Tuesday, July 25, 2023


*Ph.D. thesis defense*

# Tool Support for Knowledge Foraging, Structuring, & Transfer During Online Sensemaking

**Michael Xieyang Liu**
@lxieyang(@hci.social) / xieyangl@cs.cmu.edu
CMU HCII

Committee
Brad A. Myers
Aniket Kittur
Kenneth Holstein
Daniel M. Russell

# Sensemaking happens everyday…


Choosing a code library


Planning a vacation


Buying a stroller

Deciding treatment options

# Infinite amount of information available...

## Vue.js Is Good, But Is It Better Than Angular Or React?

by Mantra Malhotra / May 19, 2021 / 16 Comments / 106302 Views

A few years
mainly arguing
**React** for thei
in a third playe

*According*
*stars of Vue*

SIMFORM

Menu

Simform → Blog → Web App Development →

## Best Frontend Frameworks of 2021 for Web Development

*If you are looki*
*frameworks in*

Hiren Dhadu
January 5, 2

*Quick Summary*
*the software de*
*choose when it*
*high on user ex*
*the best fronten*

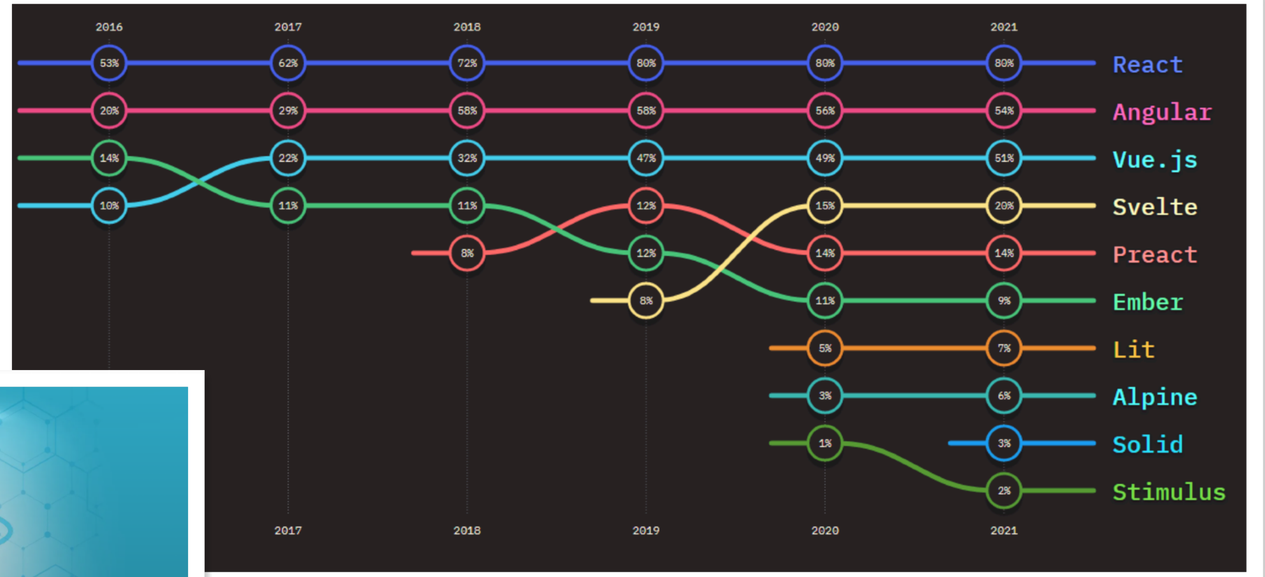
User experience
market today. As
talks about the s
feature. No matt
the background
That is the princ
on- Netflix, Face


Reading Time: 8 minutes

Which JavaScript Framework/Library to choose for your business web app in 2021? In this React vs Angular vs Vue comparison, we will talk about the pros and cons of each and much more.

JavaScript, hands down, is the best language to choose for frontend development, and rightfully so! It provides a plethora of functionalities that let you create the UI of your web app exactly how you want.

Like everything, the world of JavaScript has evolved to make it easier to quickly create intuitive user interfaces. You can now choose from a long list of JS frameworks and UI Libraries for your business web app in 2021.



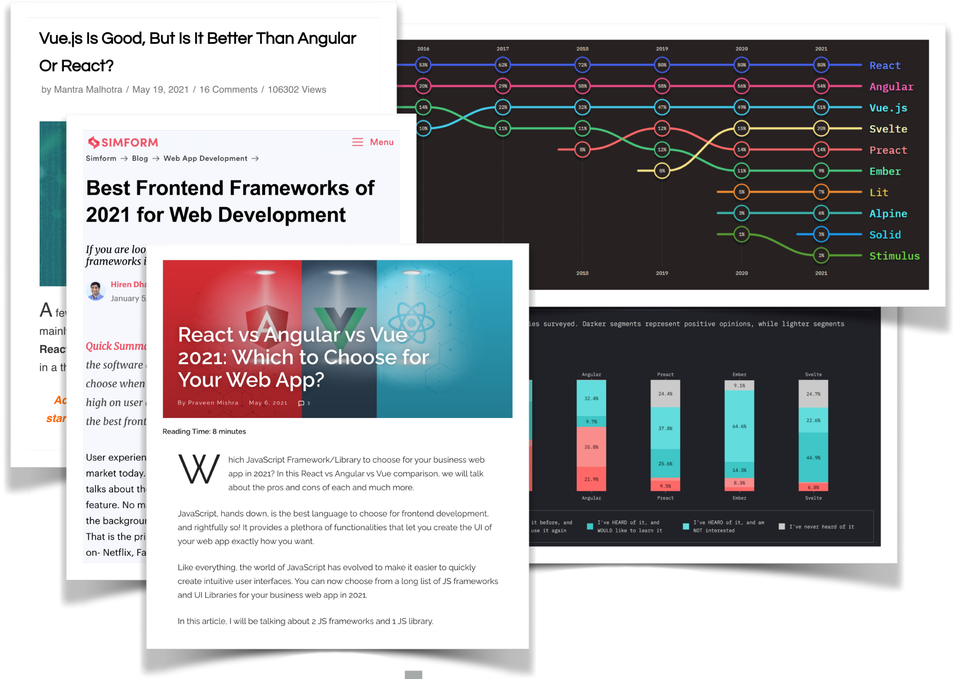

# Infinite amount of information available...

Our working memory too limited for the scattered evidence & tradeoffs.

Our working memory too limited for the scattered evidence & tradeoffs.

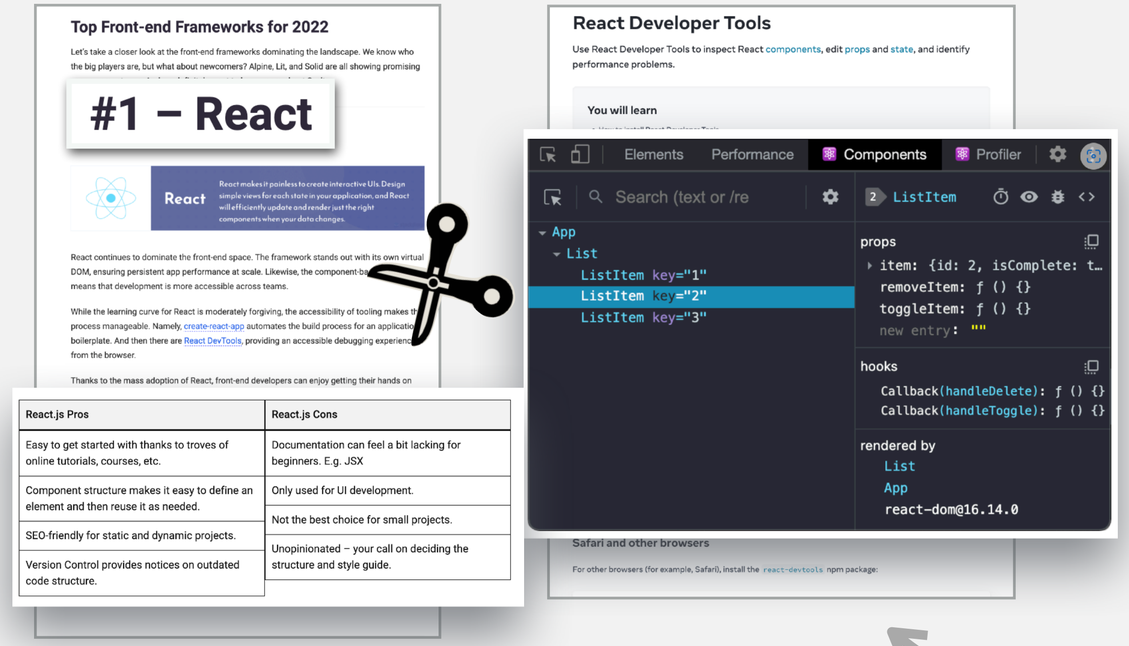
Need to **externalize our mental models** during sensemaking…

into e.g., a structured table that **organizes** all the evidence!




| | Fast? | Community | Documentation | Supported by |
|---|---|---|---|---|
| **React** | Yes | Really large | https://reactjs.org | Facebook |
| **Angular** | ? | Also large | Not easy to understand<br>https://angularjs.org/docs | Google |
| **Vue** | Yes | ? | Very detailed & intuitive<br>https://vuejs.org/v2/guide | Alibaba |

*Actual table from formative study!*



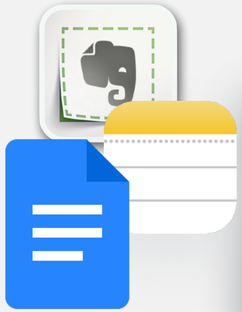


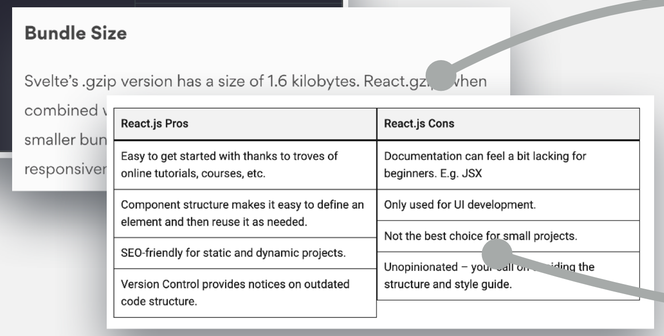






# Organizing is hard!

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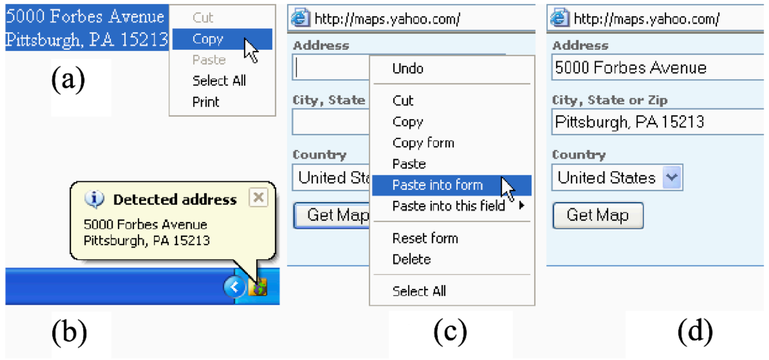
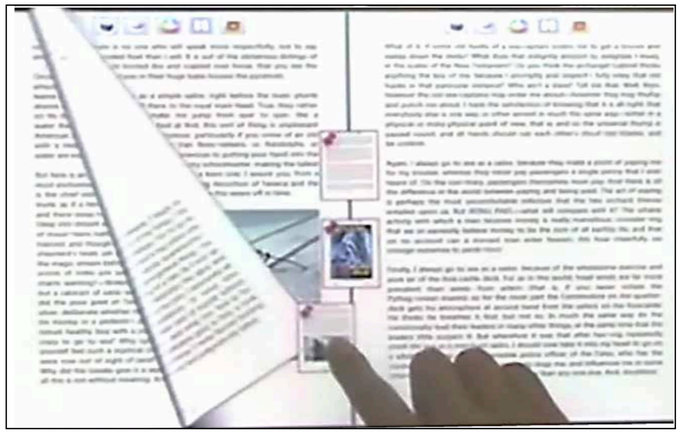
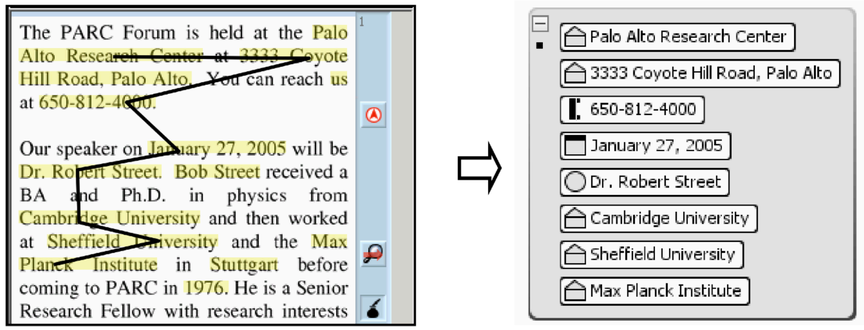
# Prior research – saving information



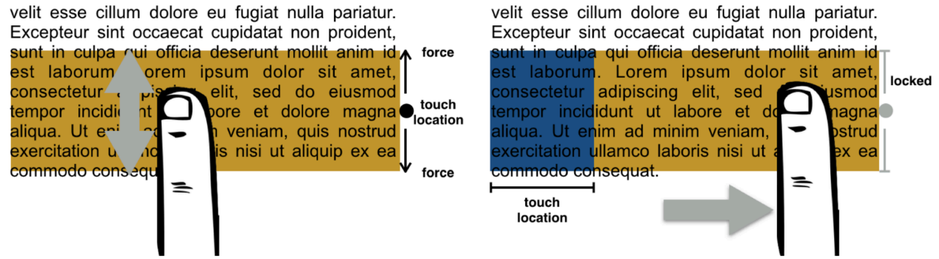

*Citrine: providing intelligent copy-and-paste*
Stylos et al. (UIST 2004)



*GatherReader: gathering information while active reading*
Hinckley et al. (CHI 2012)




*Entity quick click: rapid text copying based on automatic entity extraction*
Bier et al. (CHI 2006)

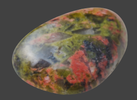



*Supporting Mobile Sensemaking Through Intentionally Uncertain Highlighting*
Changes al. (UIST 2016)

# Externalizing is challenging…

*Too much cost & interruptions*

*Lack tool support*



Unakite (UIST 2019)

*Honorable Mention (top-6)*

Crystalline (CHI 2022)

Wigglite (UIST 2022)

Minimize cognitive & physical cost,

through **lightweight interactions**


| | Intuitiveness | Popularity | Used by |
|---|---|---|---|
| React | 👍 | 👍 | Facebook |
| Angular | 👍 | 👍 | Google |
| Vue | 👍 | 👎 | Alibaba |
| EmberJS | 👍 👎 | 👎 | Heroku |

# Externalizing is challenging…

*Too much cost & interruptions*

*Lack tool support*

I build and study **human-centered interactive tools** that facilitate & accelerate sensemaking.

Minimize cognitive & physical cost, through **lightweight interactions**


| | Intuitiveness | Popularity | Used by |
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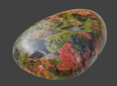

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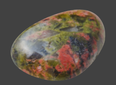
Externalizing



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*Honorable Mention (top-6)*

Crystalline (CHI 2022)

Wigglite (UIST 2022)

Minimize cognitive & physical cost,
through **lightweight interactions**

Reading

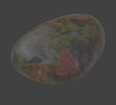


Selenite (2023)

*Lack global perspective of key points*

*Difficulty in selective reading*

Externalizing



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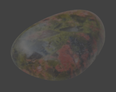
Wigglite (UIST 2022)

Reading



Selenite (2023)

Externalizing



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Assist reading & comprehension,
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Minimize cognitive & physical cost,
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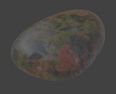
Reading

Externalizing

Reusing

Selenite (2023)



Unakite (UIST 2019)

*Honorable Mention (top-6)*

Crystalline (CHI 2022)

Wigglite (UIST 2022)

Strata (CSCW 2021)

*Best paper (top 1%)*

Assist reading & comprehension,
via **AI-retrieved global perspectives**

Minimize cognitive & physical cost,
through **lightweight interactions**

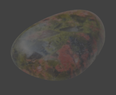
*Lost access to original decision context*
*Unable to judge trustworthiness*

Reading

Externalizing

Reusing

Selenite (2023)



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Guide knowledge reuse evaluations,
with **systematic framework + tools**

Reading

Externalizing

Reusing

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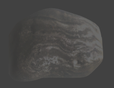
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*Michael Xieyang Liu, Jane Hsieh, Nathan Hahn, Angelina Zhou, Emily Deng, Shaun Burley, Cynthia Taylor, Aniket Kittur, Brad A. Myers*

*UIST 2019*

***U**sers **n**eed **a**ccelerators for **k**nowledge for **i**mplementations in **t**echnology **e**nvironments*

# Trade-offs


REQUIRE·JS
npm
TS
REQUIRE·JS
D3
BABEL
JS
REQUIRE·JS
REQUIRE·JS
npm
TS
D3

# Unakite

A chrome extension that helps developer **collect** and **organize** information while searching and browsing

# **Design Goals** (based on formative studies + prior work)

**[D1] Scaffolding**: *helping developers form systematic models when approaching decision making problems with tradeoffs.*

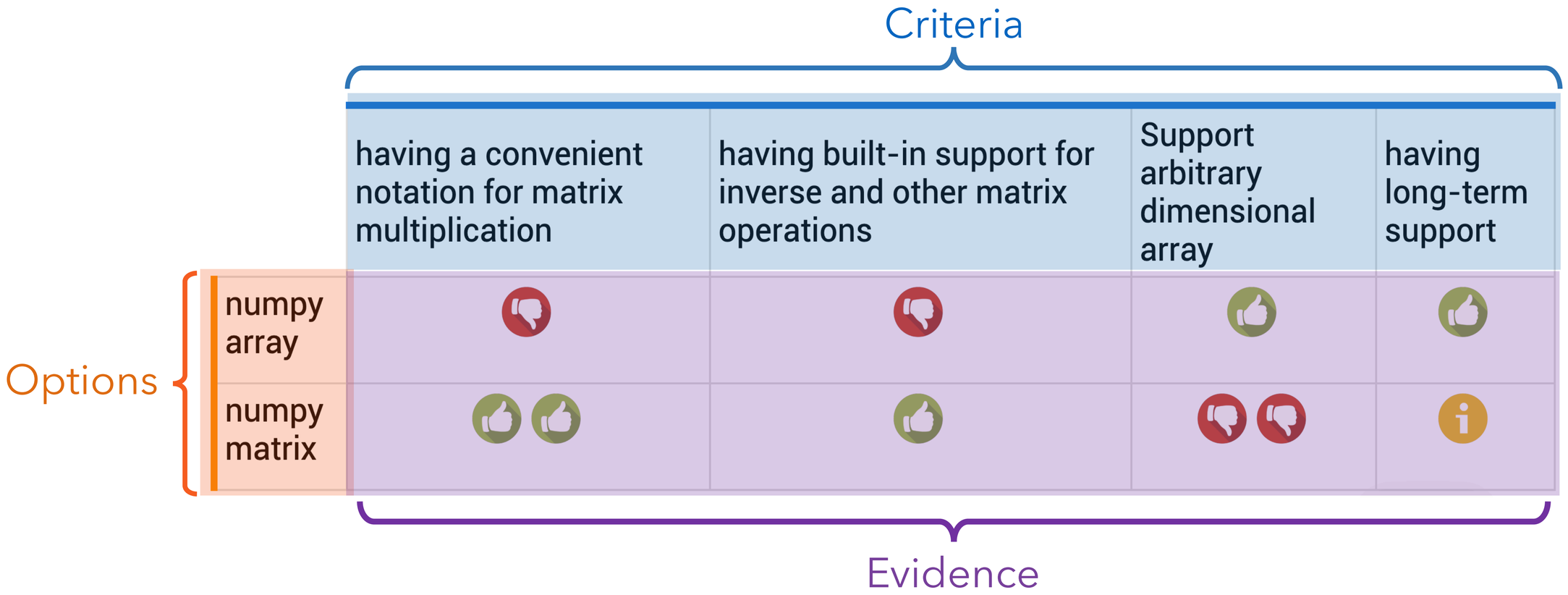
**[D2] Lightweight interactions**: *reducing the cost of collecting and organizing content so that the entry barriers to use the tool are low.*

**[D3] Summarization**: *helping developers synthesize and summarize different pieces of content together and manage them.*

**[D4] Contextualization**: *enabling developers to recreate the context from which information snippets were collected and copied.*

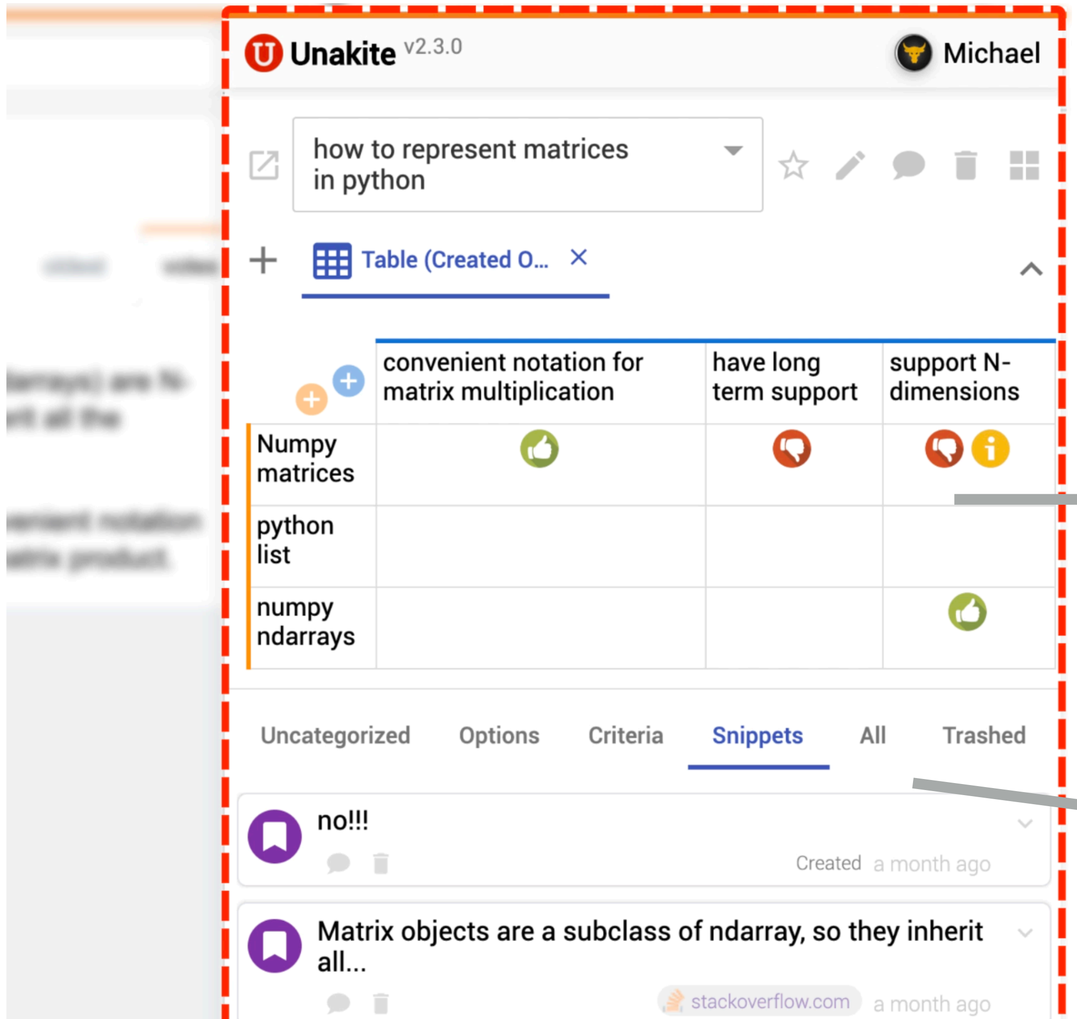
# [D1] Scaffolding: Option-Criterion-Evidence framework

*Helping developers form **systematic models** when approaching decision making problems with **tradeoffs**.*



# [D2] Lightweight interactions

*Reducing the cost of collecting and organizing content so that* ***the entry barriers to use the tool are low***

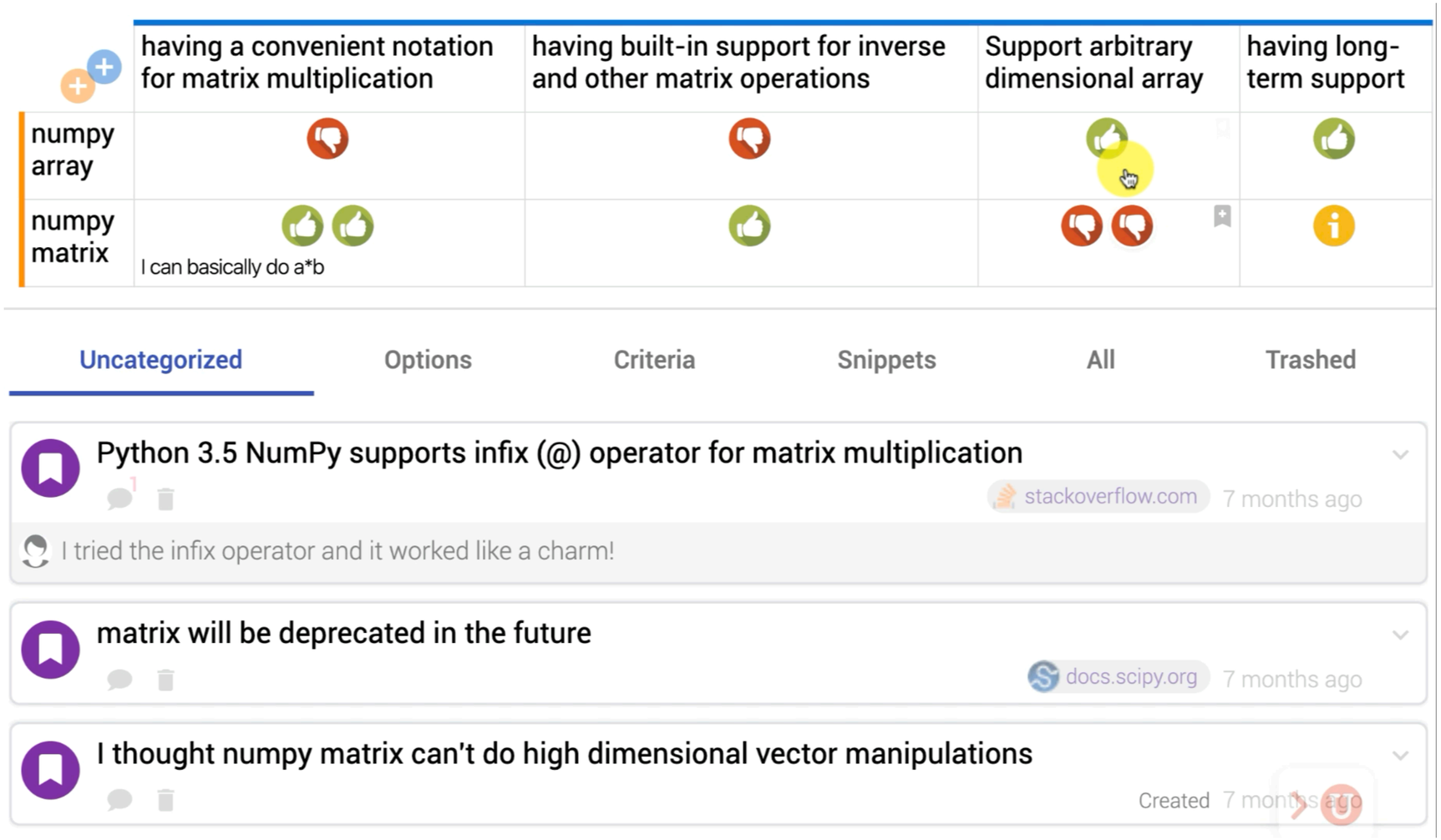



Comparison table

Snippet repository

# [D3] Summarization

Helping developers **synthesize** and **summarize** different pieces of content together and manage them.




**Comparison table**:
*high-level summary of the decision-making space*

**Ratings**:
*Summary of developer utilization of collected evidence*

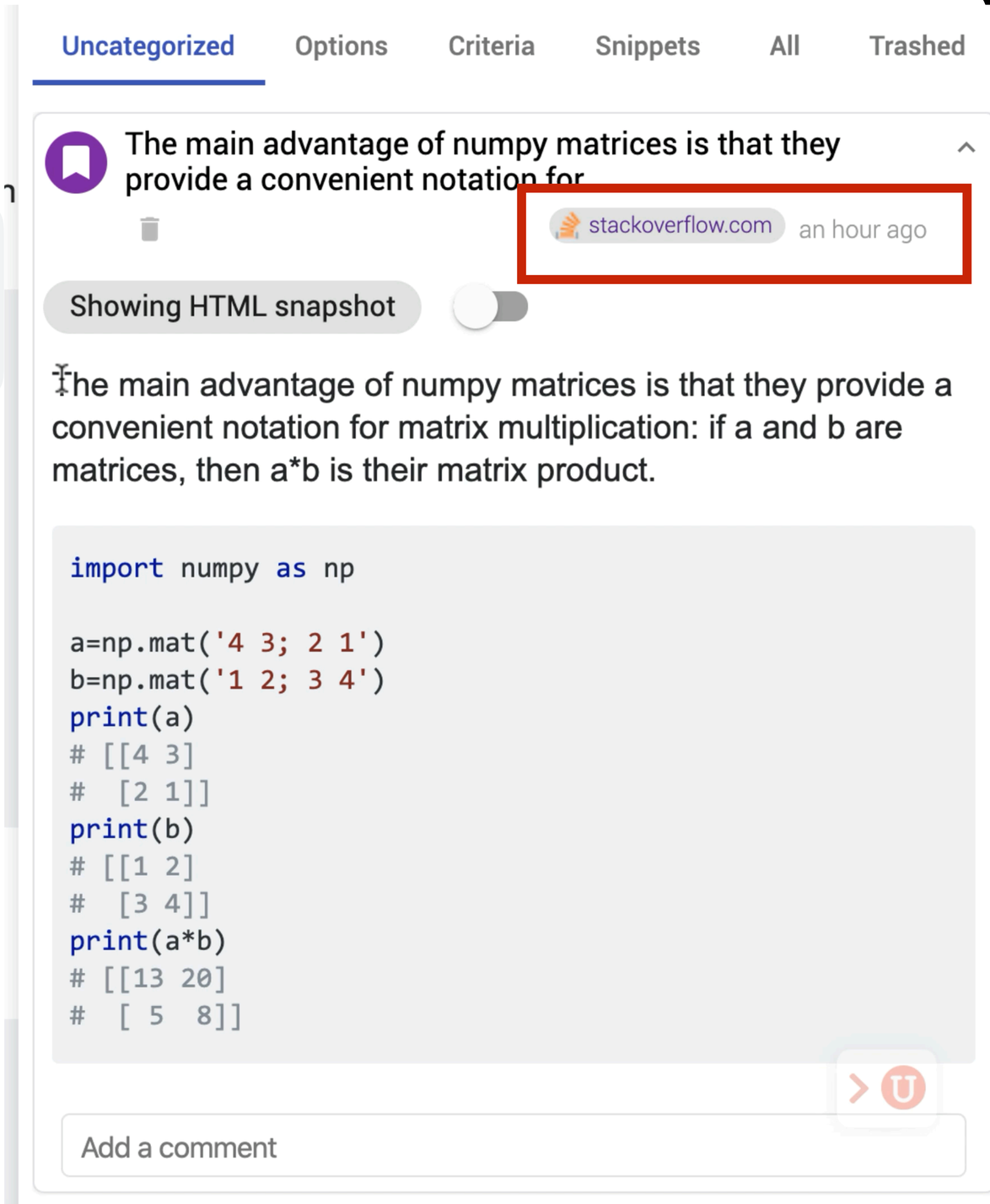
**Concrete evidence**:
*Detailed text snippet of corresponding evidence*

# [D4] Contextualization

*enabling developers to **recreate the context** from which information snippets were collected and copied.*

**Ease-of-recognize:** Snippets use original HTML with styling.

**Ease-of-back-tracking:**They involve metadata (e.g., information source & track time)



# Study 1: **Unakite for authoring**

**Task**: Collect information from Stack Overflow pages and organize them into comparison tables.

**Condition & measurement**: **Overhead cost** – % of the time spent on directly using tool features

Unakite: selecting (snapshot), drag & drop, etc.

vs. Google Doc: copy-pasting, formatting, maintaining table, etc

**Between-subject**: 20 participants, each completed 3 tasks in the same condition

(2 pre-defined, 1 self-proposed)

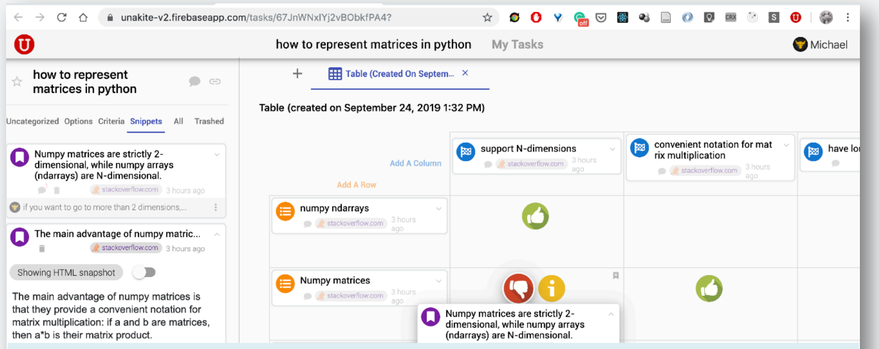
Unakite (**25%**) v.s. Google Doc (44%) ($p < 0.01$)

Unakite reduces the **overhead** of context switch and copy pasting!

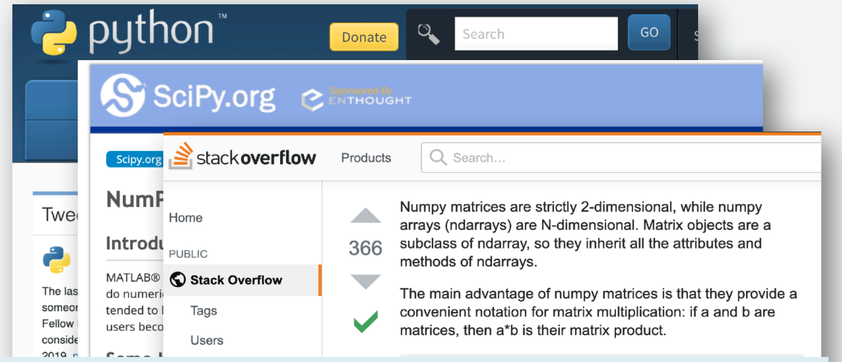
# Study 2: **Unakite for understanding trade-offs**

**Task**: Explain code decisions made by a previous developer.

**Within-subject**: 16 participants, each completed one task in each condition

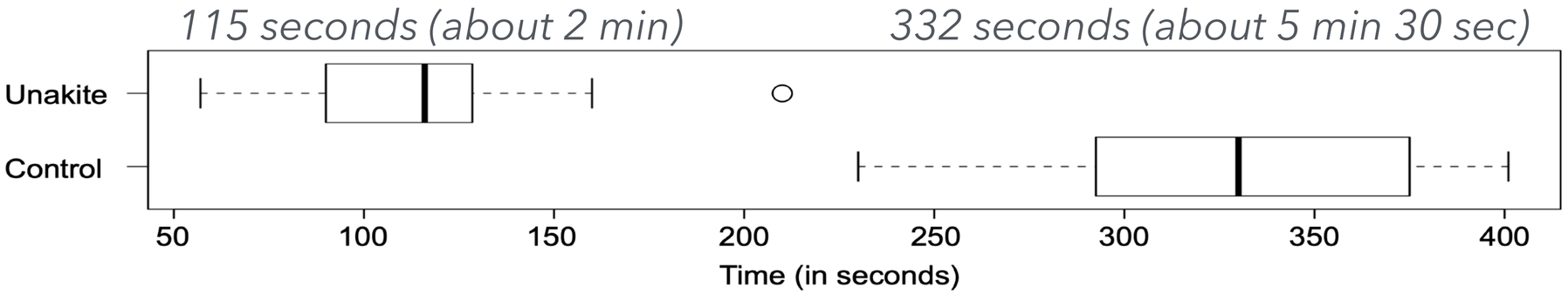



Unakite condition:
explore pre-made comparison table




Control condition:
read *the same* set of web resources

Synthesized table in Unakite speeds up understanding decisions!

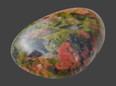



($p < 0.01$)

Reading

Selenite (2023)

Externalizing



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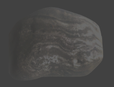

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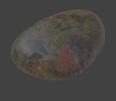
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Can we **automate** everything?

& what do we automate?

# Implicit behaviors while browsing...

Vue, also known as Vue.js, is the youngest member of the group. It was developed by ex-Google employee Evan You in 2014. Over the last several years, Vue has seen a substantial shift in popularity, even though it doesn't have the backing of a large company. The most current version is always announced on the official Vue website on their releases page. Contributors for Vue are supported by Patreon. It should be noted that Vue also has its own GitHub repo, and functions using TypeScript.

Further reading: Vue.js Tutorial for Beginner Developers

React, developed by Facebook, was initially released in 2013. Facebook uses React extensively in their products (Facebook, Instagram, and WhatsApp). Similar to Vue, the React developers also announce their newest version on the blog section of the React website.

Here's a short summary of Angular vs React vs Vue, in terms of their status and history:

The history of Angular vs React vs Vue

| | Angular | React | Vue |
|---|---|---|---|
| Initial release | 2010 | 2013 | 2014 |
| Official site | angular.io | reactjs.org | vuejs.org |
| Current version | 13.x | 17.x | 3.x |

*Huang, Jeff, et al. "Improving searcher models using mouse cursor activity." SIGIR 2012.*

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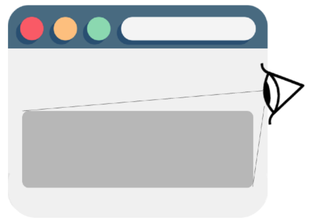
| Current version | 13.x | 17.x | 3.x |
| Used by | Google, Wix | Facebook, Uber | Alibaba, GitLab |



Content dwelling

Our existing behavior signals can already **reflect our attentions**.

*Huang, Jeff, et al. "Improving searcher models using mouse cursor activity." SIGIR 2012.*

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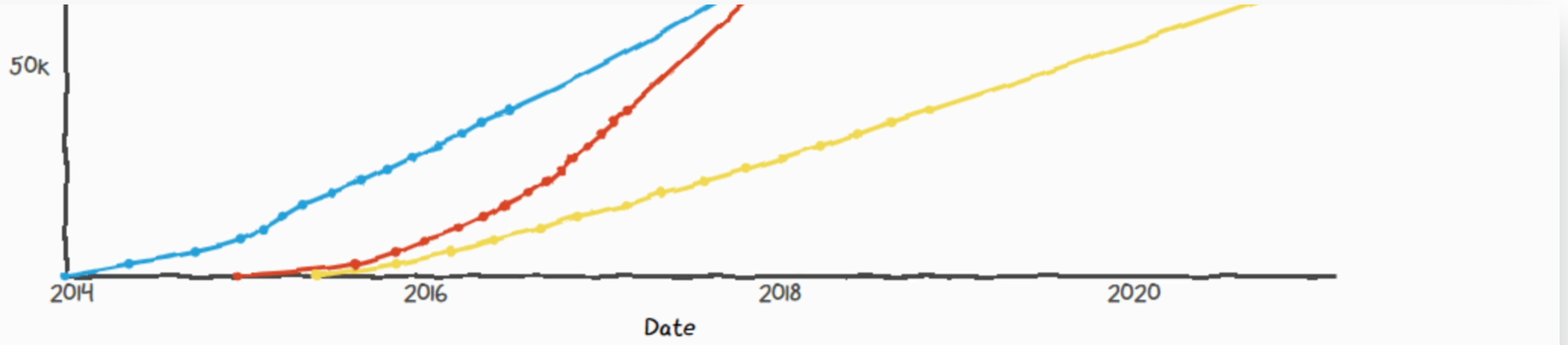


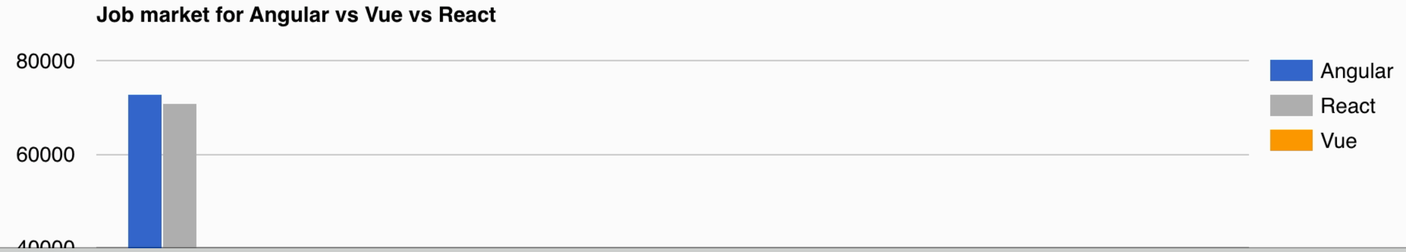

*Number of stars on GitHub projects for Angular, React, and Vue*

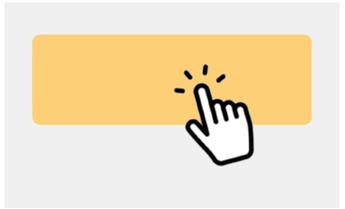
Let us check how the job market is for Angular vs React vs Vue, which is also a good measure of popularity:

...

## Job market for Angular vs React vs Vue 👷

The best sources of data that indicate the trends on the job market are the various job boards.



Clicking

*Yoshinori Hijikata. "Implicit user profling for on demand relevance feedback" IUI 2004*

# Implicit behaviors while browsing...

| | | | |
|---|---|---|---|
| # Stars | 78.4k | 180k | 218k |
| # Forks | 20.6k | 36.5k | 35.7k |
| # Contributors | 1,500+ | 1,500+ | 400+ |

When comparing Vue vs React, Vue has a huge number of watchers, stars, and forks. This shows Vue's popularity among users and its value compared to React. However, the number of contributors for Vue are lower than Angular and React.

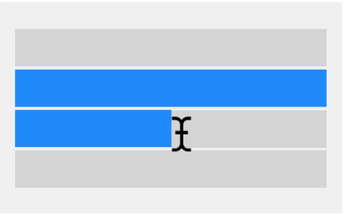
One possible explanation is that **Vue is driven entirely by the open source community, whereas Angular and React have a significant share of Google and Facebook employees contributing to the repositories**.

From the statistics, all three projects show significant development activity, and this is surely going to continue in the future — just these statistics cannot be the basis of not deciding to use either of them.

An additional metric that you'll want to consider is GitHub's "Used By" badge, which needs to be enabled by the repository author. This shows how many other repositories on GitHub are dependent on that repository. Angular's GitHub repo shows 1.7 million, React currently shows almost 5.7 million users, while Vue shows over 167,000 for both of its repos combined. Quite a difference among the three frameworks, but this is largely due to Vue being the newer framework and doesn't tell the full picture on overall demand.

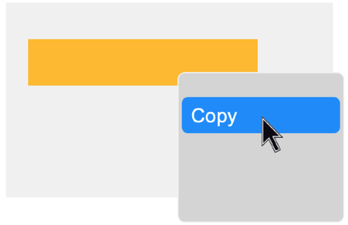
---

## Part 3: Migrations



Text highlighting

*Roy, Nirmal, et al. "Note the highlight: incorporating active reading tools in a search as learning environment." CHIIR 2021.*

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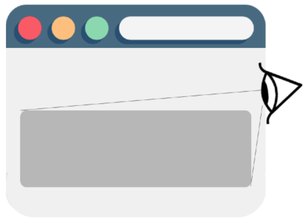

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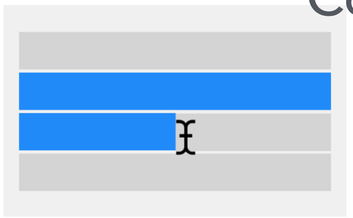

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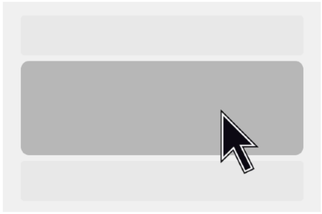
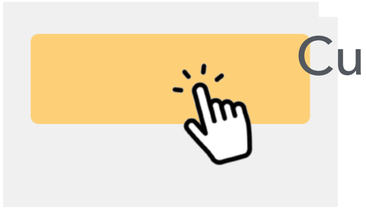


Cursor hovering



Clicking

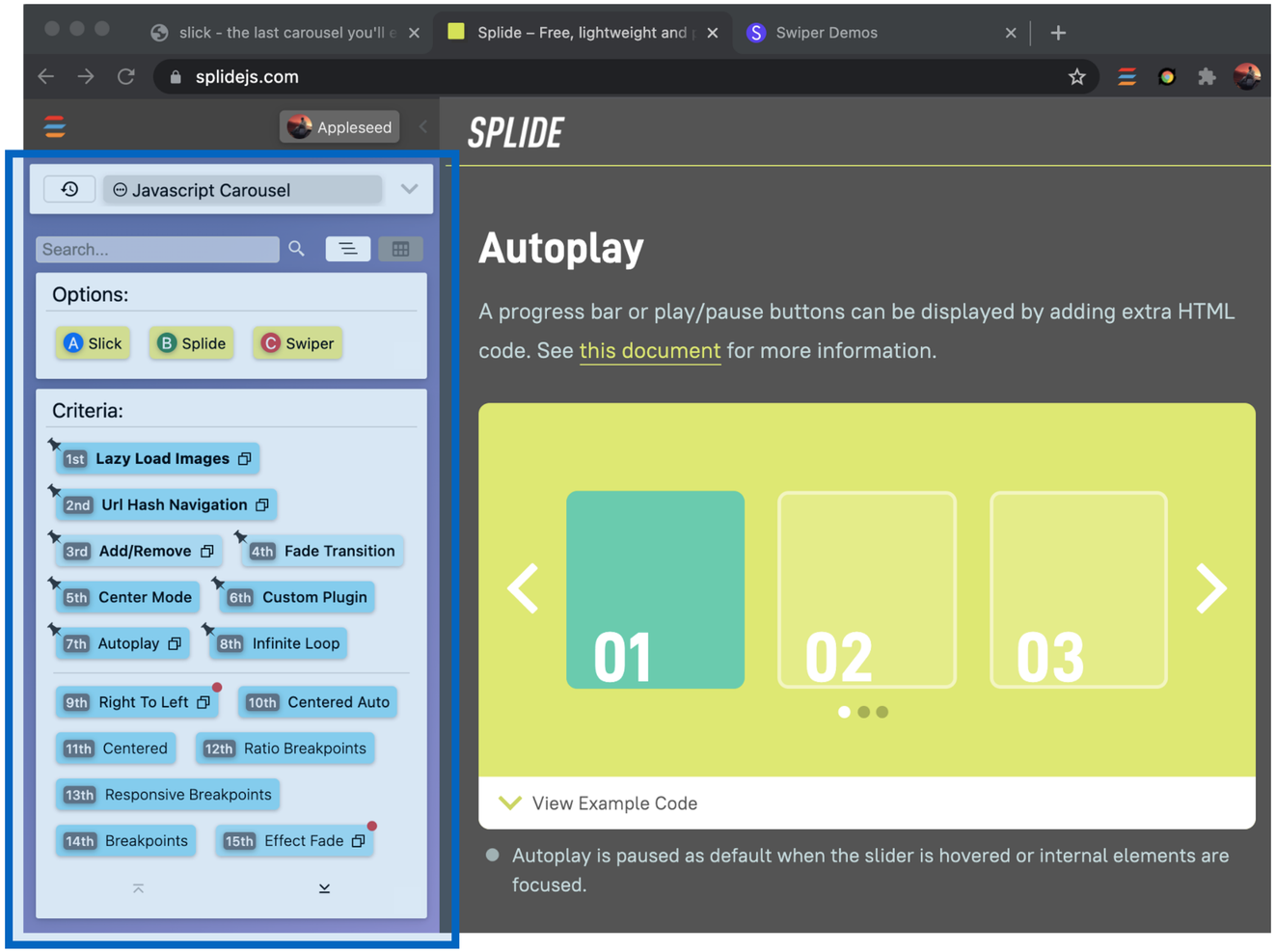
**Spontaneous** interactions contain **signals** relevant to mental model construction.

Crystalline: Lowering the Cost for Developers to Collect and Organize Information for Decision Making

*Michael Xieyang Liu, Aniket Kittur, Brad A. Myers*

*CHI 2022*

***C**lipping **r**esulting in **y**our **s**tructure as **t**ables **a**nd **l**ists **l**inked to **i**mplicit **n**otetaking **e**asily*




As a browser extension sidebar!

**Spontaneous** interactions contain **signals** relevant to mental model construction.

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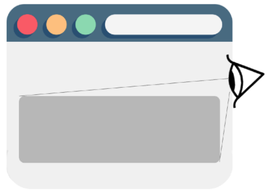
# Automation by tracking implicit behavior signals

**Capture** implicit interaction relevant to mental model building.



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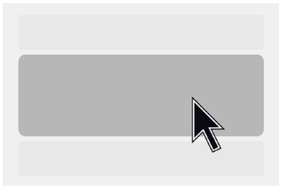

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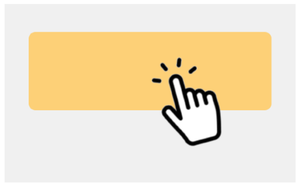

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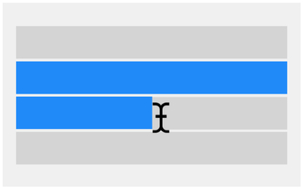

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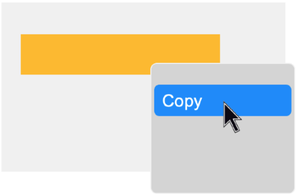
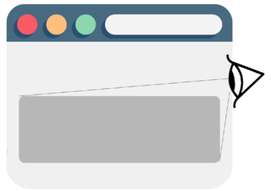



Copy content

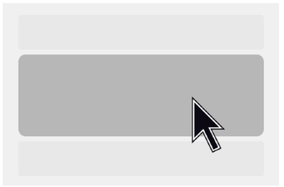
**But not all behavioral signals are equally informative.**

# Automation by tracking implicit behavior signals

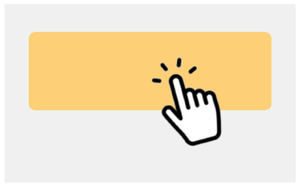
**Capture** implicit interaction that **might be** relevant to mental model building.



Content dwell



Cursor hover



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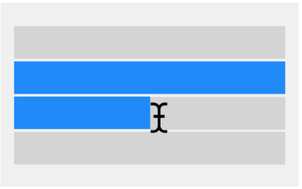

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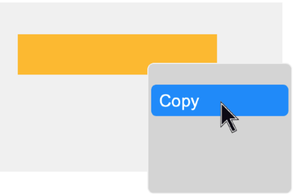


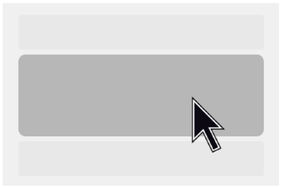

Copy content

**But not all behavioral signals are equally informative.**

# Automation by tracking implicit behavior signals

**Capture** implicit interaction that **might be** relevant to mental model building.

Content dwell



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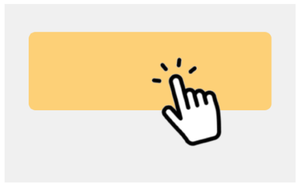

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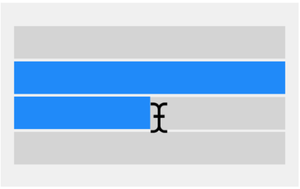

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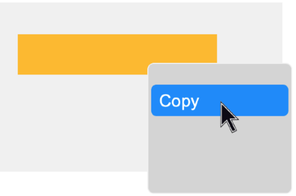



Copy content

**Extract** information that **actually** reflects users' mental model.

Rank by signal strength

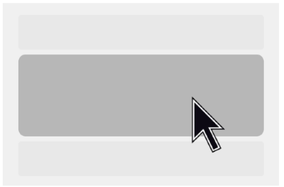
Filter out interaction noises

Filter out noise in context

# Automation by tracking implicit behavior signals

**Capture** implicit interaction that **might be** relevant to mental model building.

Content dwell



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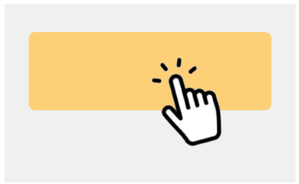

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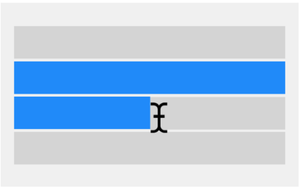
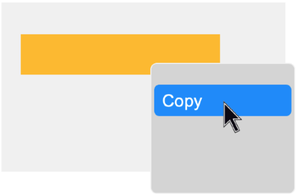


Text highlight




Copy content

**Extract** information that **actually** reflects users' mental model.

Rank by signal strength | Filter out interaction noises | Filter out noise in context

Weakest

Strongest

Javascript Carouse | Javascrip

Search...

Options:

A Swiper | B Slick | C Splide

Criteria:

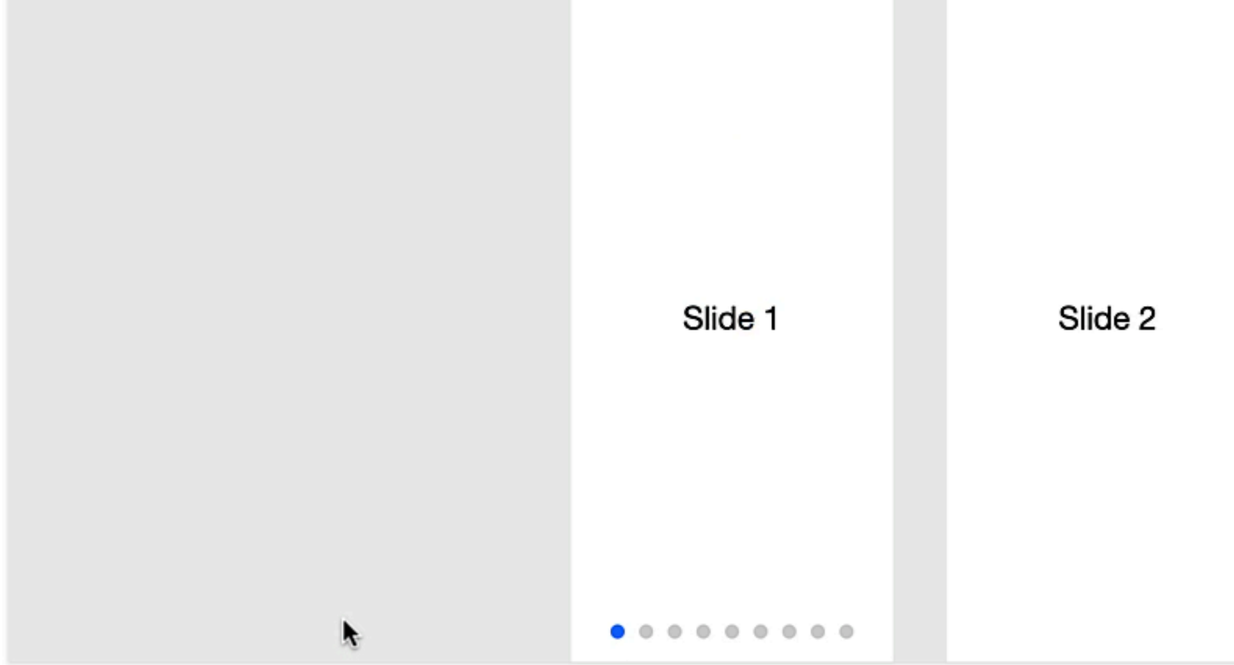
1st Focus Center | 2nd Multiple Slides | 3rd Grab Cursor | 4th Nested | 5th Slides Grid | 6th Custom Pagination | 7th Scroll Container | 8th Centered Auto | 9th Filtering | 10th Freemode | 11th Drag Free | 12th Slides | 13th Virtual Slides | 14th Slides Per View | 15th Watch Slides Visiblity

(1)

History:

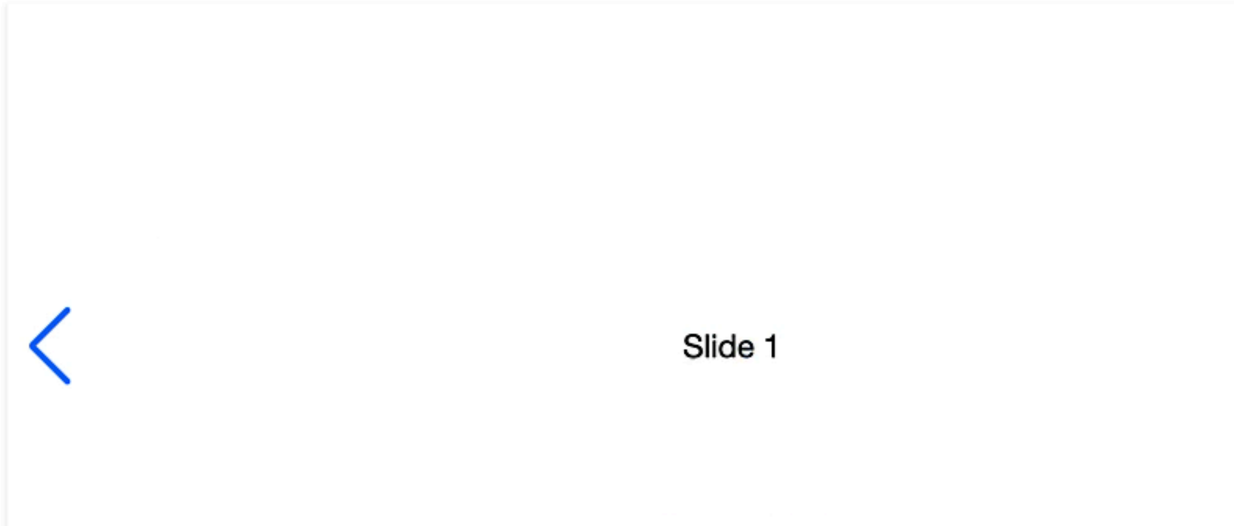
- javascript carousel
- Splide - The lightweight, flexible and accessible slider/carousel
- slick - the last carousel you'll ever need
- Swiper Demos


- Default
- Navigation
- Pagination
- Pagination dynamic
- Pagination progress
- Pagination fraction
- Pagination custom
- Scrollbar
- Vertical
- Space between
- Slides per view
- Slides per view auto
- Centered
- Centered auto
- CSS mode
- Freemode
- Scroll container
- Slides Grid



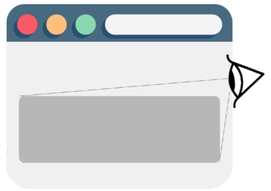

## Infinite loop

Open in new window | Core | React | Vue | Angular | Svelte

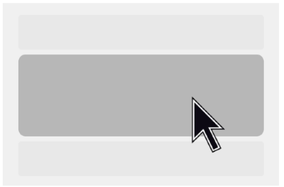


# **Automation** by tracking implicit behavior signals

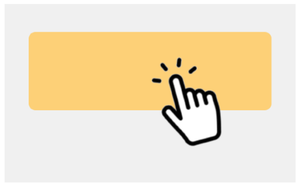
**Capture** implicit interaction that **might be** relevant to mental model building.



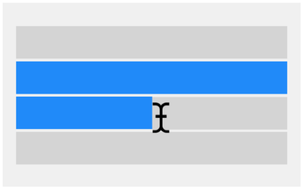
Content dwell



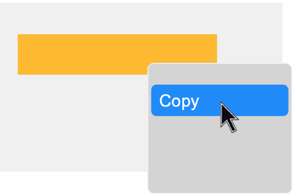
Cursor hover



Click



Text highlight




Copy content

**Extract** information that **actually** reflects users' mental model.

Rank by signal strength

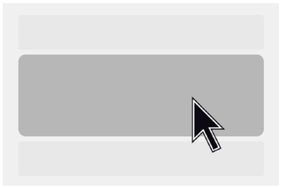
Filter out interaction noises

Filter out unintentional interactions
through time, length, etc. signals.

# Automation by tracking implicit behavior signals

**Capture** implicit interaction that **might be** relevant to mental model building.

Content dwell



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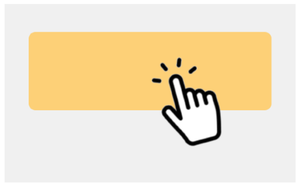
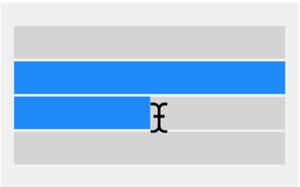
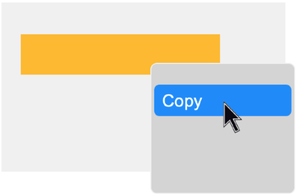


Click



Text highlight

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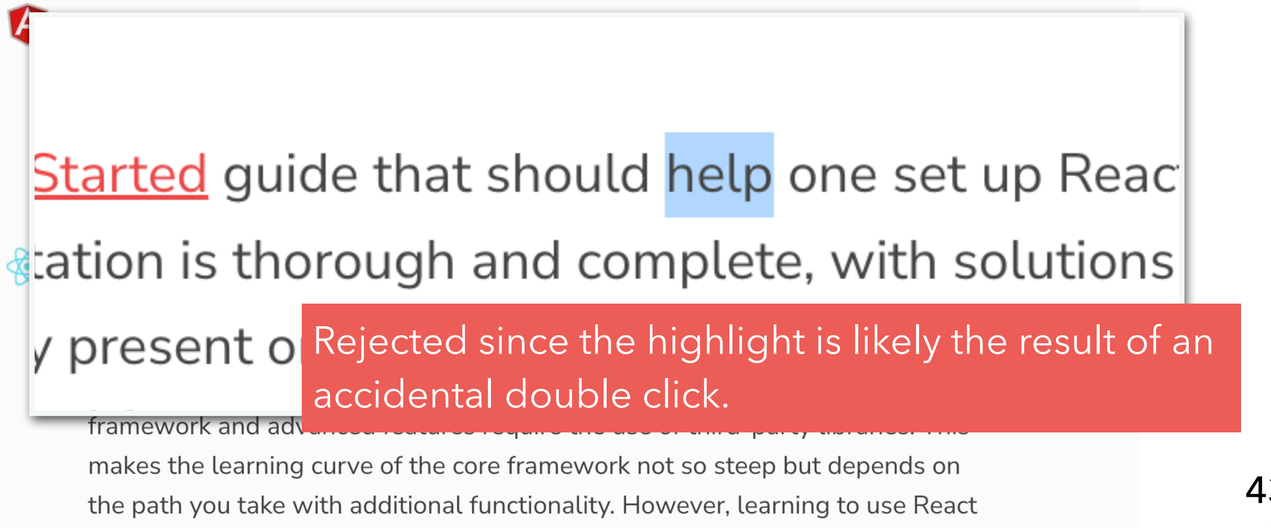
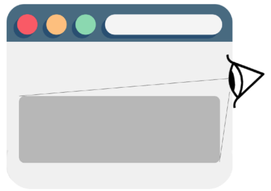
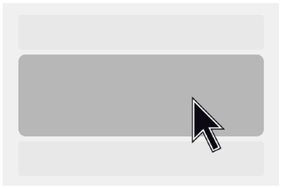


# **Automation** by tracking implicit behavior signals

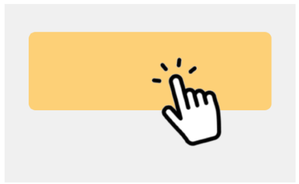
**Capture** implicit interaction that **might be** relevant to mental model building.



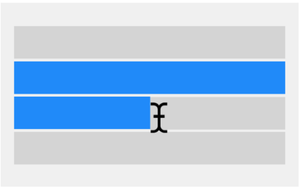
Content dwell



Cursor hover



Click



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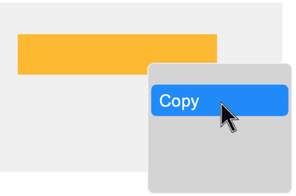



Copy content

**Extract** information that **actually** reflects users' mental model.

Rank by signal strength

Filter out interaction noises

Filter out noise in context

Use key entities as **criteria** and **options**.
*Named entity extraction + Noun chunk extraction*

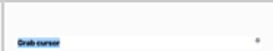
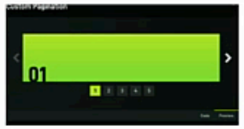
**Size and load times**

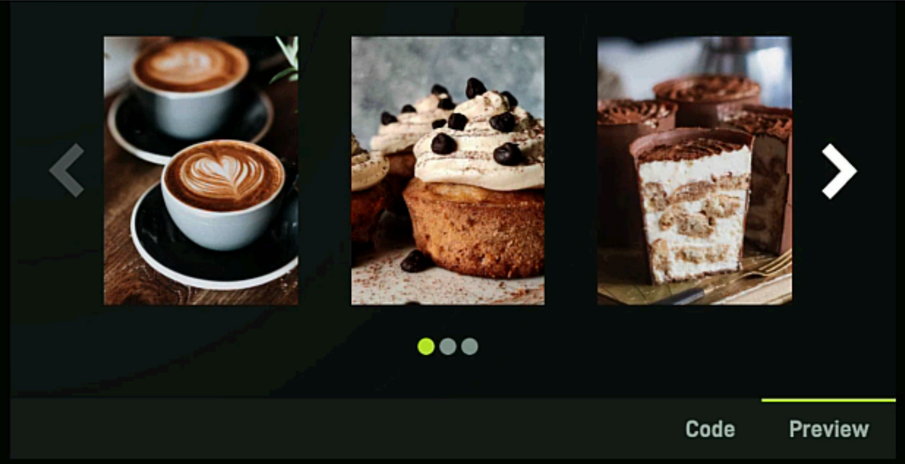
The sizes of the libraries won't be as big of a factor since caching and minification are pretty standard nowadays. Although there can be a significant difference between the sizes of the frameworks (e.g. Angular is the largest), they are still small as compared to the average webpage size (about 2MB according to the most recent data). Additionally,

Crystalline

Tribbiani

Compact mode

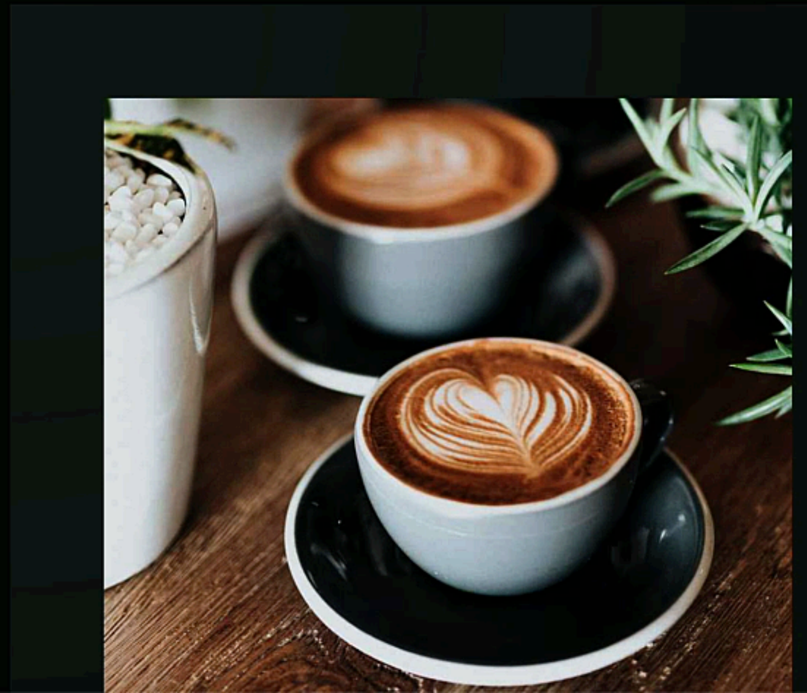
| | A Swiper | B Slick | C Splide |
|---|---|---|---|
| 1st Grab Cursor |  | | |
| 2nd Fade Transition | |  |  |
| 3rd Nested |  | |  |
| 4th Add/Remove | |  | |
| 5th Thumbnails | | |  |
| 6th Slides Grid |  | | |
| 7th Custom Pagination |  | |  |
| |  | | |



Code Preview

## Thumbnails

Splide sliders can be synchronized with one another. By utilizing this, you can make a gallery with thumbnails navigation.



# Crystalline is **useful**!

N=12, within-subjects, Unakite as baseline

With Crystalline, participants built comparison tables…

in **20%* less** time

with **60%* less** overhead cost.

time spent having to use tool features

Crystalline-style automation is **significantly faster** and more **efficient** because users shifts from **manual collecting & organizing** ➜ **monitoring**

** denotes statistically significant differences ($p < 0.05$)*

# However, automation can make **errors**…

N=12, within-subjects

With Crystalline, participants built comparison tables

Manual collecting & organizing ➜ monitoring **& error fixing**

*"[I needed to] occasionally peeking into what it's been doing and fixing whatever that's not correct."*

**Crystalline-style automation is significantly faster and more efficient.**

* denotes statistically significant differences ($p < 0.05$)

# In fact, users do expect to take some initiatives.

**Despite automation, participants wanted and tried to exercise more control over system behavior.**

*"it looks like if I spend a little bit more time on a particular place, the corresponding thing (criterion) can get picked up and bubble up quickly… the same thing with clicking or maybe selecting some text… so, at some point, I think I just started taking advantage of that and tried to bump what I really cared about up to the top…"*

# What if we shift error fixing to lightweight control?

**Despite automation, participants wanted and tried to exercise more control over system behavior.**

*"it looks like if I spend a little bit more time on a particular place, the corresponding thing (criterion) can get picked up and bubble up quickly… the same thing with clicking or maybe selecting some text… so, at some point, I think I just started taking advantage of that and tried to bump what I really cared about up to the top…"*

# What if we shift error fixing to **lightweight control**?

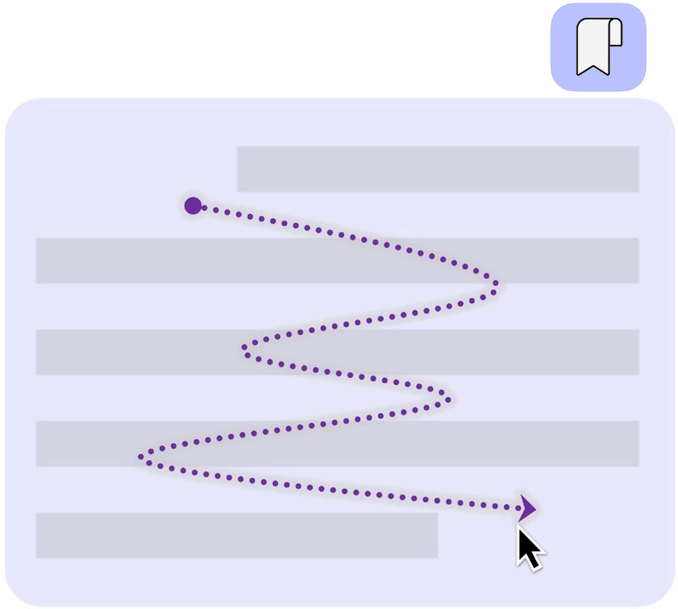
In addition to automation, how can we offer users **lightweight** interactions that promises **direct control**?

**Wigglite**: **streamlines** information collection and triage via a wiggle-based mouse gesture (or finger gesture on mobile devices).

Wigglite: Low-cost Information Collection and Triage

*Michael Xieyang Liu, Andrew Kuznetsov, Yongsung Kim, Joseph Chee Chang, Aniket Kittur, Brad A. Myers.*
*UIST 2022*

# Collecting content using **wiggling.**



**Wiggle** the cursor back-and-forth over the content of interest to collect it.

```
npm install @vue/cli-plugin-unit-jest @vue/test-utils
```

The next step is to create a test file, naming it **browserstack.test.js**. Jest can catch any file named ***.test.js** or ***.spec.js**.

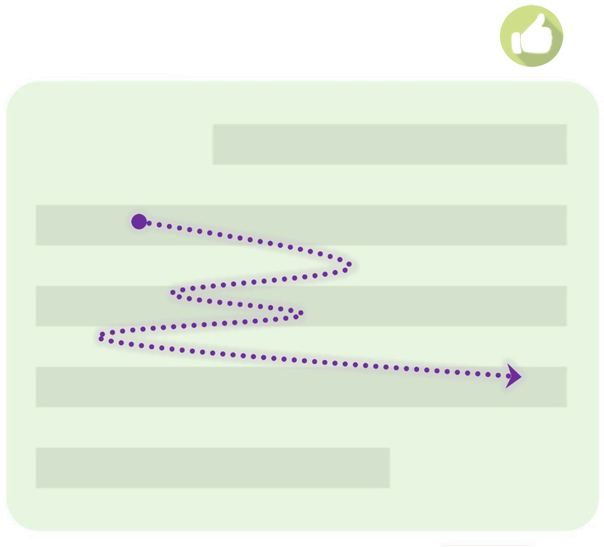
```
import { mount } from '@vue/test-utils'
import Browserstack from ‘./../browserstack.js’;

it(“testing a vue app”, ()=>{
expect(wrapper.find('button').exists()).toBe(true))
})
```

Lightweight: No explicit clip, drag, drop!

Lightweight: Cursor available!

Explicit & non-intrusive: People don’t do this otherwise!

# Classifying content with wiggling.



Classifying content as “positive”, or “pro”.

Naturally extend wiggling to e.g. content judgements!

React is often the most popular choice among developers. However, before choosing React, let’s study the benefits and drawbacks of using React.

**Advantages of using React**

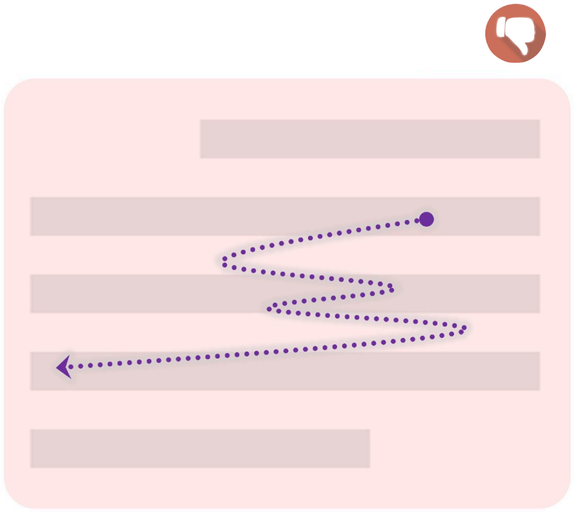
- **Reusable Components:** While developing React applications, the amount of complexity and coding is less because of the reusable components in React. It brought more functionality and a clear codebase, which is also easy to maintain.
- **Performance:** React does not depend upon the conventional DOM and uses a JavaScript structure, virtual DOM. Using virtual DOM enhances the performance and increases the speed of the programs.
- **Learning Curve:** React is way ahead of its competitors due to its easy learning curve. Moreover, it is easy for web developers who have just finished their concepts in HTML and JavaScript to learn React.

**Read More:** Browser Compatibility for ReactJS Web Apps

**Limitations of using React**

- **Development Pace:** Since React is the most widely used JavaScript library, React is

# Classifying content with wiggling.



Classifying content as "negative", or "con".

**Read More:** Browser Compatibility for VueJS Web Apps

**Limitations of using Vue.Js**

- **Ecosystem:** The ecosystem plays a vital role in applications to adapt to several browsers and operating systems. Vue has a very narrow ecosystem, therefore, does not render in older versions of operating systems and web browsers.
- **Developers:** Other frameworks such as Angular and React are backed by Google and Facebook, which automatically build trust among the people, however, Vue is generally not trustworthy among the audiences.

## Core Differences: Angular vs React vs Vue

Here are some of the core differences between Angular, React, and Vue to make it easy to decide which is the best web development framework for your project.

| Parameter | Angular | React | Vue |
|---|---|---|---|
| Initial Release | 2016 | 2011 | 2014 |

# More expressive power with directions + Intensity!

# Evaluating wiggling **efficiency**

N=12, within-subjects

With wiggling, participants collected and organized clips…

in **24%* less** time

with **58%* less** overhead cost.

*"I just wiggle and move on, in fact, when I am wiggling on something, my eyes are already onto the next paragraph, no more stopping to do the regular clipping thing any more."*

** denotes statistically significant differences ($p < 0.05$)*

# Evaluating wiggling accuracy & integration

True positives

**0** false positive (FP)

Suggesting that normal mouse movements would not trigger a wiggle activation

**3.53%** false negative (FN)

With the current implementation, 2.01% did not activate, 1.48% activated on the wrong content

True negatives

Robust against false negatives!

Does not interfere with existing interactions!

Reading

Externalizing

Reusing

Selenite (2023)

Unakite (UIST 2019)

*Honorable Mention (top-6)*

Crystalline (CHI 2022)

Wigglite (UIST 2022)

Strata (CSCW 2021)

*Best paper (top 1%)*

Minimize cognitive & physical cost,

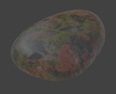
through **lightweight interactions**

Reading

Externalizing

Reusing

Selenite (2023)



Unakite (UIST 2019)

*Honorable Mention (top-6)*

Crystalline (CHI 2022)

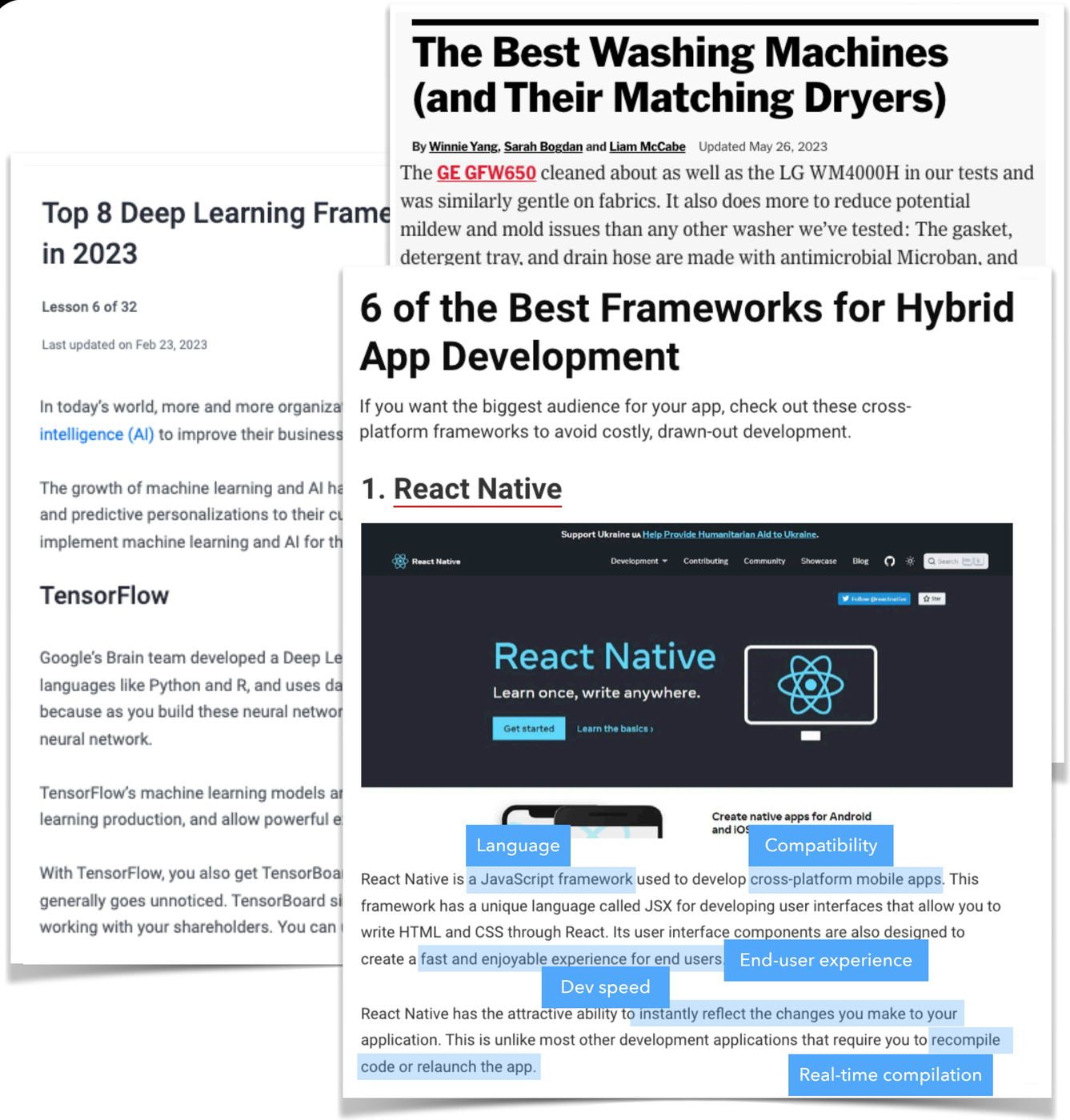
Wigglite (UIST 2022)

Strata (CSCW 2021)

*Best paper (top 1%)*

Assist reading & comprehension,
via **AI-retrieved global perspectives**

Minimize cognitive & physical cost,
through **lightweight interactions**




Many pages prioritize Options (used as headers), but embed and intertwine multiple **criteria** in **paragraphs**

But both prior observations and a formative study with 8 participants suggested that this format is **suboptimal** for people's reading & sensemaking!

# Formative Study

*"This looks like a promising stroller, let me read…"*

**Best less-expensive full-featured four-wheeler: Evenflo Pivot Xpand Modular Stroller**

**Our pick**

**Evenflo Pivot Xpand Modular Stroller**

A four-wheeled stroller that offers bang for the buck

This less-expensive take on a fully loaded "designer" stroller has flaws, but it delivers lots of features on a tighter budget.

**$282* from Amazon**

**$350 from Evenflo**

*At the time of publishing, the price was $350.

**Best for:** Families who want the features of an Uppababy, but want or need to spend much less.

**Why we like it:** The Evenflo Pivot Xpand Modular Stroller is a solid stroller that ticks the essential boxes, with adjustable handlebar height, a reversible toddler seat, and an accessible storage basket. It doesn't feel as thoughtfully designed or streamlined as our other four-wheeled pick, the Uppababy Cruz, but it's more than half as good for less than half the cost.

**Notable features:** The Pivot Xpand's handlebar has four height settings—38.5 inches, 39.5 inches, 40.5 inches, and 41 inches—and it is adjusted like

# Formative Study

Option-oriented reading is **overwhelming**: too many criteria to capture, digest, and formalize.

*"This looks like a promising stroller, let me read…"*

*"Wow this review is so* long and time-consuming*, if I were reading on my own I'd give up already…"*

Strap the two buckles under the bassinet to quickly turn it into a toddler seat. Gif: Marki Williams

The toddler seat reclines smoothly via a handle on the back. The recline angle goes back to around 30 degrees, inviting enough for naps. The toddler seat also has an "infant mode" for children under 6 months old; by unbuckling a strap under the seat, the seat becomes almost flat, creating a suitable position for small babies (and making the stroller particularly cost efficient since you don't have to purchase a separate bassinet, as you do with the Uppababy Cruz).

The Pivot Xpand's belly bar, though, is one area where it feels particularly cheap. Most strollers' belly bars unlock on either side and pivot away from the child to open. But the belly bar on the Pivot Xpand is designed to be fully detached from the stroller in order to get the child in and out. In practice, I found that I could easily get my son in and out of the stroller without removing the belly bar, but that might be more challenging with larger kids—or a mid-tantrum toddler.

# Formative Study

Option-oriented reading is **overwhelming**: too many criteria to capture, digest, and formalize.

People **prefer selective reading**, but: "laundry list" of criteria forces unnecessary linear information digestion.

> *"This is my dealbreaker, but of course they make the cons hard to find.* Some simple metadata of what's covered in a paragraph would be helpful; *if I got to see this first I could have jumped to read the next stroller."*

cheap. Most strollers' belly bars unlock on either side and pivot away from the child to open. But the belly bar on the Pivot Xpand is designed to be fully detached from the stroller in order to get the child in and out. In practice, I found that I could easily get my son in and out of the stroller without removing the belly bar, but that might be more challenging with larger kids—or a mid-tantrum toddler.

At 24 inches, the canopy on the Pivot Xpand was one of the shortest that we tested; the canopy on the Uppababy Cruz extends to a full 32 inches. On the plus side, the canopy does have a mesh peekaboo window and can be adjusted to three different heights on the toddler seat, a nice option for taller and kids with longer torsos. Unlike most canopies, which are zipped or clipped to the frame of the stroller on the side and the top, the Pivot Xpand attaches to the toddler seat on the sides only. This makes it easy to adjust the height, but it also means that if you pull the canopy out quickly, it can pull away from the top—a potential hassle in a rainy and windy situation.

The Pivot Xpand can be converted from a single to a double stroller, with the purchase of a **second toddler seat**. (We did not test this stroller as a double; read more on convertible strollers here.) It is the only one of our main stroller picks that converts.

Refreshingly, the Pivot Xpand actually comes with a cupholder—the only one of our picks that does; this is an especially welcome bonus, given the price.

Evenflo offers a 90-day warranty for manufacturer defects, which is an unusually short warranty period. This does not cover normal wear and tear or accidental damage.

**Cleaning:** The Pivot Xpand's polyester fabric cannot be removed from the stroller frame, so spot-cleaning it is the only option. (Ditto for the storage basket.)

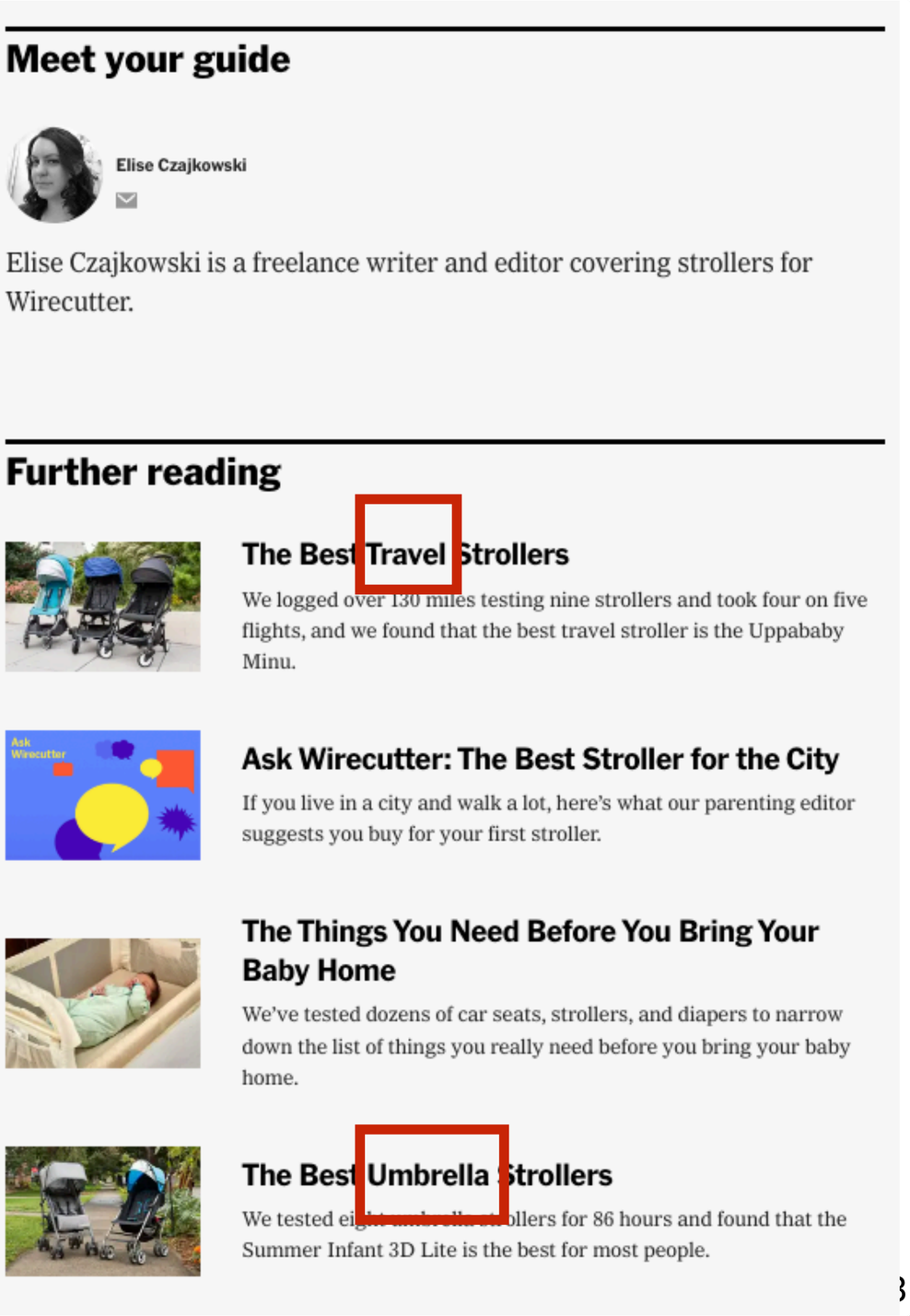
# Formative Study

Option-oriented reading is **overwhelming**: too many criteria to capture, digest, and formalize.

People **prefer selective reading**, but: "laundry list" of criteria forces unnecessary linear information digestion.

Dealing with **unknown-unknown**: no "intuition or guidance" on what to care about.

> *"Hmm so this page didn't talk about traveling or umbrella… I wonder what else is missing. What can't there be some* guidance or intuition of what I should care about?*"*



# Formative Study ➡️ Design Rationale

Reading is not a process we can take for granted – People need help…

Developing **well-rounded knowledge** about what might be important for a topic;

Reading more **targetedly** about what they care.

**Selenite**: AI-assisted, grounded reading and information discovery!

[D1] **Global grounding for overview** upon entering a page, using common criteria and the options encountered.

[D2] **Local grounding for guided reading**, using page/paragraph-level summaries and annotations.

[D3] **Suggestions on next steps** upon finishing, based on criteria already covered.

Best Strollers of 2023

https://www.babylist.com/hello-baby/best-strollers

# The Best Baby Strollers of 2023, According to Our Testing

Lightweight, affordable and luxury picks for newborns, toddlers and first-time parents.

BY JAMIE SPAIN AND JESSICA HARTSHORN UPDATED: APR 24, 2023

REVIEWED BY RACHEL ROTHMANCHIEF TECHNOLOGIST & EXECUTIVE TECHNICAL DIRECTOR

SAVE ARTICLE


BOB GEAR

***FYI:*** *We've updated this guide and swapped in the Chicco Corso LE Modular Travel System and Colugo The Compact Stroller for out-of-stock products.*

Topic: **Best strollers of 2023**

Options encountered so far:

Thule Spring | Nuna TAVO Next | Evenflo Pivot Xplore Wagon | Doona Car Seat Stroller | UPPAbaby Vista v2 | Bugaboo Butterfly | Baby Jogger City Mini GT2 Double Stroller | Zoe Traveler | Thule Urban Glide 2 | UPPAbaby Cruz v2 | Joovy Twin Roo+

Criteria that people consider regarding the topic:

Safety 11 | Comfort 5 | Maneuverability 21 | Durability 1 | Foldability 14 | Weight and Size 17 | Storage 4 | Versatility 40 | Price 8 | User Reviews 3 | Safety Features 4 | Comfort for the Child 6 | Ease of Use 8 | Storage Space 7 | Weight Capacity 2 | Cleaning and Maintenance | Style and Design 2 | Brand Reputation | Accessories and Add-ons | Longevity 1

Request more criteria | + Add a criterion

Best Strollers of 2023

# The Best B… Accord…

Lightweight, affordable and lu…

BY JAMIE SPAIN…

REVIEWED BY RACHEL RO…

BOB GEAR

*FYI: We've updated this guide and swapped in the Chicco Corso LE Modular Travel System and Colugo The Compact Stroller for out-of-stock products.*

Criteria that people consider regarding the topic:

- Safety 11
- Comfort 5
- Maneuverability 21
- Durability 1
- Foldability 14
- Weight and Size 17
- Storage 4
- Versatility 40
- Price 8
- User Reviews 3
- Safety Features 4
- Comfort for the Child 6
- Ease of Use 8
- Storage Space 7
- Weight Capacity 2
- Cleaning and Maintenance
- Style and Design 2
- Brand Reputation
- Accessories and Add-ons
- Longevity 1

Request more criteria

Add a criterion

# Global overview w/ criteria

XI

What are some criteria that people consider regarding the topic of "best baby strollers" that are most relevant to the topic, frequently considered, and can cover a broad range of perspectives?

*Using GPT-4 as a **knowledge retriever***

What are some criteria that people consider regarding the topic of "best baby strollers" that are **most relevant to the topic**, **frequently considered**, and **can cover a broad range of perspectives**?

+

Please give me 5 more that are **different, more diverse, and more important**.

Iterative Self-refine technique

*Madaan et al. 2023*

# In-context criteria annotations

Versatility | Storage Space | Price | Weight and Size

If you like the Uppababy Cruz V2 but want a larger stroller with even more storage space (and the ability to convert it to carry two kids): The Uppababy Vista V2 is basically a supersized version of the Uppababy Cruz V2, our four-wheeled pick for daily urban use. The Vista V2's frame is bigger than that of the Cruz V2 (it's 3.5 inches wider and 2 inches longer), and it expands on an already generous storage basket by another 3 inches in width. As for the handling, we thought the Vista V2 maneuvered slightly better than the Cruz V2, since its larger frame distributed weight differently across the stroller, but we also found it harder to navigate tight spaces with a stroller that had a bigger footprint. Neither the Cruz V2 nor the Vista V2 is ideal for folding and carrying, and the Vista V2's additional heft—it weighs 28 pounds versus the Cruz V2's 25 pounds—makes it that much more cumbersome to lift. Another key difference is that the Vista V2 can convert from a single stroller to a double stroller with the purchase of an additional seat; we named the earlier-generation Vista model the upgrade pick in our guide to the best double strollers. And unlike the Cruz V2, the Vista V2 comes with an infant bassinet attachment. Still, considering the price and weight differences—and the fact that it can be hard to predict when (or if) you'll need a convertible stroller and what type you may want—we've concluded that the Cruz V2 is a better choice for most people looking for a full-size stroller for one child.


Analyze paragraphs with **natural language inference (NLI)**:

"[paragraph content] **discusses** [criterion]"

↓

bart-large-mnli (an NLI model)

↓

Yes ✅ No ❌

# In-context criteria annotations

Versatility | Storage Space | Price | Weight and Size

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Foldability | Folding Mechanism | Travel-Friendly | Versatility | Weight and Size | Maneuverability

Analyze

**Why we like it:** The Baby Jogger City Mini GT2 All-Terrain Stroller is a three-wheeled stroller that's excellent at taking on tricky terrain like grass and gravel. (Despite the brand name, however, it's not designed for running.) It is sturdy and wide, but also very light, and it has a quick, ridiculously simple one-handed fold—the best of any stroller we tested—making it easy to pop into the back of your car before you head off on an adventure.

Durability | Maneuverability | Comfort | Adjustability | Versatility

Analyze

The City Mini GT2 doesn't put on airs: It delivers rugged functionality. The stroller's rubberized handlebar is comfortable for long-term pushing and gripping as you go over bumps and curbs, and its large canopy and deeply reclining, nap-friendly toddler seat lend themselves well to extended day trips. (Hello, theme parks.)

Adjustability | Adjustable Handlebar

Analyze

This stroller has the longest toddler seat of any of our picks, and its adjustable handlebar can go up the highest, 44 inches, making this stroller a potentially great fit for particularly tall families.

Foldability | Versatility | Travel-Friendly | Maneuverability

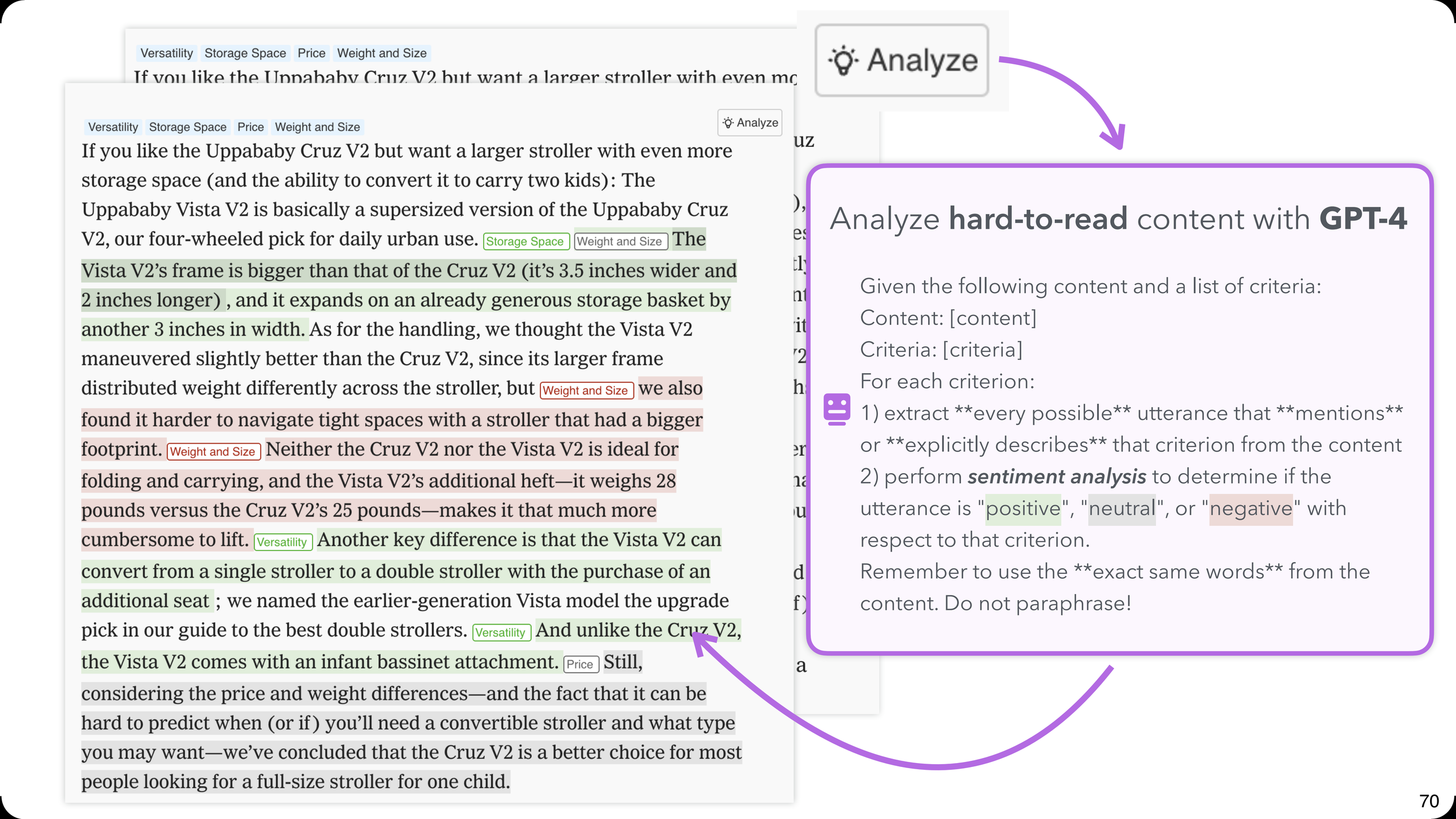
Analyze

Note that the City Mini GT2 shares some similarities, including its quick fold, with the Baby Jogger City Mini 2, our top pick in the original version of this guide. At this writing, Baby Jogger is in the process of phasing out the City Mini 2.

Durability | Storage Space

Analyze

**Size and storage:** At 25.5 inches wide and 33 inches long, the City Mini GT2


Versatility Storage Space Price Weight and Size
Analyze
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Analyze hard-to-read content with GPT-4
Given the following content and a list of criteria:
Content: [content]
Criteria: [criteria]
For each criterion:
1) extract **every possible** utterance that **mentions** or **explicitly describes** that criterion from the content
2) perform ***sentiment analysis*** to determine if the utterance is "positive", "neutral", or "negative" with respect to that criterion.
Remember to use the **exact same words** from the content. Do not paraphrase!

# After reading...

## Status report

Criteria that you looked at:

Safety | Comfort | Price | Weight and size | Foldability | Ease of cleaning | Durability

Criteria that you ignored:

Maneuverability | Storage space | Design

You might be interested in further searching for “Best baby strollers” based on:

Ease of assembly | Brake & locking system

## Suggesting new searches

“Best baby stroller + **ease of assembly**”

“**Brake and locking system** of baby strollers”

# Study 1: Performance Evaluation

How well can Selenite:

1) *accurately* report **options** that are present on a web page;

2) *comprehensively* report critical **criteria** people commonly consider

*by testing on a diverse set of 10 topics:*

5 reported in **formative study** + 5 most popular from **Wirecutter**

*each compared to:*

100%!

**top 5 SERPs** –> **hand-annotated groundtruth** options + criteria

# Groundtruth v.s. Selenite

*e.g., “best air purifier”*

| | | | | | |
|---|---|---|---|---|---|
| Ease of use | Noise | Room size suitability | Price | Smart features | |
| User-friendly control | Noise level | Coverage | Price | Smart features | |
| Speed settings | Air quality indicator | Portability | Warranty | Customer reviews | |
| Fan speed settings | Additional features | Portability | Warranty | Customer reviews | |
| Design | Customer support | Filter type | Sleep mode | Power consumption | |
| Design | Customer support | Filter type | Sleep mode | Power consumption | |
| Smell removal | Performance | Ozone safe | Filter replacement indicator | | |
| Odor elimination | Effectiveness | Ozone emissions | Filter indicator | | |

---

| | | | |
|---|---|---|---|
| Child lock | Certifications | Size | CADR (Clean Air Delivery Rate) |

# Are the global criteria set any good?

**Precision**: % of criteria retrieved by Selenite that were in the groundtruth

**Recall**: % of groundtruth criteria that are were retrieved by Selenite

| | #Groundtruth | #Selenite | Precision | Recall | F1 |
|---|---|---|---|---|---|
| Best washing machines | 19 | 24 | 0.88 | 1.0 | |
| Birthday gift ideas | 11 | 21 | 0.57 | 0.91 | |
| Best hybrid app frameworks | 15 | 21 | 0.86 | 0.93 | |
| Best time tracking tools | 21 | 21 | 0.81 | 0.95 | |
| Deep learning frameworks | 25 | 20 | 0.80 | 0.84 | |
| Best sleeping bags | 19 | 21 | 0.81 | 0.89 | |
| Best air purifiers | 20 | 24 | 0.83 | 1.0 | |
| Best robot vacuums | 23 | 28 | 0.82 | 1.0 | |
| Best baby strollers | 22 | 24 | 0.92 | 1.0 | 0.96 |
| Best tropical vacation spots | 15 | 19 | 0.74 | 0.93 | 0.82 |
| **Mean** | 19.0 | 22.3 | 0.80 | 0.95 | 0.87 |

**High recall**: criteria retrieved by Selenite can **cover most of the criteria relevant to a topic**.

# Are the global criteria set any good?

**Precision**: % of criteria retrieved by Selenite that were in the groundtruth

**Recall**: % of groundtruth criteria that are were retrieved by Selenite

| | #Groundtruth | #Selenite | Precision | R | |
|---|---|---|---|---|---|
| Birthday gift ideas | 19 | 24 | 0.88 | | |
| | 11 | 21 | 0.57 | | |
| Best hybrid app frameworks | 15 | 21 | 0.86 | | |
| Best time tracking tools | 21 | 21 | 0.81 | 0.95 | 0.88 |
| Deep learning frameworks | 25 | 20 | 0.80 | | |
| Best sleeping bags | 19 | 21 | 0.81 | | |
| Best air purifiers | 20 | 24 | 0.83 | | |
| Best robot vacuums | 23 | 28 | 0.82 | | |
| Best baby strollers | 22 | 24 | 0.92 | | |
| Best tropical vacation spots | 15 | 19 | 0.74 | | |
| **Mean** | 19.0 | 22.3 | 0.80 | 0.95 | 0.87 |

Lower-than-avg **precision** on some topics – **not necessarily bad**!

What **Selenite** suggests: “Practicality”, “Sentimental value”, “Durability”, etc.

What **webpages** talks about: “Fun”, “Cool”, etc. –– **hard for comparison**

# How good is the local grounding?

**Precision**: % of criteria recognized by Selenite that were indeed discussed in paragraph

**Recall**: % of criteria discussed in paragraph that were indeed recognized by Selenite

| | Precision | Recall | F1 |
|---|---|---|---|
| Best washing machines | 0.91 | 1.0 | 0.95 |
| Birthday gift ideas | 0.57 | 0.96 | 0.72 |
| Best hybrid app frameworks | 0.83 | 1.0 | 0.91 |
| Best time tracking tools | 0.88 | 0.98 | 0.93 |
| Deep learning frameworks | 0.87 | 0.95 | 0.91 |
| Best sleeping bags | 0.95 | 1.0 | 0.97 |
| Best air purifiers | 0.83 | 0.98 | 0.90 |
| Best robot vacuums | 0.95 | 1.0 | 0.97 |
| Best baby strollers | 0.81 | 1.0 | 0.90 |
| Best tropical vacation spots | 0.92 | 1.0 | 0.96 |
| **Mean** | 0.85 | 0.98 | 0.91 |

**Higher recall than precision**:

prioritize coverage!

# Study 2: Case Study

How well can Selenite support users' reading and understanding?

*8 participants, each performed…*

**2 pre-defined tasks**: use Selenite to read about an **unfamiliar topic**
*Selected from the 28 topics in formative study, based on screening survey*

**1 self-selected task**: Read a 3rd topic that **they intend to explore in real-life**
*Can revisit previous topics of interest and potentially uncover fresh perspectives*

**Weight:** 14.3 lbs | **Folded Size:** 3,534 cubic inches

**REASONS TO BUY**

- High-quality
- Sleek design
- Easy to push

**REASONS TO AVOID**

- Expensive for an umbrella
- Harder to nap in

Foldability | Travel-Friendly | Price | **Versatility** | Weight and Size | Style and Design | Maneuverability | User-Friendliness | Analyze

The BabyZen Yoyo2 is a lightweight umbrella stroller with a compact fold. This high-end, lighter product has many features parents want in a small package that is good for travel. While the Yoyo2 is more expensive than most secondary travel-friendly competitors, it is also a high-quality choice with excellent materials that function well. The Yoyo2 is easy to push and turn (a rarity in the umbrella world); plus, it is stylish and sleek.

Price | Analyze

While it is harder to push and a wee bit heavier than the smallest product, it is easier to use and earned a higher score for quality than most of the best umbrella strollers we tested. It is also more expensive than similar choices, so it isn't the best option for families on a tight budget or parents who only need a travel option for a single event. If budget isn't a concern, and you want the absolute best in a lightweight product, the BabyZen Yoyo2 stands out in its field.

**Read more:** BabyZen Yoyo2 review

# Selenite prioritizes users' reading needs

**8/8** participants immediately started with common criteria

**7/8** frequently jumped between criteria mentions for easy reading and comparison

*"just have to hunker down and read" (P7)*

*"you don't gotta stick to what the authors say anymore, ya know? Because, let's face it, their storylines can get all tangled and complicated sometimes." (P1)*

# Selenite helps save user time and effort

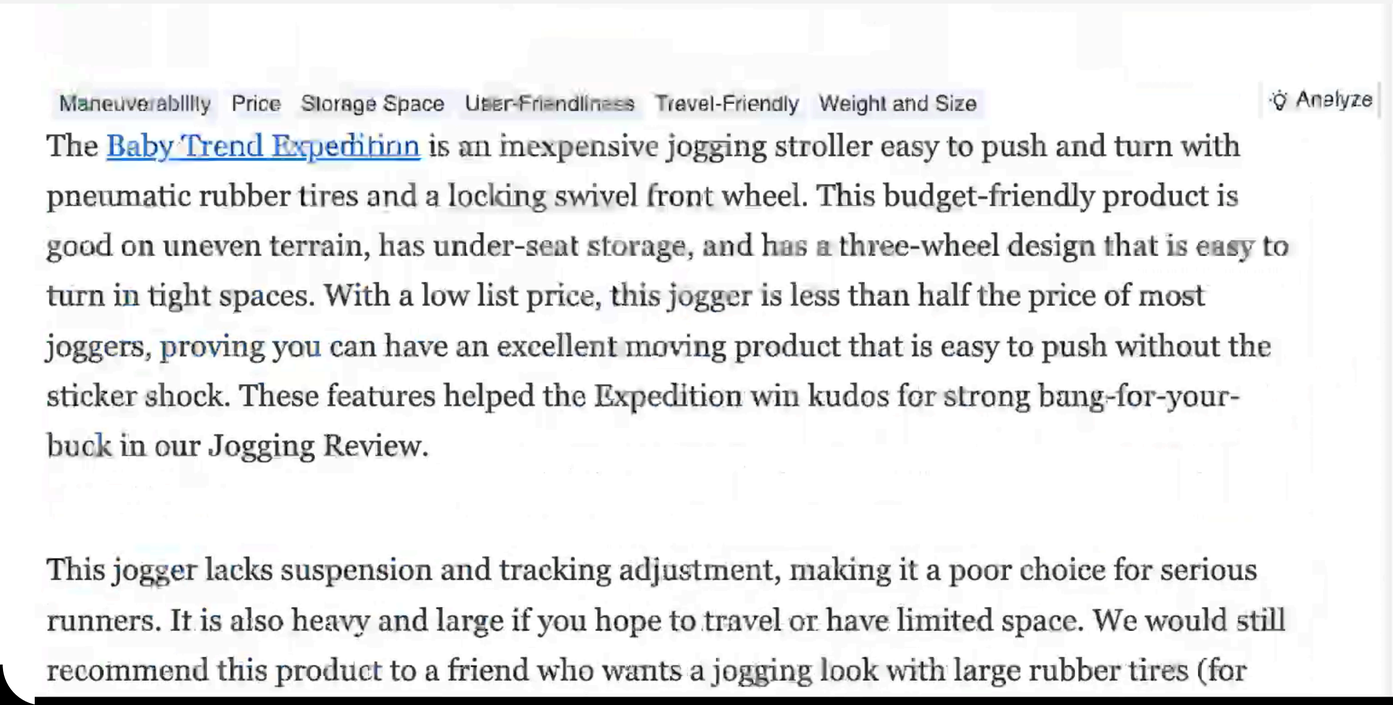
**8/8** participants appreciate the “bird-eye overview” (P4) & “expert opinion” (P1)

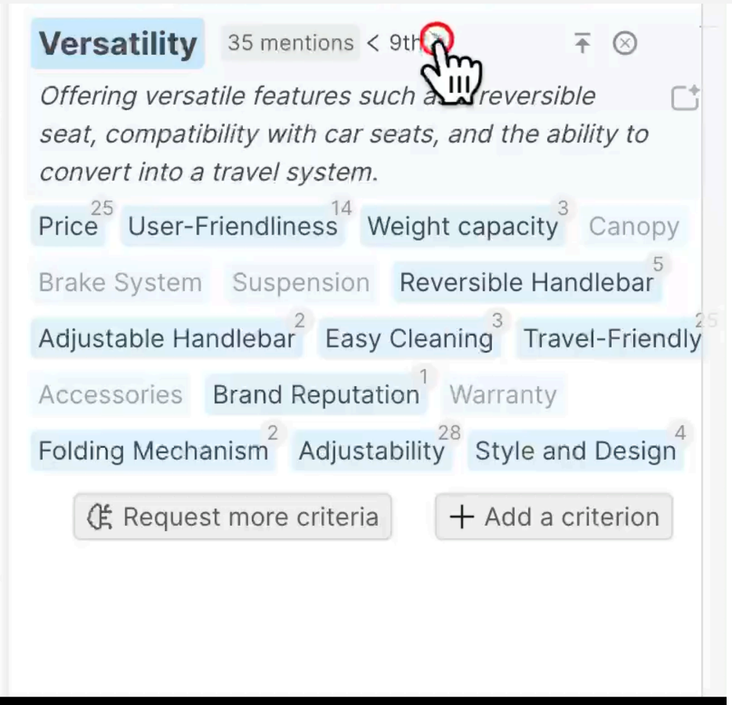
**8/8** used paragraph overview for grasping the key points

*“the anxiety and guesswork of wondering what other folks would actually care about ” (P7)*
*“figuring out stuff that I’m not used to” (P6)*

➔

*“felt like back in the day when my classmate would mark all the important stuff in the textbook after a class when I couldn’t make it.“ (P1)*



# Selenite helps capture easy-to-miss information

**3/8** participants used the zoom-in option and noticed additional logic flow

(Others thought the webpages were well-written, NLI label was enough, and zoom-in would take too long)

*"finding a needle in a haystack" (P8)* ➜ *"it's more like following a well-lit path" (P5)*

the handlebar was uniquely uncomfortable. Safety When we pushed the empty stroller on uneven pavement, one of the front wheels popped up, which we found unsettling—we also heard stories about the entire stroller frame collapsing mid-push. Safety Following multiple reports of structural issues with the frame when the stroller was being used as a double, Mockingbird issued a voluntary recall on certain models and sent out frame-reinforcement kits. Our reservations extend to the Mockingbird Single Stroller, which is a similar stroller that has a slightly smaller frame and one fewer recline option but doesn't convert to a double. Safety Mockingbird's voluntary recall applies to some lot numbers of the Single model, as well. Safety Since we tested these strollers, Mockingbird says that "significant strength improvements" have been made to the construction of both the Single and Single-to-Double strollers, and as of May of 2023, all Mockingbird strollers for sale are not subject to the recall.

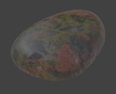
*People early stop when they see one description on a criteria,*
*vs. Selenite helps find inline contrasts!*

Reading

Externalizing

Reusing

Selenite (2023)



Unakite (UIST 2019)

*Honorable Mention (top-6)*

Crystalline (CHI 2022)

Wigglite (UIST 2022)

Strata (CSCW 2021)

*Best paper (top 1%)*

Assist reading & comprehension,
via **AI-retrieved global perspectives**

Minimize cognitive & physical cost,
through **lightweight interactions**

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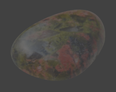

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Reusing

Strata (CSCW 2021)

*Best paper (top 1%)*

Guide knowledge reuse evaluations,
with **systematic framework + tools**

# Evaluating mental models is hard.

*Author: Past me*

| | Intuitiveness | Popularity | Used by |
|---|---|---|---|
| React | 👍 | 👍 | Facebook |
| Angular | 👍 | 👍 | Google |
| Vue | 👍 | 👎 | Alibaba |
| EmberJS | 👍 👎 | 👎 | Heroku |

*Reader: Current me…*

Can I **trust** this table?

Is this **relevant** to what I want to do?

Is it **thorough**? Does it include everything?

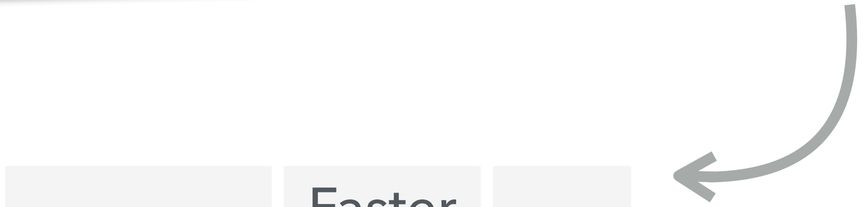
How can we help people evaluate different aspects of a mental model?

Flanagin & Metzger 2000, Hoorn & Wijngaarden 2010, Markus 2001, Dorisch & Bellotti 1992, Paul & Morris 2009, Fisher et al. 2012

**Key observation:**

Evidence in the table…

To compare performance, I did the following in iPython. It turns out that arrays are significantly faster.



| | Faster | … |
|---|---|---|
| np.array | 👍 | … |
| np.matrix | 👎 | … |
| … | | … |

# Key observation:

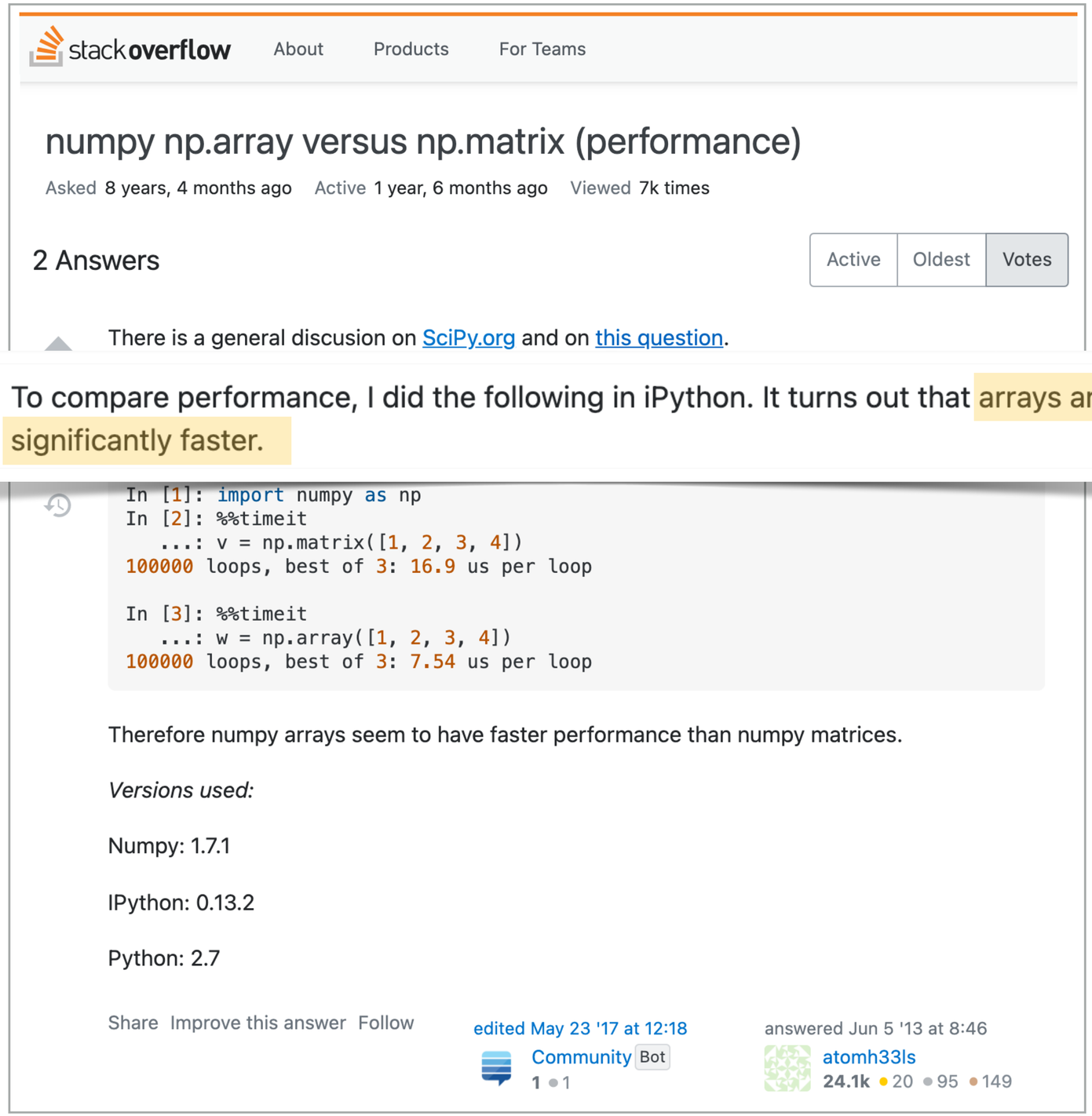
Evidence in the table…

Has richer context.

And the contexts are useful for evaluation!

*From interviews & prior work*

| | Faster | … |
|---|---|---|
| np.array | 👍 | … |
| np.matrix | 👎 | … |
| … | | … |



# Contexts are useful…


**Title == search query?**

**Programming context?**

| | Faster | … |
|---|---|---|
| np.array | 👍 | … |
| np.matrix | 👎 | … |
| … | | … |

stackoverflow About Products For Teams

## np.array versus np.matrix (performance)

2 Answers

Active Oldest Votes

There is a general discusion on SciPy.org and on this question.

5

To compare performance, I did the following in iPython. It turns out that arrays are significantly faster.

```
In [1]: import numpy as np
In [2]: %%timeit
   ...: v = np.matrix([1, 2, 3, 4])
100000 loops, best of 3: 16.9 us per loop

In [3]: %%timeit
                          ([1, 2, 3, 4])
                       7.54 us per loop
```

…o have faster performance than numpy matrices.

*Versions used:*

Numpy: 1.7.1

IPython: 0.13.2

Python: 2.7

Share Improve this answer Follow

edited May 23 '17 at 12:18 Community Bot 1 • 1

answered Jun 5 '13 at 8:46 atomh33ls 24.1k • 20 • 95 • 149

**Strata:** A **framework** and a **system** that systematically **extracts** and **visualizes** useful signals to help users evaluate mental models for reuse.

To Reuse or Not To Reuse? A Framework and System for Evaluating Summarized Knowledge

*Michael Xieyang Liu, Aniket Kittur, Brad A. Myers.*
*CSCW 2021*
*Best Paper (top 1%)*

| | Faster | ... |
|---|---|---|
| np.array | 👍 | ... |
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| ... | | ... |

stackoverflow About Products For Teams

numpy np.array versus np.matrix (performance)

Asked 8 years, 4 months ago Active 1 year, 6 months ago Viewed 7k times

2 Answers

Active Oldest Votes

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Therefore numpy arrays seem to have faster performance than numpy matrices.

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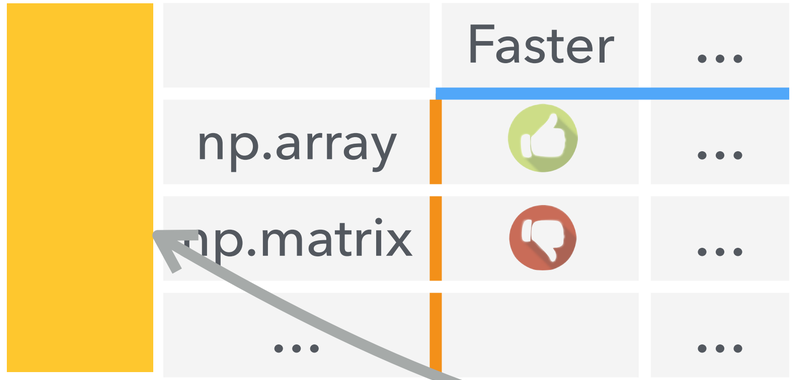


stackoverflow About Products For Teams

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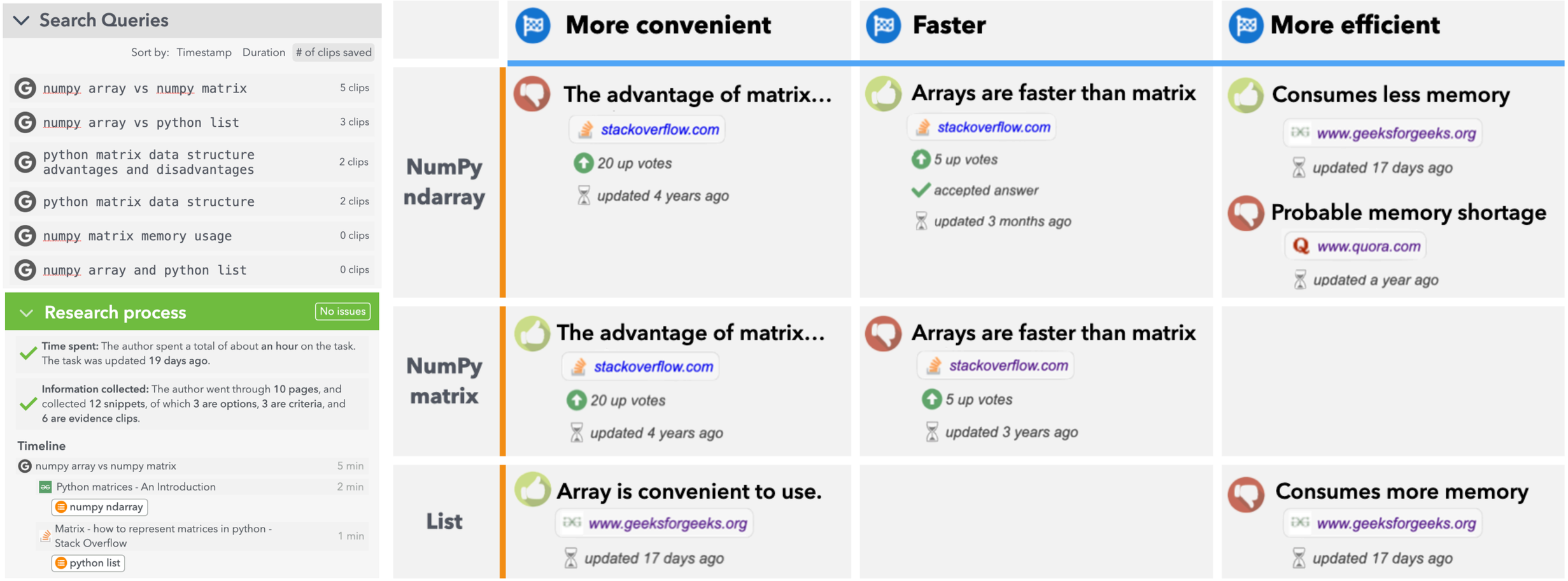
Search Queries
Sort by: Timestamp Duration # of clips saved
numpy array vs numpy matrix 5 clips
numpy array vs python list 3 clips
python matrix data structure advantages and disadvantages 2 clips
python matrix data structure 2 clips
numpy matrix memory usage 0 clips
numpy array and python list 0 clips
Research process
No issues
Time spent: The author spent a total of about an hour on the task. The task was updated 19 days ago.
Information collected: The author went through 10 pages, and collected 12 snippets, of which 3 are options, 3 are criteria, and 6 are evidence clips.
Timeline
numpy array vs numpy matrix 5 min
Python matrices - An Introduction 2 min
numpy ndarray
Matrix - how to represent matrices in python - Stack Overflow 1 min
python list
More convenient
Faster
More efficient
NumPy ndarray
The advantage of matrix...
stackoverflow.com
20 up votes
updated 4 years ago
Arrays are faster than matrix
stackoverflow.com
5 up votes
accepted answer
updated 3 months ago
Consumes less memory
www.geeksforgeeks.org
updated 17 days ago
Probable memory shortage
www.quora.com
updated a year ago
NumPy matrix
The advantage of matrix...
stackoverflow.com
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Arrays are faster than matrix
stackoverflow.com
5 up votes
updated 3 years ago
List
Array is convenient to use.
www.geeksforgeeks.org
updated 17 days ago
Consumes more memory
www.geeksforgeeks.org
updated 17 days ago

| | More convenient | Faster | More efficient |
|---|---|---|---|
| NumPy ndarray | The advantage of matrix… | Arrays are faster than matrix | Consumes less memory<br>Probable memory shortage |
| NumPy matrix | The advantage of matrix… | Arrays are faster than matrix | |
| List | Array is convenient to use. | | Consumes more memory |

| | More convenient | Faster | More efficient |
|---|---|---|---|
| **NumPy ndarray** | The advantage of matrix…<br>stackoverflow.com<br>20 up votes<br>updated 4 years ago | Arrays are faster than matrix<br>stackoverflow.com<br>5 up votes<br>accepted answer<br>updated 3 months ago | Consumes less memory<br>www.geeksforgeeks.org<br>updated 17 days ago<br>Probable memory shortage<br>www.quora.com<br>updated a year ago |
| **NumPy matrix** | The advantage of matrix…<br>stackoverflow.com<br>20 up votes<br>updated 4 years ago | Arrays are faster than matrix<br>stackoverflow.com<br>5 up votes<br>updated 3 years ago | |
| **List** | Array is convenient to use.<br>www.geeksforgeeks.org<br>updated 17 days ago | | Consumes more memory<br>www.geeksforgeeks.org<br>updated 17 days ago |

| | More convenient | Faster | More efficient |
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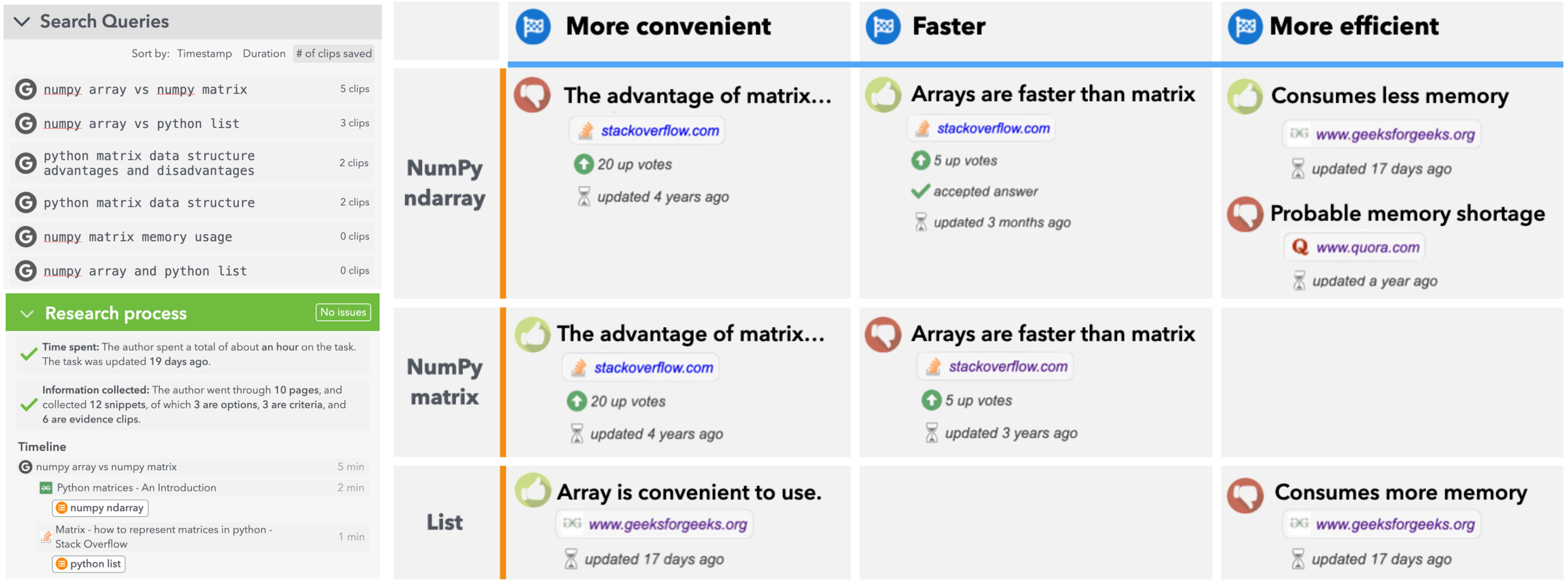
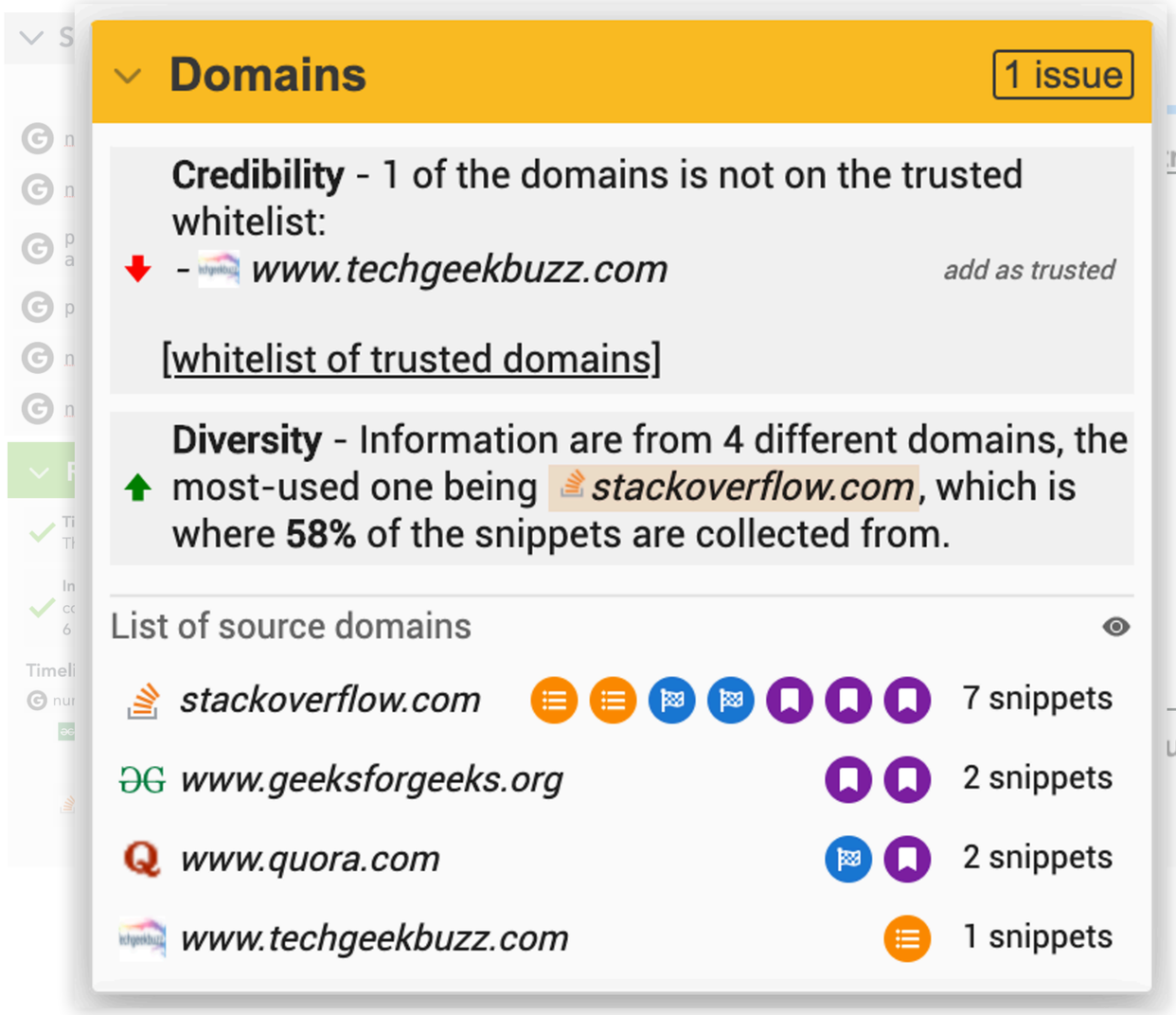
| **NumPy ndarray** | **The advantage of matrix...**<br>stackoverflow.com<br>20 up votes<br>updated 4 years ago | **Arrays are faster than matrix**<br>stackoverflow.com<br>5 up votes<br>accepted answer<br>updated 3 months ago | **Consumes less memory**<br>www.geeksforgeeks.org<br>updated 17 days ago<br>**Probable memory shortage**<br>www.quora.com<br>updated a year ago |
| **NumPy matrix** | **The advantage of matrix...**<br>stackoverflow.com<br>20 up votes<br>updated 4 years ago | **Arrays are faster than matrix**<br>stackoverflow.com<br>5 up votes<br>updated 3 years ago | |
| **List** | **Array is convenient to use.**<br>www.geeksforgeeks.org<br>updated 17 days ago | | **Consumes more memory**<br>www.geeksforgeeks.org<br>updated 17 days ago |

# Also, a side panel for more summaries…




Guide users interpret the trustworthiness, relevance, and thoroughness of a Unakite table!

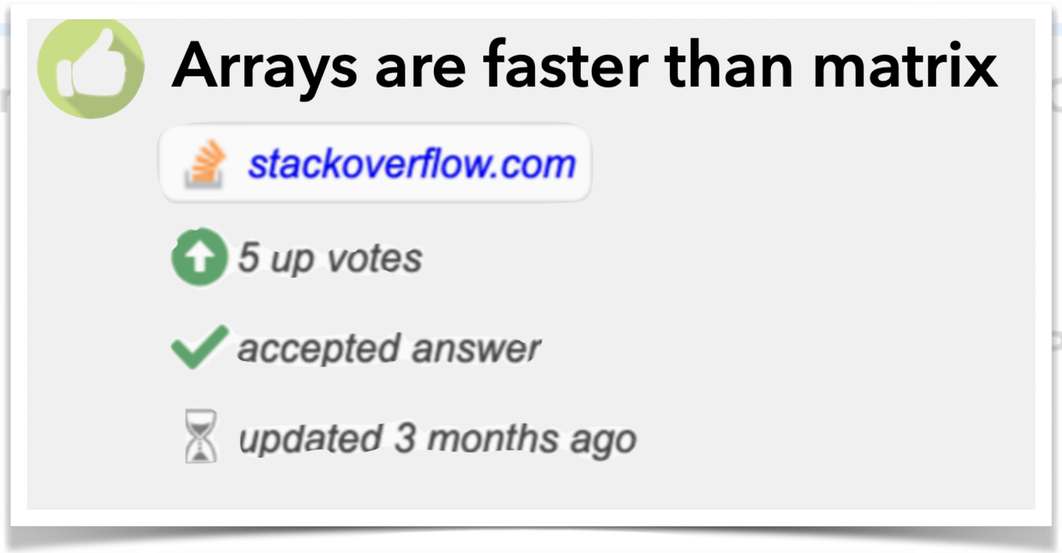
# Evaluating Mental Model Trustworthiness




Can I **trust** this table?

Summarize various sources information are gathered from for readers' overview.

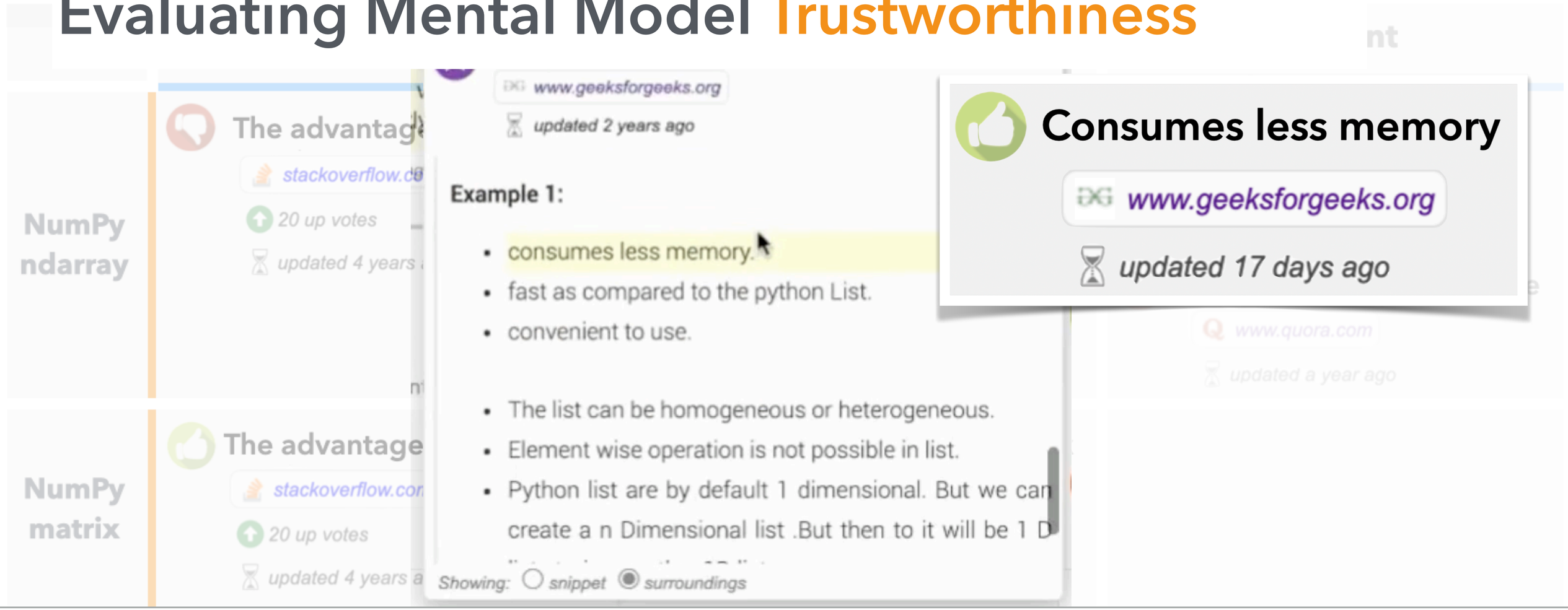
# Evaluating Mental Model Trustworthiness




Can I **trust** this table?

Link evidence with its **popularity** and **up-to-dateness**.

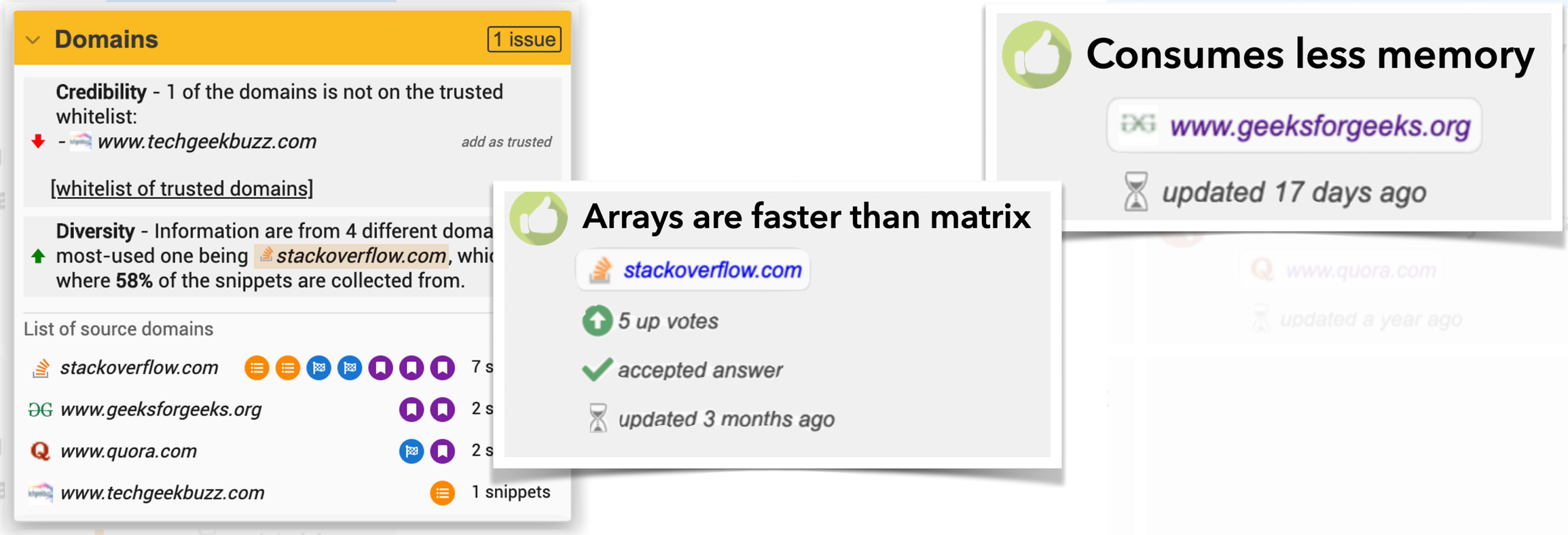
# Evaluating Mental Model Trustworthiness




Can I **trust** this table?

Link evidence with its **original context.**

# Evaluating Mental Model Trustworthiness




Can I **trust** this table?

Core support: Reconstruct the information source!

# Evaluating Mental Model Thoroughness

## Research process

No issues

**Time spent:** The author spent a total of about **an hour** on the task. The task was updated **19 days ago**.

**Information collected:** The author went through **10 pages**, and collected **12 snippets**, of which **3 are options**, **3 are criteria**, and **6 are evidence clips**.

### Timeline

- numpy array vs numpy matrix — 5 min
  - Python matrices - An Introduction — 2 min
    - numpy ndarray
  - Matrix - how to represent matrices in python - Stack Overflow — 1 min
    - python list
  - Python Matrix and Introduction to NumPy - Program — 1 min

Faster

Arrays are faster than matrix

More efficient

Consumes less memory

Consumes more memory

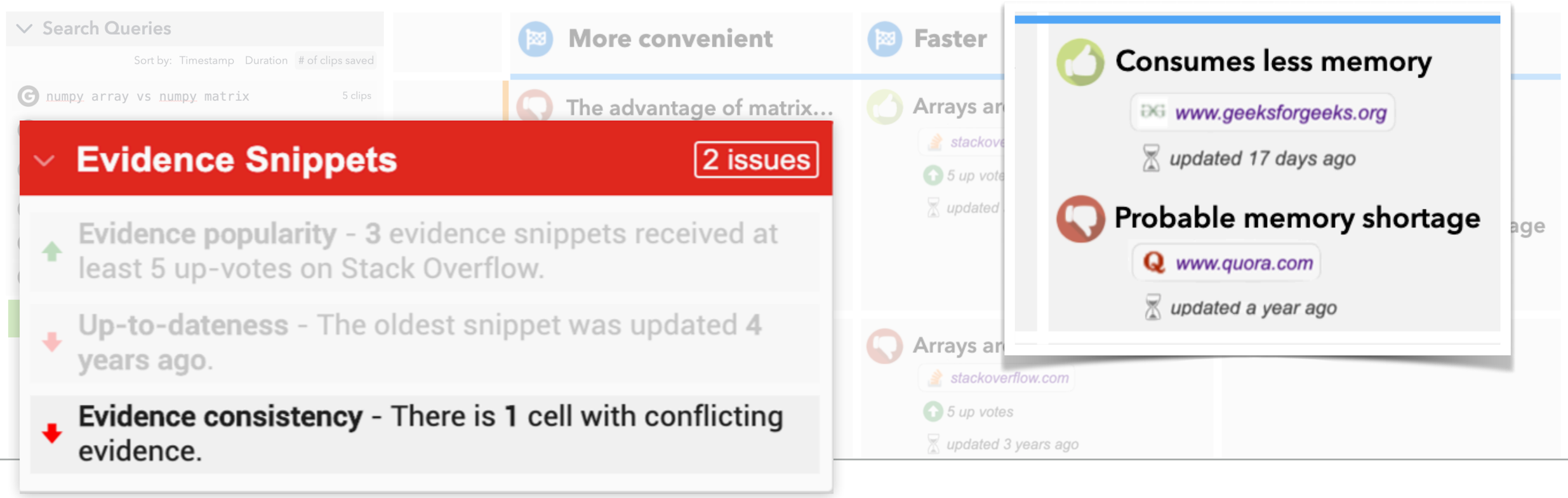
www.geeksforgeeks.org

updated 17 days ago

Is it **thorough**? Does it include everything?

Visualize the **research trajectory** and **spent effort**.

# Evaluating Mental Model Thoroughness




Is it **thorough**? Does it include everything?

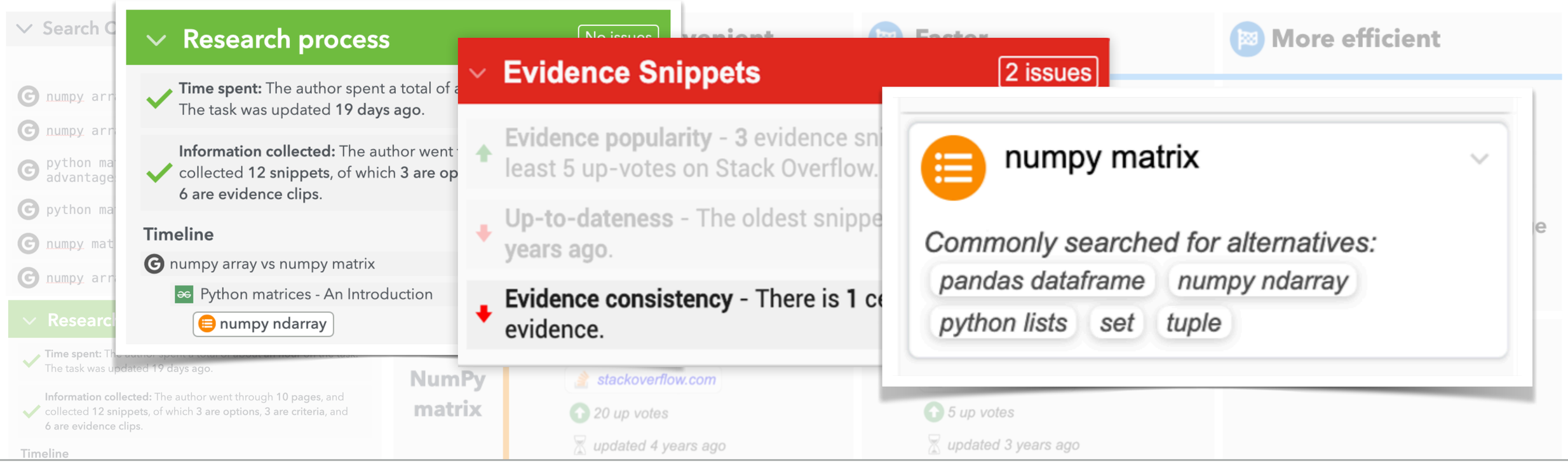
Alert evidence **inconsistency**

# Evaluating Mental Model Thoroughness


Is it **thorough**? Does it include everything?

Suggest **alternative** search

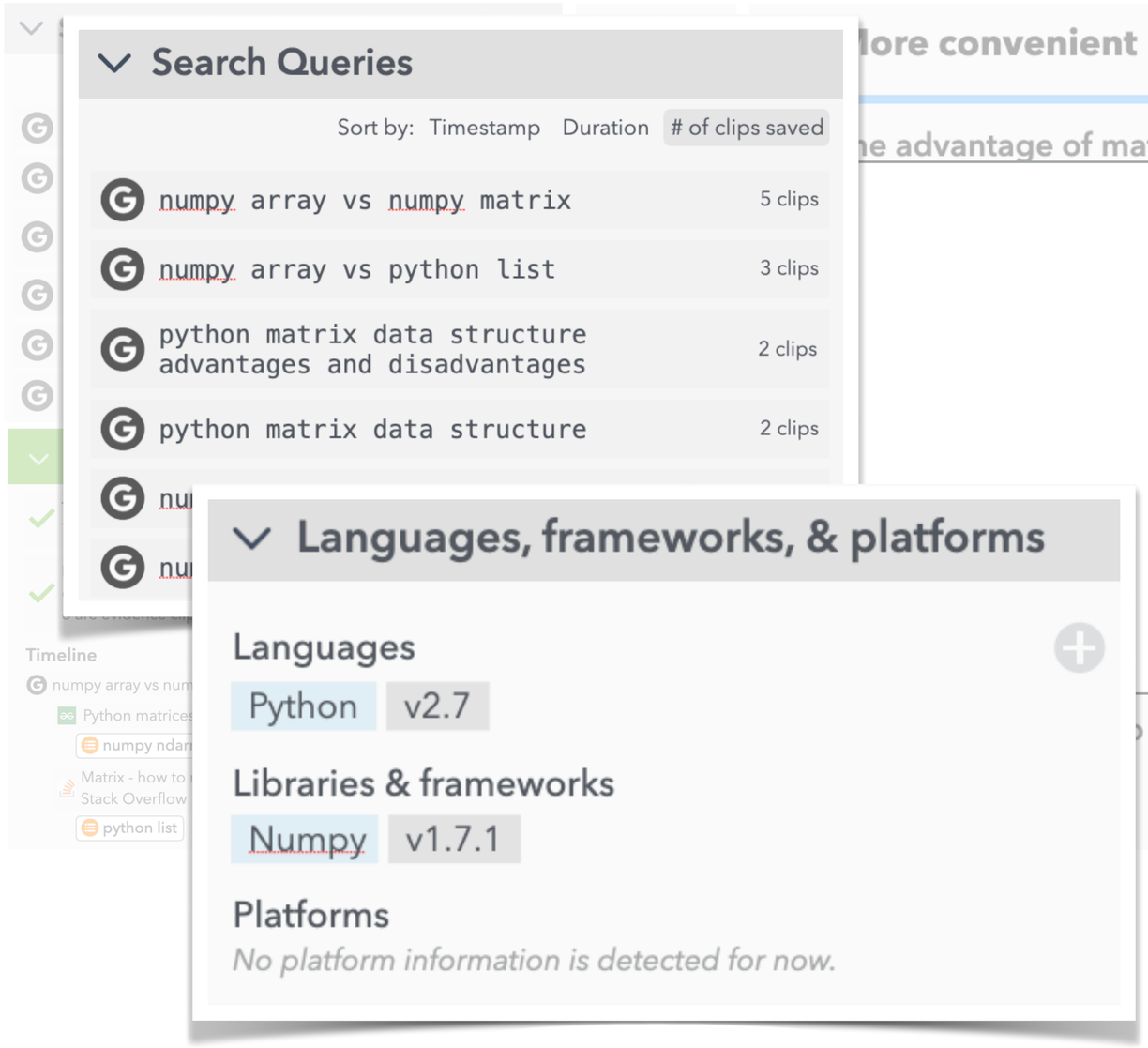
# Evaluating Mental Model Thoroughness




Is it **thorough**? Does it include everything?

Core support: reflect & alert conflicts & potentials for extension.

# Evaluating Mental Model Relevance




Is this **relevant** to what I want to do?

Core support: Reconstruct the information foraging trajectory!

# Study: evaluating if to reuse mental models

N=20, between-subjects, Unakite as baseline

With Strata, users explained their rationale for reuse…

in **33%* less** time

with **126%* more** valid & high-quality reasons.

* denotes statistically significant differences ($p < 0.05$)

# Study: evaluating if to reuse mental models

N=20, between-subjects, Unakite as baseline

Strata provides **guidance** for verification.

*"It serve(d) as a comprehensive guidance for things that I should pay attention to…"*

ale for reuse…

in **33%* less** time

with **126**

Strata **reminds** users of important signals to check that they would otherwise overlook.

*"I realize that I'm more of a grab-and-go kinda person and I don't usually remember to check how many up-votes a Stack Overflow answer gets or when it was last updated…"*

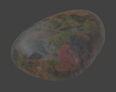
* denotes statistically significant differences ($p < 0.05$)

Reading

Selenite (2023)

Assist reading & comprehension,
via **AI-retrieved global perspectives**

Externalizing



Unakite (UIST 2019)

*Honorable Mention (top-6)*

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Minimize cognitive & physical cost,
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Reusing

Strata (CSCW 2021)

*Best paper (top 1%)*

Guide knowledge reuse evaluations,
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# Summary of Contributions

Reading

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Assist reading & comprehension,
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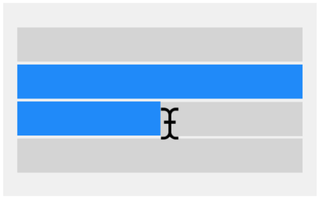
# Overall Takeaways

**Lightweightness:** Minimize the overhead of externalizing through interaction design

## Reduce context switch

| | Fast? | Community |
|---|---|---|
| React | Yes | Really large |
| Angular | ? | Also large |
| Vue | Yes | ? |

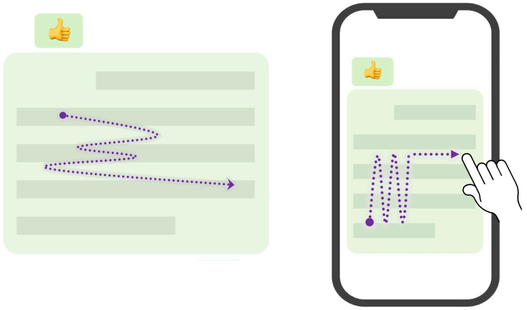
## Harvest implicit human behavior



Text highlighting

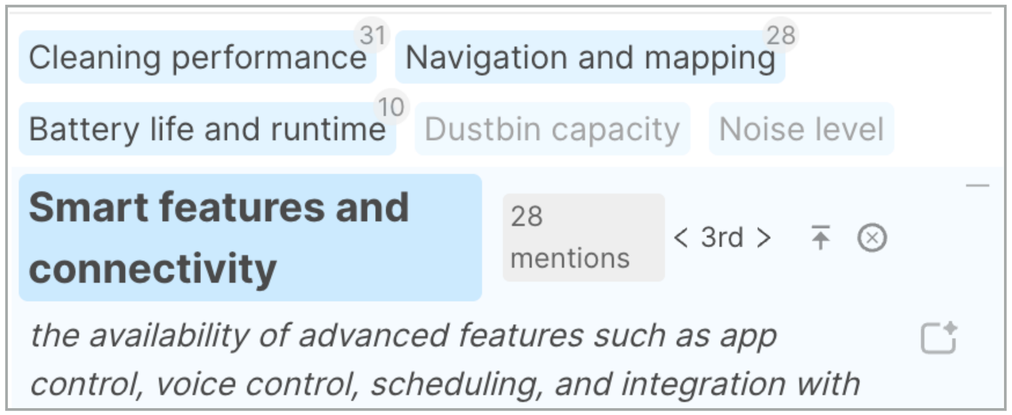
Cursor hovering

## Utilize intuitive gestures

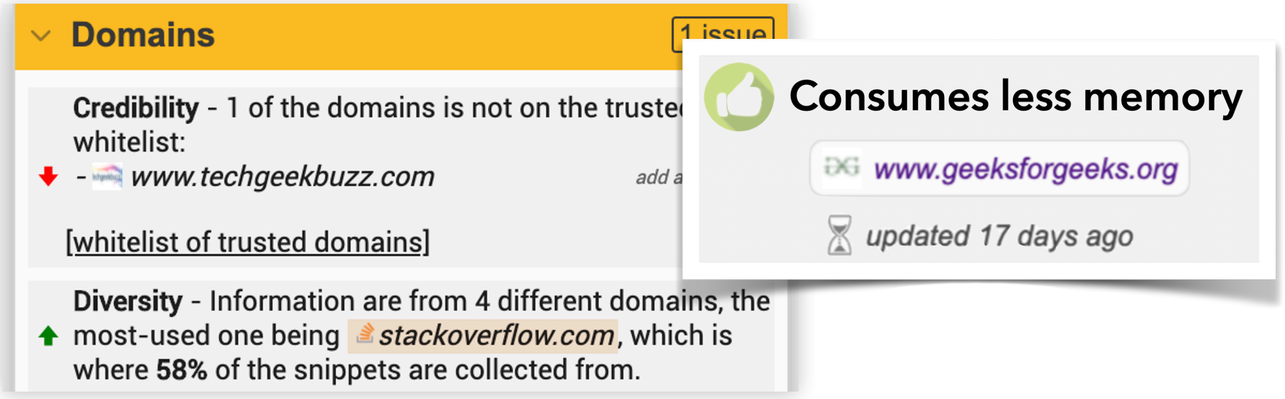


**Augmentation:** Help people comprehend existing info. by providing context

## Guide reading for deeper comprehension




## Guide evidence eval. for knowledge reuse



# Future Work

## **Lightweightness:** lightweight interactions ➡️ **lightweight & flexible structures**?

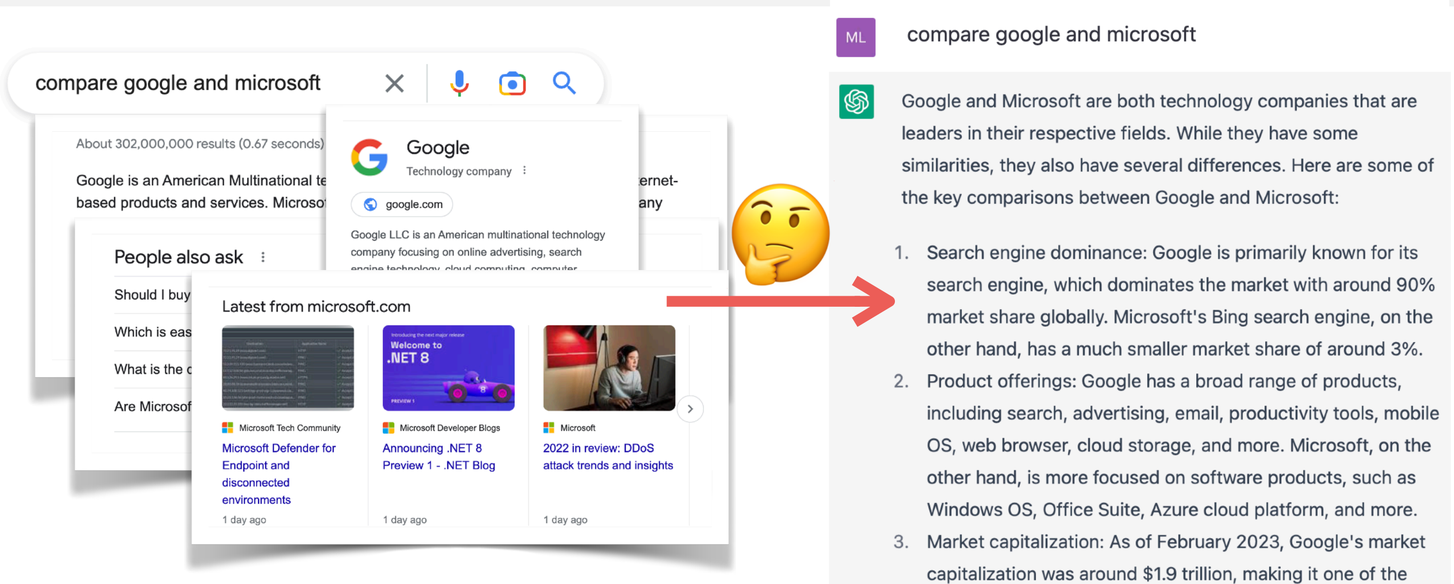
| | Intuitiveness | Popularity | Used by |
|---|---|---|---|
| React | 👍 | 👍 | Facebook |
| Angular | 👍 | 👍 | Google |
| Vue | 👍 | 👎 | Alibaba |
| EmberJS | 👍👎 | 👎 | Hero |

🤔

Existing table structure can be **too rigid** for some use cases, especially in early sensemaking stages.

Can we support **multiple different structures** (e.g., lists, trees, maps, etc.) , as well as **fluid transition** between those structures?

## **Augmentation:** augmented reading & understanding ➡️ **augmented searching**?




🤔




How do we integrate the AI data source into users' **natural search flow**, possible by leveraging **existing UI affordances and interactions?**

# Conclusion

I design and build **user interfaces**, **interactions**, **and computational scaffolds** that enable initial users to more efficiently and effectively **read**, **comprehend**, **collect**, and **organize** information to make and justify decisions, while automatically capturing the sensemaking context to help subsequent people **understand** and **evaluate** those decisions.

- Investigated this core thesis by designing and building five systems.
- Through lab and case studies, I demonstrated how users can benefit from sensemaking systems that minimize interaction costs as well as provide appropriate augmentation.

Committee

# Thank you ❤️

Collaborators, friends,

R2, participants, & instant noodle


Sponsors

Tuesday, July 25, 2023


*Ph.D. thesis defense*

# Tool Support for Knowledge Foraging, Structuring, & Transfer During Online Sensemaking

**Michael Xieyang Liu**
@lxieyang(@hci.social) / xieyangl@cs.cmu.edu
CMU HCII

Committee
Brad A. Myers
Aniket Kittur
Kenneth Holstein
Daniel M. Russell