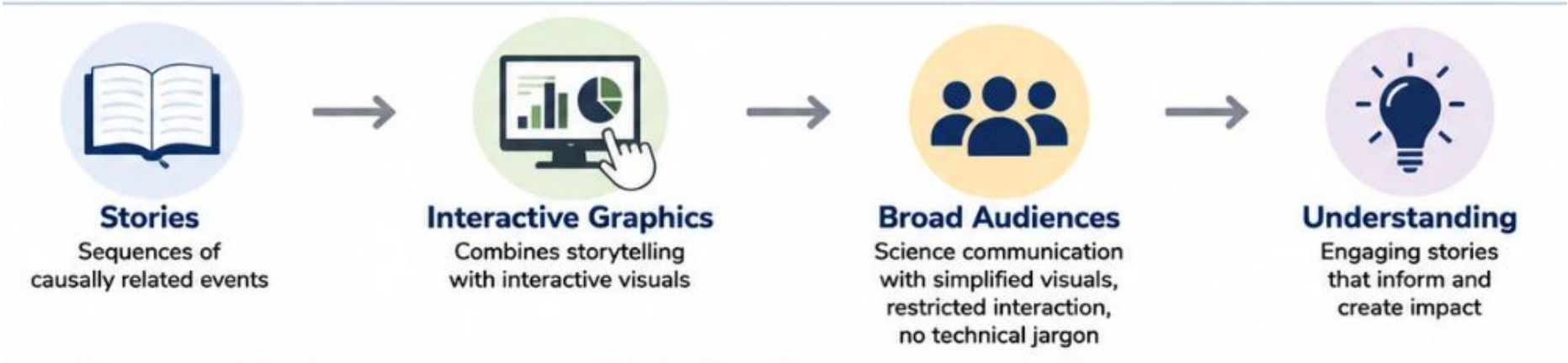
Medical journal papers contain many infoGraphics, see (Ferreira, 2022) for a discussion of their quality

Narrative Visualization

Narrative visualization (according to Segel & Heer, 2010)

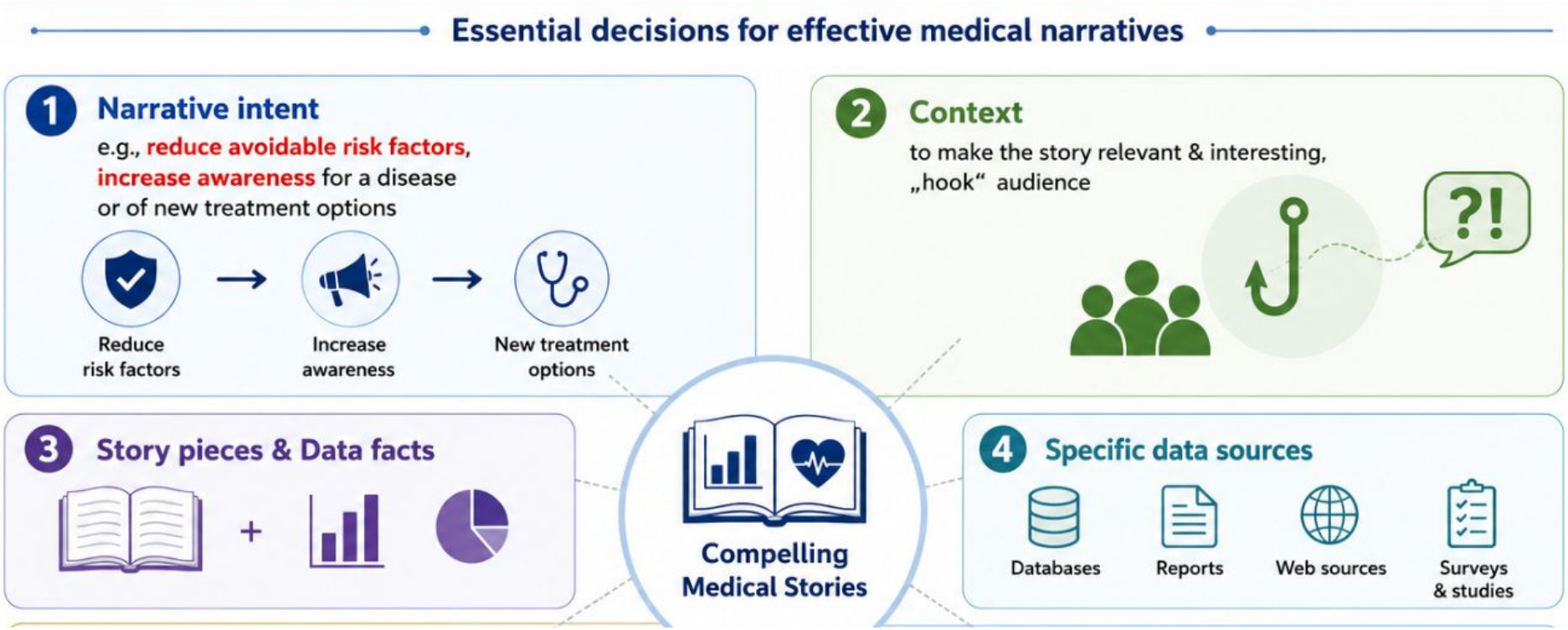
- **Employ stories** – sequences of causally related events
- Combines **storytelling** with **interactive graphics**
- Aims at **broad audiences,** e.g., science communication → simplified visualizations, restricted interaction, no technical jargon
- Employs **strategies and tactics** from journalism, theater, literature analysis, film to create engaging stories
- Very **design-oriented** (audience analysis, sketching, prototyping, ...)

Narrative Visualization

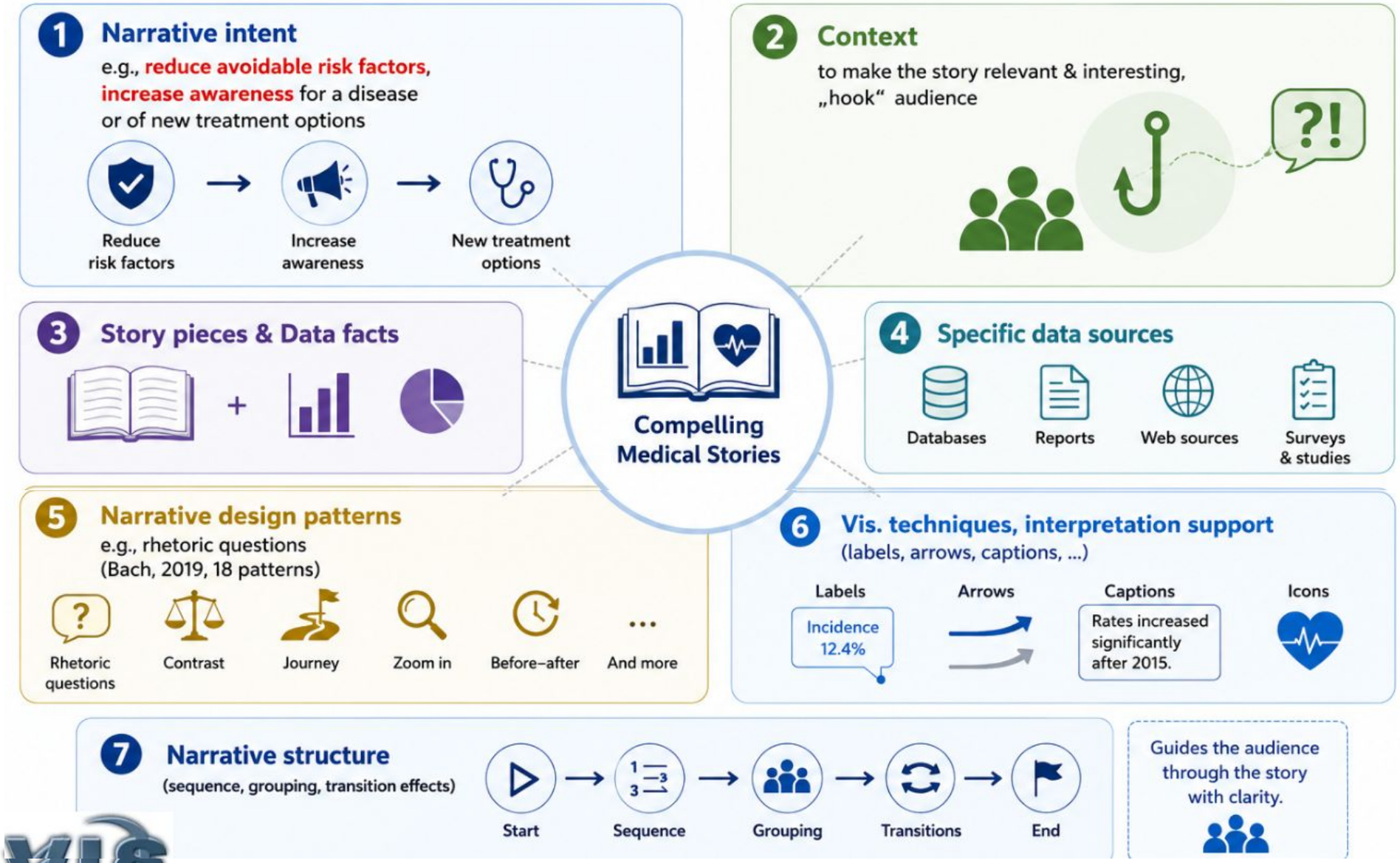


Narrative Visualization

Narrative Visualization



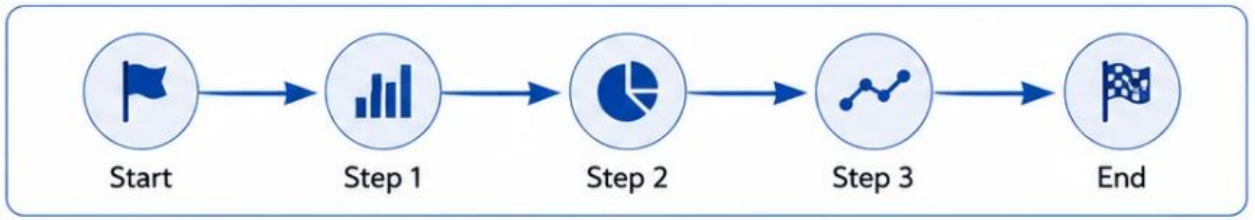
Narrative Visualization



Narrative Structures

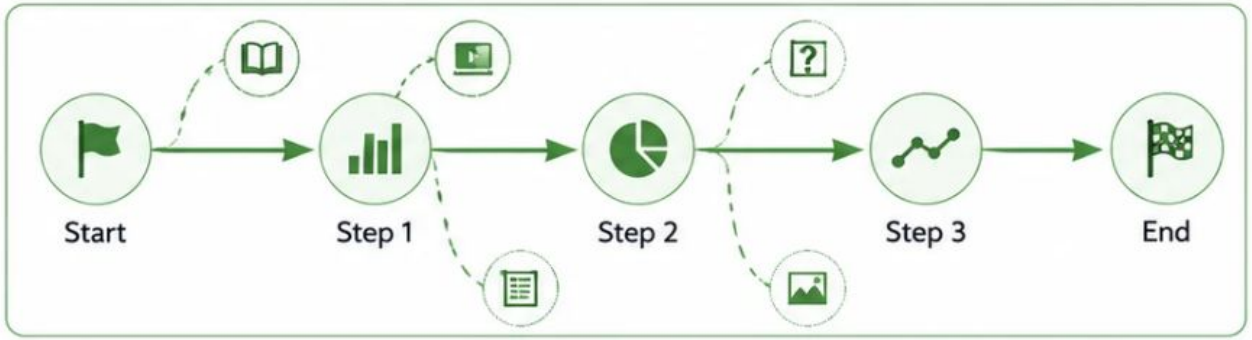
1 Linear Structure

- Often linear
  (data videos, slideshows, scrollytelling)



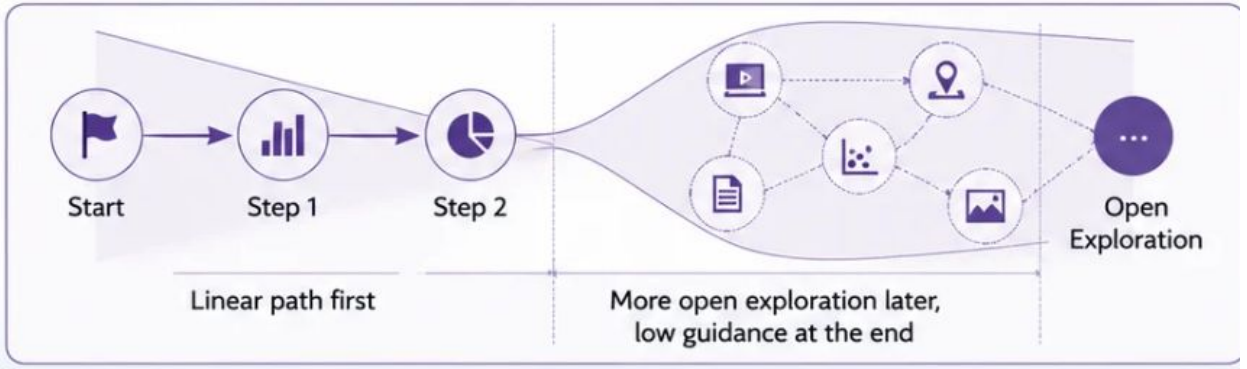
2 Elastic Structure

- Linear main path along with **optional side-branches**, more interaction but still strongly guided.



3 Martini-Glass Structure

- Linear path first, more open exploration later, low guidance at the end (Segel & Heer)



Grouping

- Often structured in **acts**, according to Aristotle's **tension arc**

1 Introduction

- Opening, where characters & conflict are introduced

2 Climactic Peak

- Tension rises, conflict becomes severe, peak

3 Denouement

- Conflict resolved, characters succeed or fail

- **Medical application:**

1 Introduction

- Characters – a patient, a physician, ...

2 Conflict

- Disease that affects life quality strongly

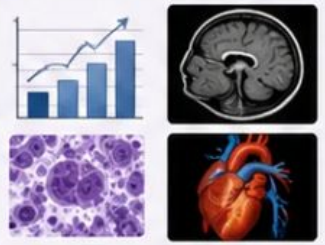
3 Peak

- Disease severe, intensive treatment, e.g., surgery

4 Denouement

- Patient cured (more or less), normal life

5 Data-driven aspects



- Statistics, 2D/3D medical image data, ...

Medical Applications

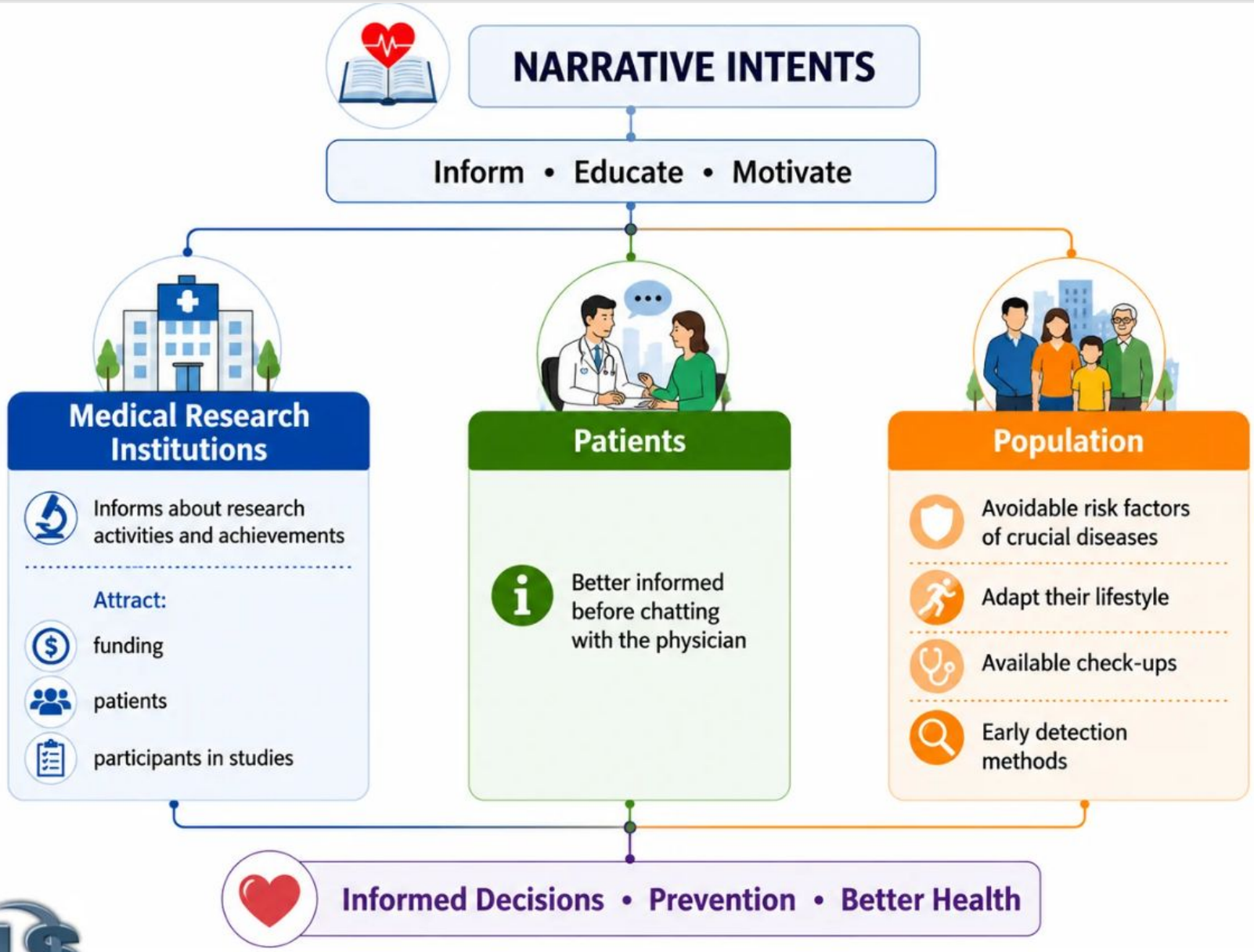
1 **Broad interest** in medical problems, diagnosis, prevention, treatment, rehabilitation (TV broadcasts, news articles, ...)

2 **Patient education** as special case (focus: appropriate risk communication)

3 **Medical treatment** also involves ambiguities, opinions, ...

4 **Scientific results & discovery:** Include also medical image acquisition, e.g., contrast agents, microscopy, ...

Medical Applications: Intents



Narrative Medical Visualization

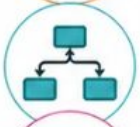
Design Approach

1. Careful discussion of the narrative intent

2. Selection of facts, representative image data

3. Personalization, i.e., a (fictionous) patient, a physician (character)
   - Consider AI-generated patients, but use real physicians

4. Selection of a narrative strategy, e.g., Campbell's Hero journey, Freytag's pyramid, tension arc



5. Definition of the story structure (grouping, sequencing)

6. Creation of a story

7. Incorporate features that raise trust

8. Many iterations needed; also systematic comparison of variants

Narrative Medical Visualization

Evaluation:

- **Knowledge gain** (what users know after experiencing the story compared to their previous knowledge)
- **Memorability** w.r.t. visual components
- **Trust/confidence** in the story
- **Engagement**
- **Willingness to change behavior,** e.g., to use screening measures, to take part in vaccination, to change lifestyle, ...

(Designed by FreePik)

„Classic“ criteria, e.g., accuracy, rate of errors, task completion time largely irrelevant!

Narrative Structure & Role of Character

Patient's disease journey

(adapted from Campbell's Hero's Journey)

Departure:
Patient leaves normal life because of symptoms

Initiation:
Examinations and tests to receive a diagnosis

Return:
Patient returns to normal life as much as possible (Mittenentzwei, 2023)

Case Study: Inform about Small Vessel Disease

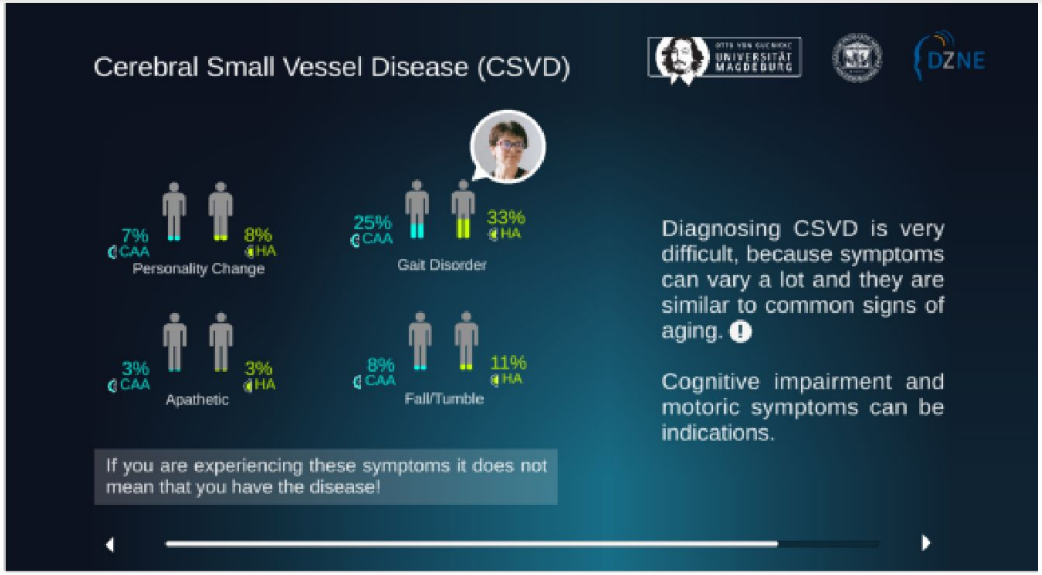
Intent:

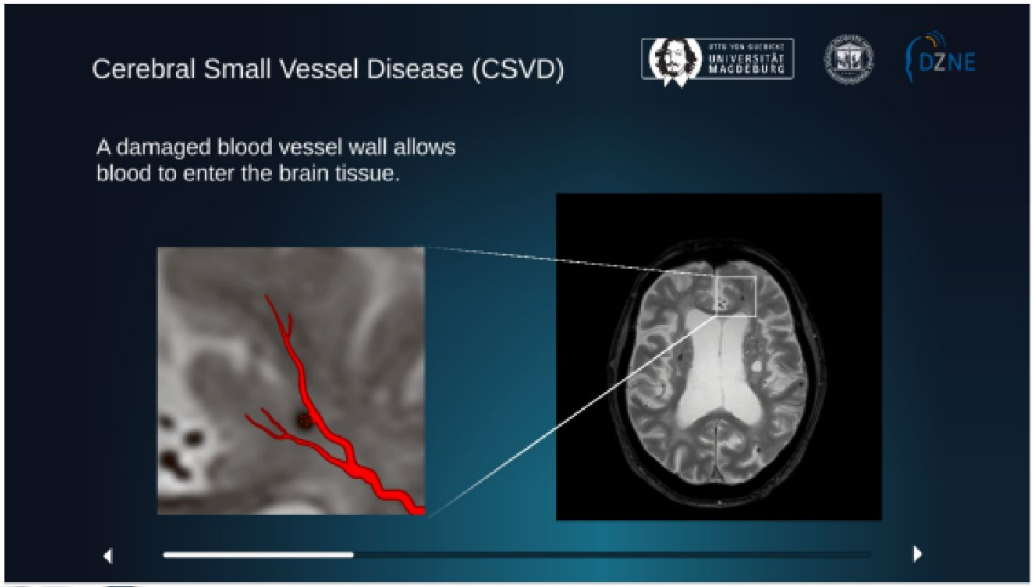
Inform about a rather unknown, but frequent neurologic disease, activate people to control their blood pressure, recruit participants for research

Personalization:

Medical collaborateur, ficitious patient

Case Study: Inform about Small Vessel Disease



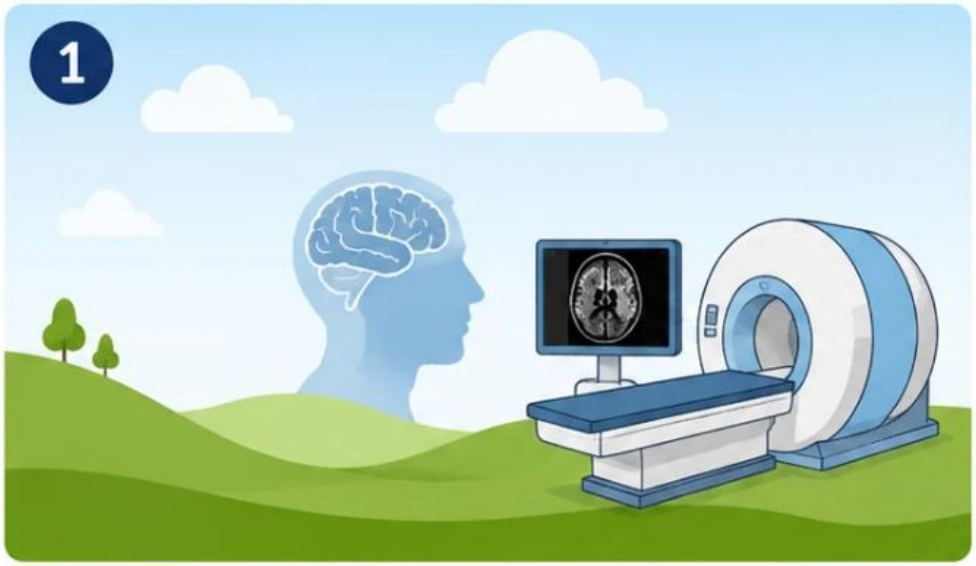


Selected slides (cont'd.):

- Pictographs of the frequency of symptoms
- Vessel drawings

(Courtesy of Sarah Mittenentzwei)

Case Study: Inform about Small Vessel Disease

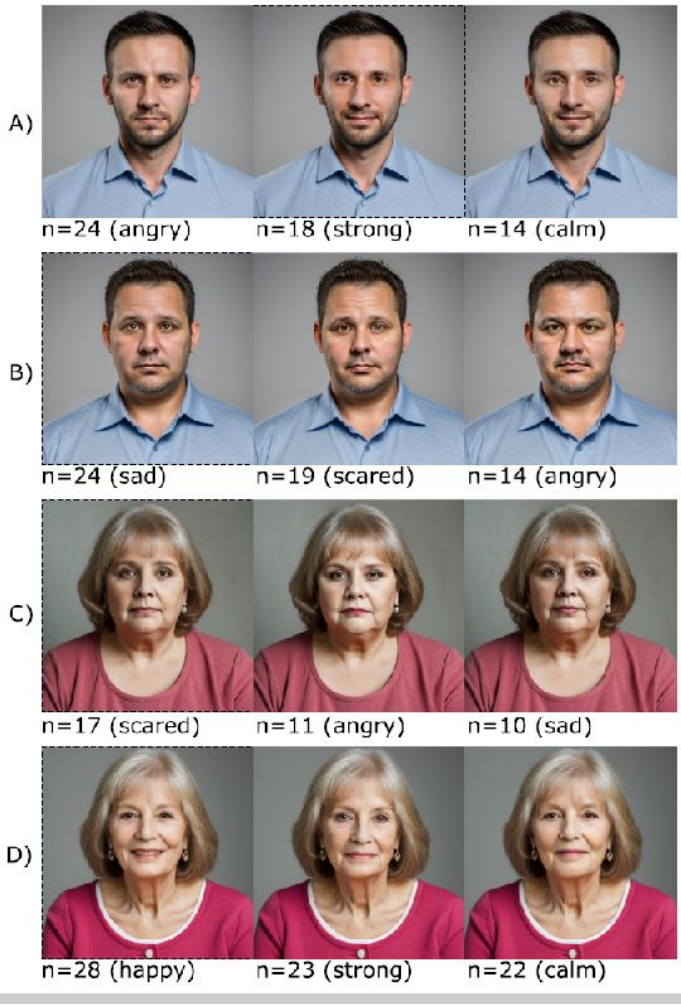


Selected slides (cont'd.):

- **Optional explanation of MRI**
- **Key message: Check and control your blood pressure**

(Courtesy of Sarah Mittenentzwei)

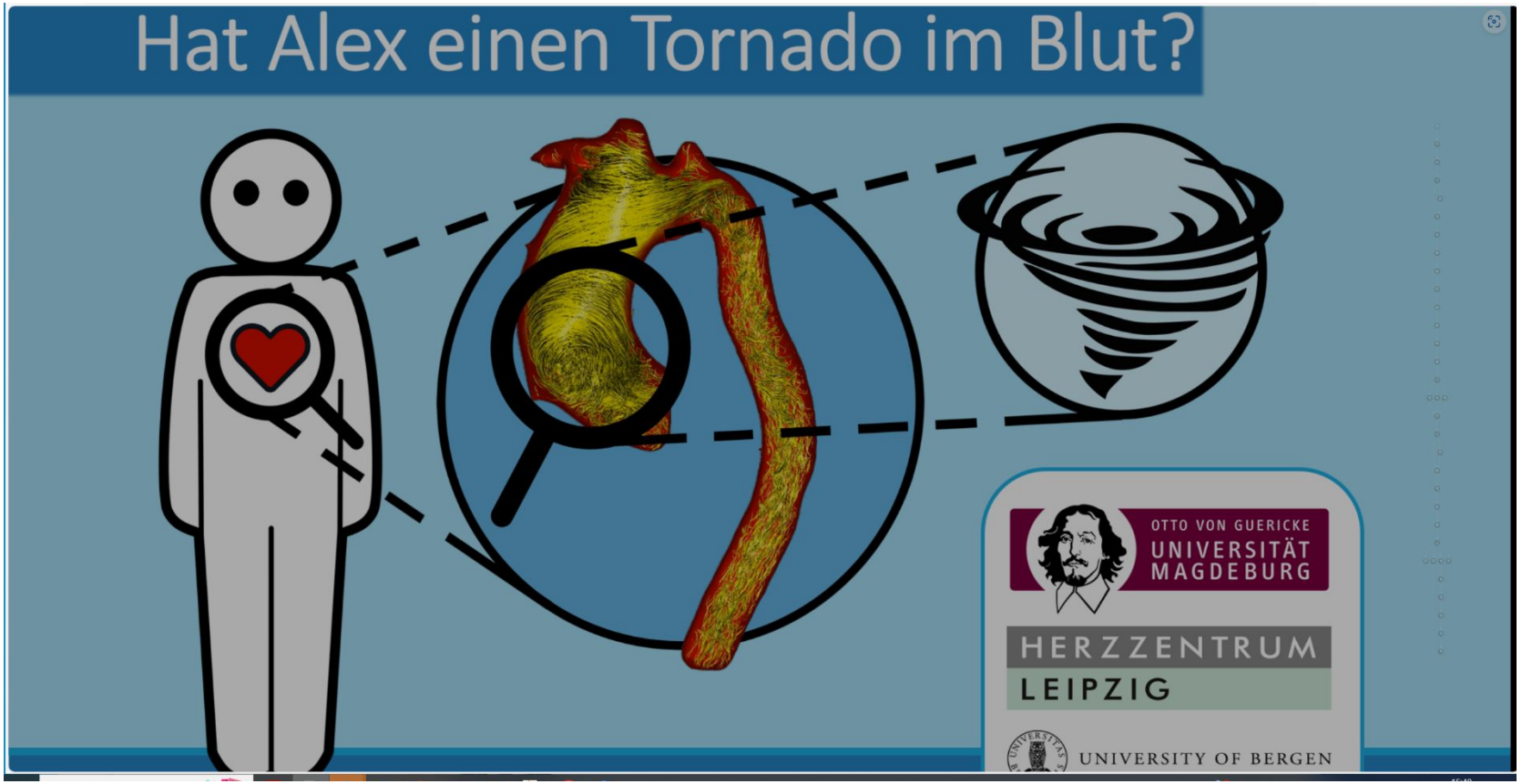
(Patient) Character Generation



1. Generation of male and female characters with Leonardo AI, midjourney and stable diffusion.
2. Adapt characters to reflect lifestyle changes and ageing
3. Ethical questions, e.g., avoiding stigmatization and stereotypes
4. Increases relatibility to medical stories (Mittenentzwei, 2025)

Examples

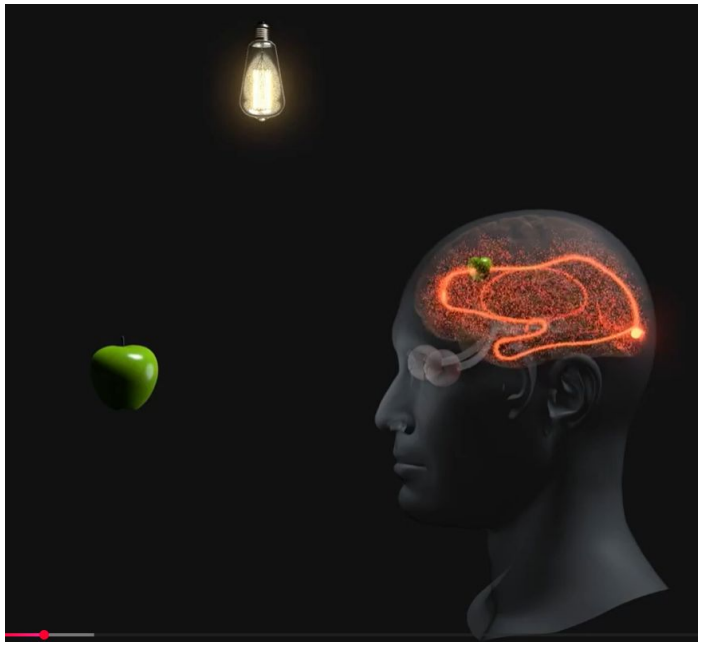
- Link: visualstories.cs.ovgu.de

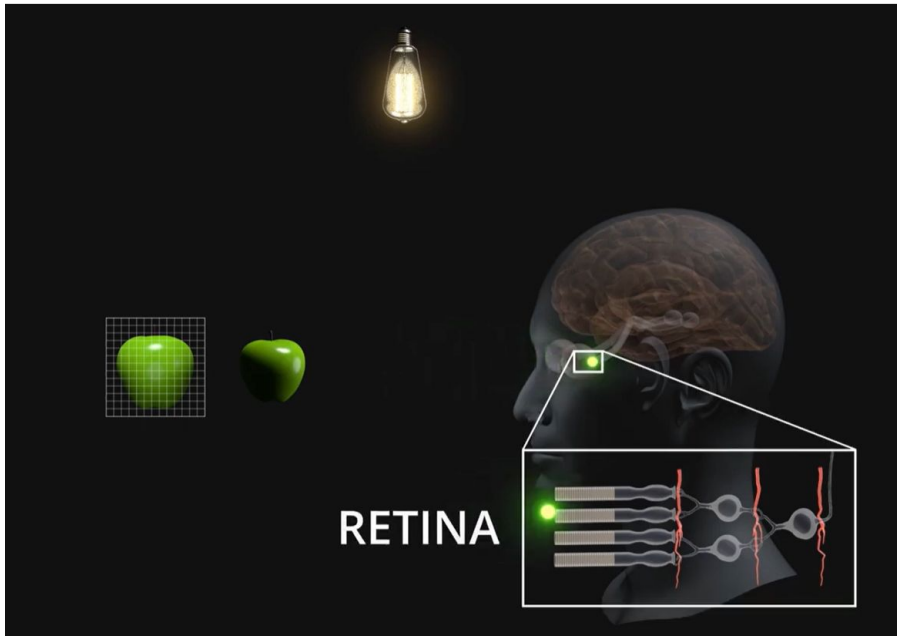


Examples: Explanation of Vision Restauration

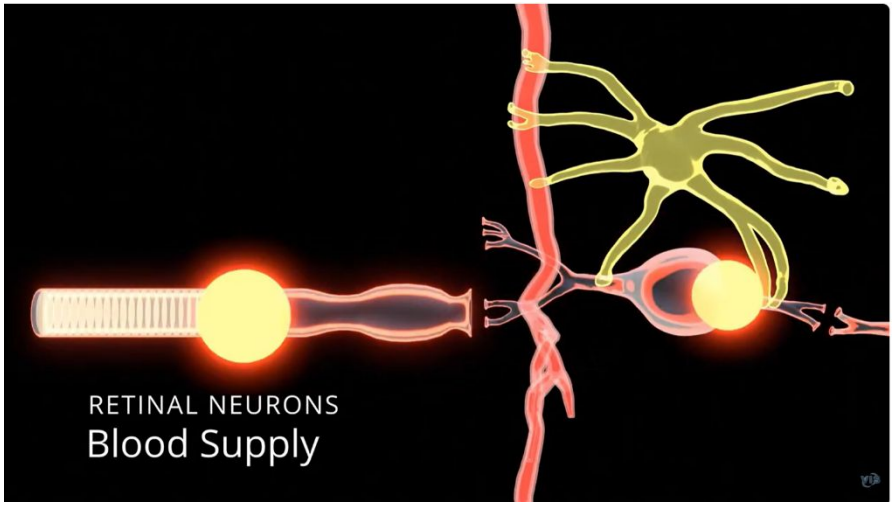
Joint work with Prof. Dr. Sabel, an expert in vision restauration

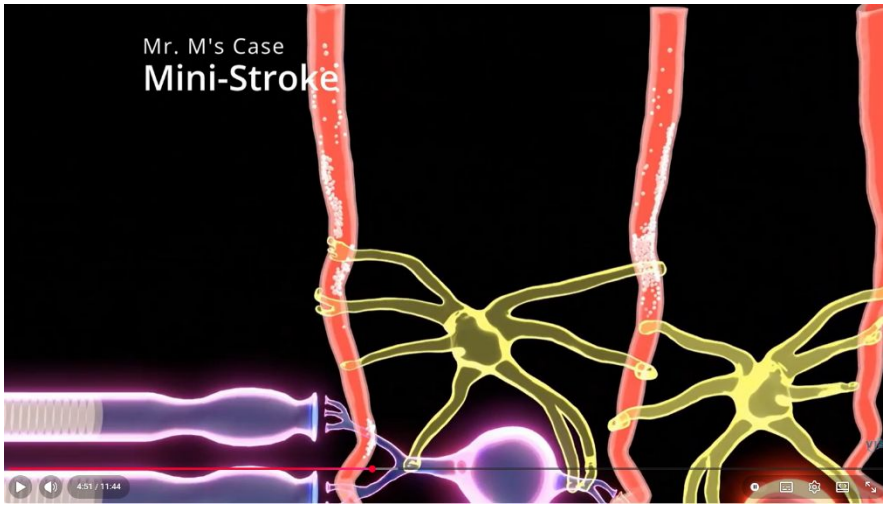
Goals: Explain normal vision, role of nutrition and blood flow on vision restauration and make his clinic visible





Examples: Explanation of Vision Restauration





Increasingly complex visualization. Pathology involved.

(Budich et al., Proc. of VCBM 2025, YouTube, starting at about 2:00 min.)

Re-Usable Components

1. Basic Structure (Template)
for communicating disease, novel treatment
(Meuschke, 2022)

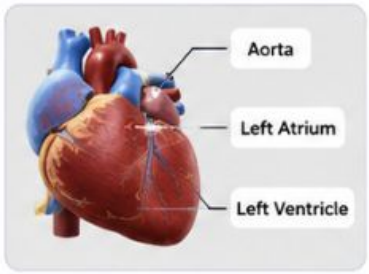
2. Patient Hero's Journey
(Mittenentzwei, 2023)

3. Pictograph of Women & Men
to convey frequency of risk factors, incidence, prognosis, ...

4. Software Components

4.1 Simple interaction with 3D medical data
e.g., restricted rotation

4.2 Labeling 3D visualizations



4.3 Creating figure captions (natural language generation)

> The 3D model shows the anatomy of the human heart, highlighting the left atrium, left ventricle, and aorta.

4.4 Creating animations
e.g., starting with an overview, "fly" close to a pathology, fade out other structures, highlight pathology (size etc.).

Conclusion

Narrative Medical Visualization

Purpose

Aims at increasing health literacy

Target Audience

Without deep domain knowledge and little familiarity with visualization techniques

Multidisciplinary Benefits

Benefits from integrating physicians (or other health care providers), patients, (medical) illustrators, interaction designers

Essential for Organizations

Considered essential by organizations, such as WHO

Conclusion

Research: Focus on Re-Usable Components

Focus on re-usable components to accelerate and standardize narrative medical visualization.

Templates

Basic structures for communicating disease and treatments

Pictographs

Pictograph of women & men to convey risk factors, incidence, prognosis, etc.

Character Generation

Patient hero's journey and other character generation

Personalization Strategies

Tailoring content for diverse audiences to improve engagement and relevance

Simple 3D Interaction

Simple interaction with 3D medical data (e.g., restricted rotation)

Future Work

- Better evaluation of engagement: So far, evaluation based on **self-reported data** acquired **after** the experience.
- **Measured data** (Electrodermal activity and eye tracking) acquired **during** the experience more objective -> integrate these measures with self-reported data (Budich et al., 2026)[1]
- **Initial tendency**: Stories may benefit from using a relatable character in the initial stage and then discuss on a population-level
- Focus on **families of diseases** and **families of treatments**, e.g., cancer diseases, vascular diseases, neurodegenerative diseases and immunotheraphies
- Patient education

[1] Budich et al., „Emotional Engagement in Narrative Medical Visualization: An Electrodermal Activity and Eye-Tracking Study“, conditionally accepted for Vis 2026

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Beatrice Budich

Open for Discussion

Contact: bernhard.preim@ovgu.de

Up to July 9: In the former office of Werner Purgathofer (desk from Johanna Schmidt)

If you are interested in the slides, please write an email

References

Christian Amesender and Siliva Ettl-Huber: "Die Wirkung von Storytelling in der Wissenschafts-PR", In: Handbuch Sprache in den Public Relations, Springer 2018

Avraamidou, Lucy, and Jonathan Osborne. "The role of narrative in communicating science." *International Journal of Science Education* 31.12 (2009): 1683-1707.

Bach, Benjamin, Moritz Stefaner, Jeremy Boy, … and Barbara Tversky. "Narrative design patterns for data-driven storytelling." In *Data-driven storytelling*, pp. 107-133. AK Peters/CRC Press, 2018

Bock, A., Axelsson, E., Emmart, C., Kuznetsova, M., Hansen, C., & Ynnerman, A. (2018). Openspace: Changing the narrative of public dissemination in astronomical visualization from what to how. *IEEE computer graphics and applications*, 38(3), 44-57.

Böttinger, M. (2020). Reaching Broad Audiences from a Research Institute Setting. In *Foundations of Data Visualization* (pp. 307-318). Springer, Cham.

Budich, B., Preim, B., Sabel, B. A., & Meuschke, M. (2025). Narrative medical visualization to communicate vision restoration to patients: a case study, *Proc. of EG Workshop on Visual Computing in Biology and Medicine*

Brand, Anna, Linde Gao, Alexandra Hamann et al. "Medical graphic narratives to improve patient comprehension and periprocedural anxiety before coronary angiography and percutaneous coronary intervention: a randomized trial." *Annals of Internal Medicine* 170, no. 8 (2019): 579-581

Clough, Michael P. "The story behind the science: Bringing science and scientists to life in post-secondary science education." *Science & Education* 20 (2011): 701-717.

Dahlstrom, Michael F. "Using narratives and storytelling to communicate science with nonexpert audiences." Proc. of the national academy of sciences 111.supplement_4 (2014): 13614-13620.

Davies, S. R., Halpern, M., Horst, M., Kirby, D., Lewenstein, B. “Science Stories as culture: experience, identity, **narrative** and emotion in public communication of science”, ***Journal of Science Communication***, Vol. 18(5), 2019

Höst, G., Palmerius, K., & Schönborn, K. (2020). Nano for the public: An exploranation perspective. *IEEE computer graphics and applications,* 40(2), 32-42.

References II

Kleinau, A., Stupak, E. Mörth, E., Garrison, L. A., Mittenentzwei, S., Smit, N. N. Lawonn, K., Bruckner, S. Gutberlet, M., Preim, B., Meuschke, M. Is there a Tornado in Alex's Blood Flow? A Case Study for Narrative Medical Visualization, *Proc. of VCBM,* 2022

B. Lee, N. Henry Riche, P. Isenberg, and S. Carpendale. More than telling a story: Transforming data into visually shared stories. *IEEE Computer Graphics and Applications*, 35(5):84–90, 2015

Lugmayr, A., Sutinen, E., Suhonen, J., Sedano, C. I., Hlavacs, H., & Montero, C. S. (2017). **Serious storytelling–**a first definition and review. *Multimedia tools and applications*, *76*, 15707-15733.

Ma, K. L., Liao, I., Frazier, J., Hauser, H., & Kostis, H. N. (2011). Scientific storytelling using visualization. *IEEE Computer Graphics and Applications*, Vol. 32(1), 12-19

Meuschke, M., L. Garrison, N. Smit, B. Bach, S. Mittenentzwei, V. Weiß, S. Bruckner, K. Lawonn, B. Preim. "Narrative medical visualization to communicate disease data", *Computers & Graphics* (2022).

Mittenentzwei, S., Weiß, V., Schreiber, S., Garrison, L. A., Bruckner, S., Pfister, M., Preim, B. & Meuschke, M. (2023). Do disease stories need a hero? Effects of human protagonists on a narrative visualization about cerebral small vessel disease. Computer Graphics Forum (Vol. 42, No. 3, pp. 123-135).

S. Mittenentzwei, L. A. Garrison, B. Budich, K. Lawonn, A. Dockhorn, B. Preim and M. Meuschke. "AI-based character generation for disease stories: a case study using epidemiological data to highlight preventable risk factors", i-Com, January 2025

Morais, C., & Araújo, J. L. (2019). "Awakening to chemistry through storytelling and practical activities: middle school students interacting with pre-school children", *Chemistry Education Research and Practice*, 20(1), 302-315.

Popper, Karl. (1972). *Objective Knowledge: An Evolutionary Approach*, Oxford: Clarendon Press.

Postman, N. (1995). *The end of education: Redefining the value of school*. New York: Vintage

Ren, Donghao, Matthew Brehmer, Bongshin Lee, Tobias Höllerer, and Eun Kyoung Choe. "Chartaccent: Annotation for data-driven storytelling", *Proc. of IEEE Pacific Visualization Symposium*, pp. 230-239, 2017.

References

Soares, S., Gonçalves, M., Jerónimo, R., & Kolinsky, R. (2023). Narrating science: Can it benefit science learning, and how? A theoretical review. *Journal of Research in Science Teaching*.

Segel, Edward, and Jeffrey Heer. "Narrative visualization: Telling stories with data“, *IEEE Transactions on Visualization and Computer Graphics*, Vol. 16(6) (2010): 1139-1148

Solomon, Joan. "Science stories and science texts: What can they do for our students?“, *Studies in Science Education* 37 (2002): 85-106

Stolper, C. D., Lee, B., Riche, N. H., & Stasko, J. (2016). Emerging and recurring data-driven storytelling techniques: Analysis of a curated collection *Cosmopolis: The hidden agenda of modernity*of recent stories.