Building Economic Models of Human-Computer Interaction

by @leifos and @guidozuc

Who are we?

Leif Azzopardi, @leifos
Associate Professor, University of Strathclyde

- Studying how information systems shape and influence people and society
- Models of User Behavior, Interaction and Performance
- Algorithmic and Cognitive Bias
- Interactive Information Retrieval

Guido Zuccon, @guidozuc
Senior Lecturer, University of Queensland University

- Formal models of search
- Ranking and search result diversification
- Health Search and Retrieval


decisions
browsing
documents
interface
intelligent
intention
assessing
search
features
queries
snippets
experience
querying
seek
system
inspecting
facets
expertise
background

User Decisions

- When should a **user stop searching**?
- What **search strategy** should a user undertake?
  - Examine lots of documents per query, and issue few queries
  - Or examine few documents per query, and issue many queries
- Is it **better to query** or **use relevance feedback**?
- How many **terms** should a user put into a query?

User Decisions

- Should a user **re-find** or **bookmark**?
- Should a user **browse** for an app or **search** for an app?
  - At what point does searching become more efficient that browsing?
- When should a user speak to a **conversational interface** or **type**?

Designer Decisions

- How good do **recommendations** need to be?
- How many **results** should be shown **per page**?
- Should we present **entity cards** or not?
- What **query suggestions** should we present?
- How much space should we dedicate to **advertisements** on a web page?
- How can we **summarize** the feed better?
- Should people use **duckduckgo** or google?

But, what about you?

- Valuing new services; new features
- Applying economics models to accessibility problems, usability tests, information presentation, (user populations) +3
- Decisions&trade-offs b/w complexity/functionalities and simplicity + 2
- Interfaces to manipulate user behavior
- Collaborative environments – also agents+humans + 2
- User understanding
- Evaluation measures of interactions
- Comparisons of interactions

Decisions, Decisions!

- **When would a user pay $10/month for Spotify?**
- What is the best army composition in Clash of Clans: Archers, Barbarians and/or Giants?
- **Should a player farm the jungle, stay in lane, or gank?**
- How many ads should we put on the interface?
- **What is the value of the cookie law?**
- When will a user switch from mobile to desktop?
- **How can we improve conversation over skype?**
- What features should be included in the app?

Tutorial's Motivations

Why make economic **models** of

Computer Human Interaction?

Economics provides us with the tools to:

- **Understand** of how people interact with systems
- **Predict** how people will adapt and respond to system changes
- **Evaluate** the value/utility of features and interactions
- **Inform** the design and development of interfaces

Tutorial's Goals

Give you the knowledge and skills to:

- **Define** and **describe** the different types of models
- **Explain** the rationale for economics models of CHI
- **Describe** and **define** the economic (optimization) models for UX/UI design
- **Explain** and **infer** the predicted user behavior given these models
- **Generate** hypotheses regarding user behavior

Schedule

9.00-9.30: Introduction

9.30-10.20: **Economic Thinking and Models**

Coffee Break

11.00-12.20: **Modelling Features and Interfaces**

Lunch

14.00-15.20: **Information Foraging Theory and Economics of Search**

Coffee Break

16.00-17.20: **Building a Model + Practical Session**

Bring your own problem

EXAMPLE

How do users behave searching for information?

Users behaving…

Typically pose short queries (2-3 terms)

wildlife extinction Search

Search Terms: ***wildlife extinction*** Showing page *1* out of *612* pages.

Rare Grouse Confirmed Extinct in Northeast China
in frigid zones is **extinct** in China. The **extinct** spruce grouse, belonging...Yu attributes the **extinction** of the bird to...to protect **wildlife**
Xinhua News Service

British bumblebee extinct; others species likely to follow
species to become **extinct** here, and a handful...fund's soon-to-be-**extinct** list are protected...known to have become **extinct** in Britain. The current
Associated Press Worldwide News Service

Venezuela Declares 42 Species in Danger of Extinction
declared 42 **wildlife** species of animals...in danger of **extinction** and banned game...of existing **wildlife**, such as the irrational
Xinhua News Service

Saving the endangered species, NEW STRAITS TIMES-MANAGEMENT TIMES
that most of the **wildlife**'s habitat is in...contribute to **wildlife extinction**. It is true that...conservation of **wildlife** resources, including
Associated Press Worldwide News Service

ALEUTIAN GOOSE MAKES A COMEBACK
was on the brink of **extinction** 25 years ago...River National **Wildlife** Refuge west of...Canada goose to **extinction**, and humans through
New York Times News Service

Tend to only examine first few results

Users behaving…

Typically pose short queries (2-3 terms)

But longer queries yield better performance

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Tend to only examine first few results

And going deeper provides more relevant information

Users behaving… badly?

Typically pose short queries (2-3 terms)

But longer queries yield better performance

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Are they "misbehaving"?

Users behaving… optimally?

Typically pose short queries (2-3 terms)

But longer queries yield better performance

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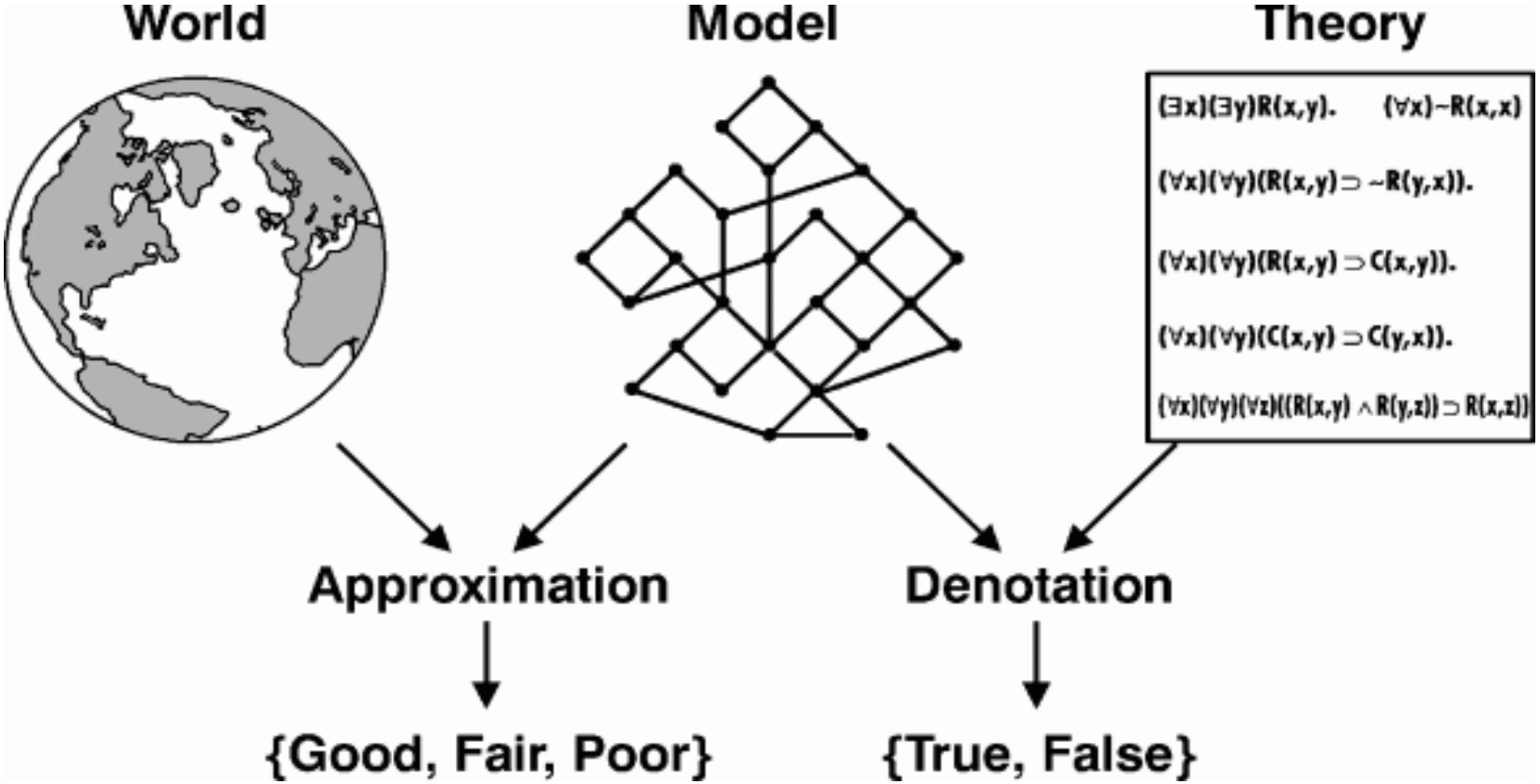
Are they being strategic?

How can we improve search, if we don't understand users?

Why do users behave like this?



THEORY AND MODELS

Types of Models

- **Descriptive & Conceptual**
  - describe the phenomena and the suggesting relationship between factors
  - pre-theoretical, without directly testable hypotheses

LACK EXPLANATORY POWER

- **Formal & Theoretical**
  - Often mathematical, explicitly defining the relationships among factors (functionally)
  - More than just predictive, but explanatory
  - Produce testable hypotheses

CAN BE USED TO EXPLAIN WHY!

Jarvelin (2003)

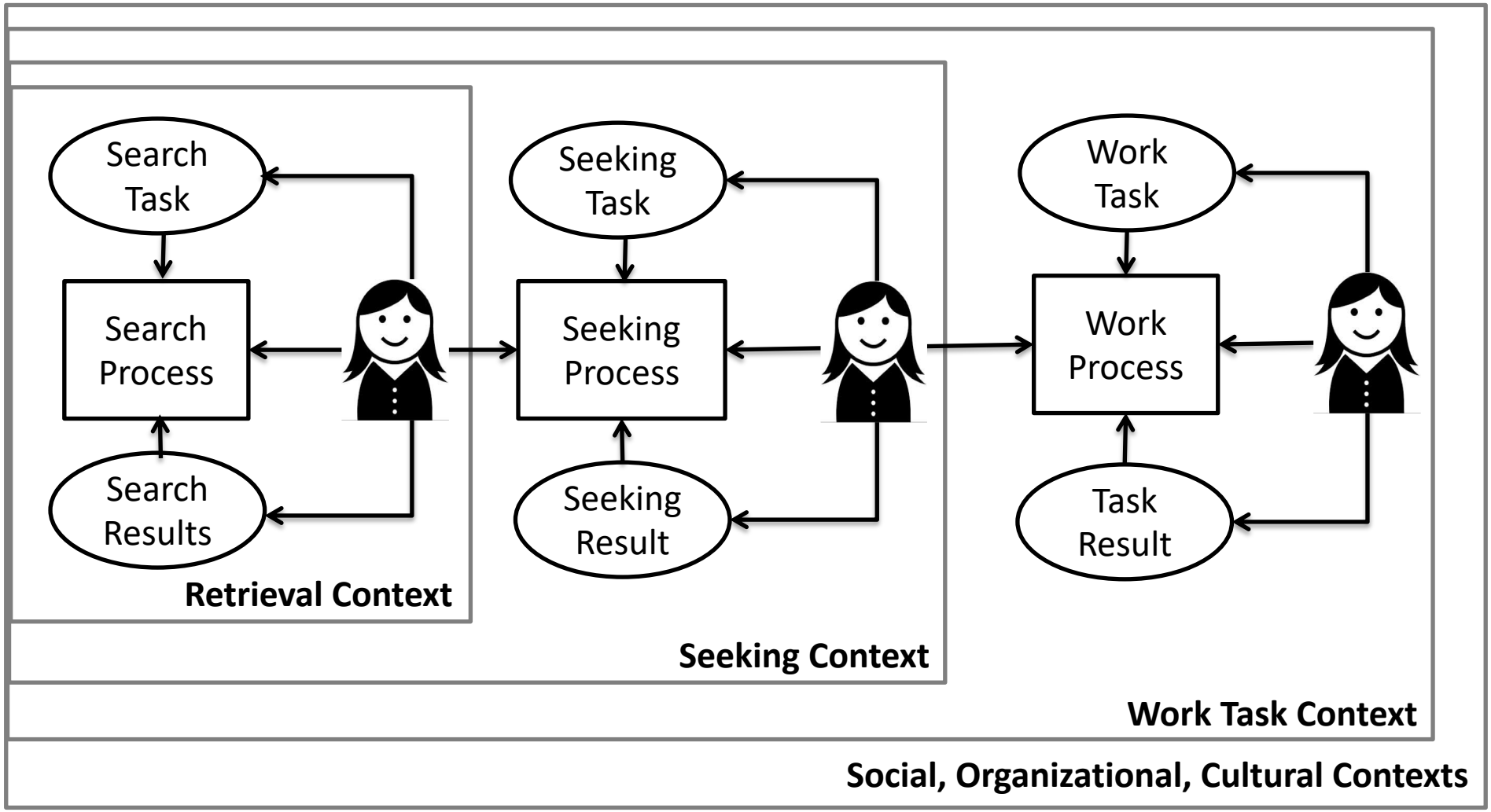
Jarvelin (2011)

Current Approach to HCI

- **HCI is largely empirical & observational**
  - Very good at cataloguing what users do, and at eliciting user requirements
- **not "formal theory" driven!**
  - Few formal models
  - The models usually come after the design, the experiments
  - Not good at explaining why!

Kelly & Sugimoto (2013)

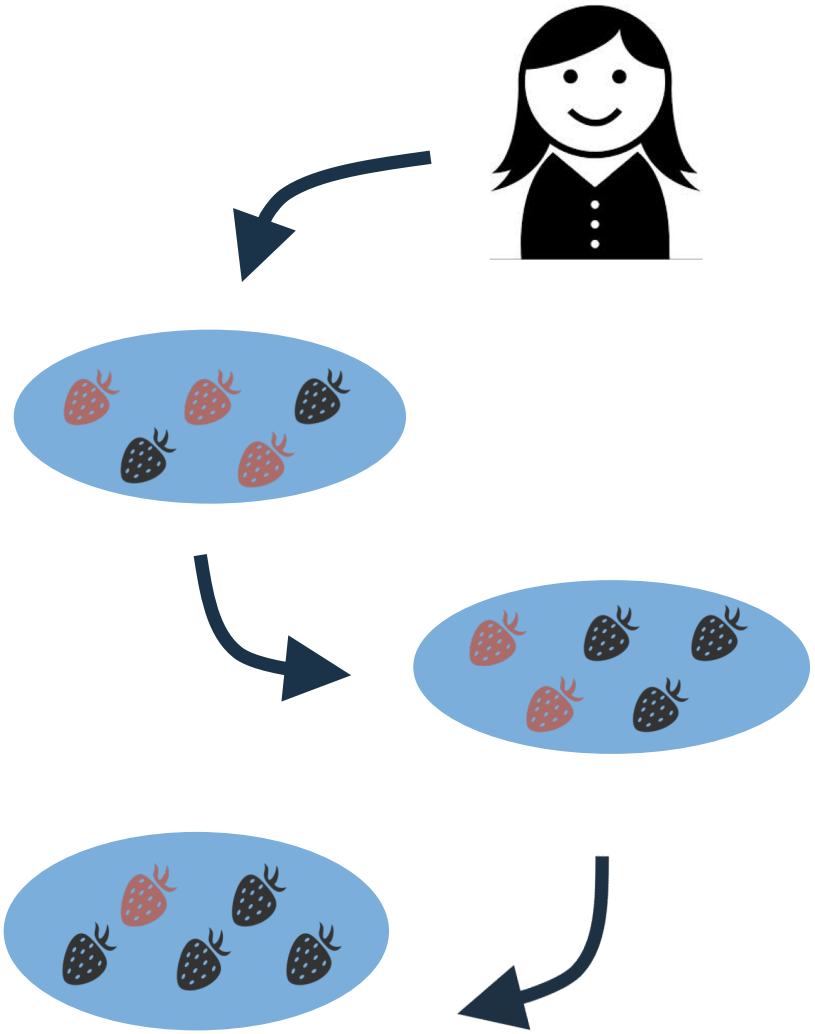
Information Seeking & Retrieval Model



An example of a conceptual model

Ingwersen & Jarvelin (2005)

Bates' Berry Picking Models



An example of a conceptual model

Descriptive models are useful.

But we need models that are also **predictive** and **explanatory.**

Bates (1989)

Major Research Challenge

Human Computer Interaction needs formal models to:

- **describe**, **predict** and **explain** user behaviors
- provide a basis on which to **reason** about interaction,

Solution: Economics

help guide the design, development and research of information systems, interfaces and agents and

- derive **laws** and **principles** of interaction
  - e.g. Fitt's Law, Hicks' Law

ECONOMIC THINKING

Some core concepts

Scarcity and Choice

- People always want more! **Unlimited Wants**!
  - I want to see all the CHI papers
  - I want to upgrade all the Pokemons
- But, **people** often **don't have enough resources**
  - I don't have enough time, candy, energy, etc.
- There **aren't enough resources** to go around or satisfy all our needs and desires.
  - This leads to trade-offs

Poverty of Attention

*"What **information consumes** is rather obvious: it consumes the **attention** of its recipients.*

*Hence a **wealth of information creates a poverty** of attention, and a need to **allocate** that **attention efficiently** among the overabundance of information sources that might consume it."*

Simon (1955)

Scarcity and Choice

- Economics is the study of how people
  - choose to use their scarce resources in an attempt to satisfy their unlimited wants.
  - And the trade-offs and choices that people make, given the fact of scarcity
  - I'll upgrade Pikachu and not Eevee
- People make decisions in their own self-interest, weighing benefits and costs.
  - 2 pcs candies to power up to get few more combat points VS. 25 pcs to evolve and get special abilities and a new Pokemon

Resources

- Four types of productive resources
  - Resources have to be able to produce something
  - **Land**: any natural resource
  - **Economic Capital**: anything that's manufactured in order to be used in the production of goods and services
  - **Labor**: any human service (physical or intellectual)
  - **Entrepreneurship**: the ability of someone to recognize or look for opportunities, organize the other factors of productions and take risk

Opportunity Cost

- **Limited resources**, means **making** a **choice** about how to use them
  - When you choose one option, you forego other options
  - **Opportunity Cost**
    - indicates what must be given up to obtain something that else
    - And is the value of the next best alternative
  - Since people must choose, they inevitably face trade-off
- Provides a means for reasoning about how good/bad a decision is

Division of Labor

- The way a good or service is produced can often be divided into a number of tasks
  - These can be performed by different workers

- This lead to **specialization**
  - In MOBAs like DOTA, players specialize (supports, mid, carries, feeders, noobs, etc.)

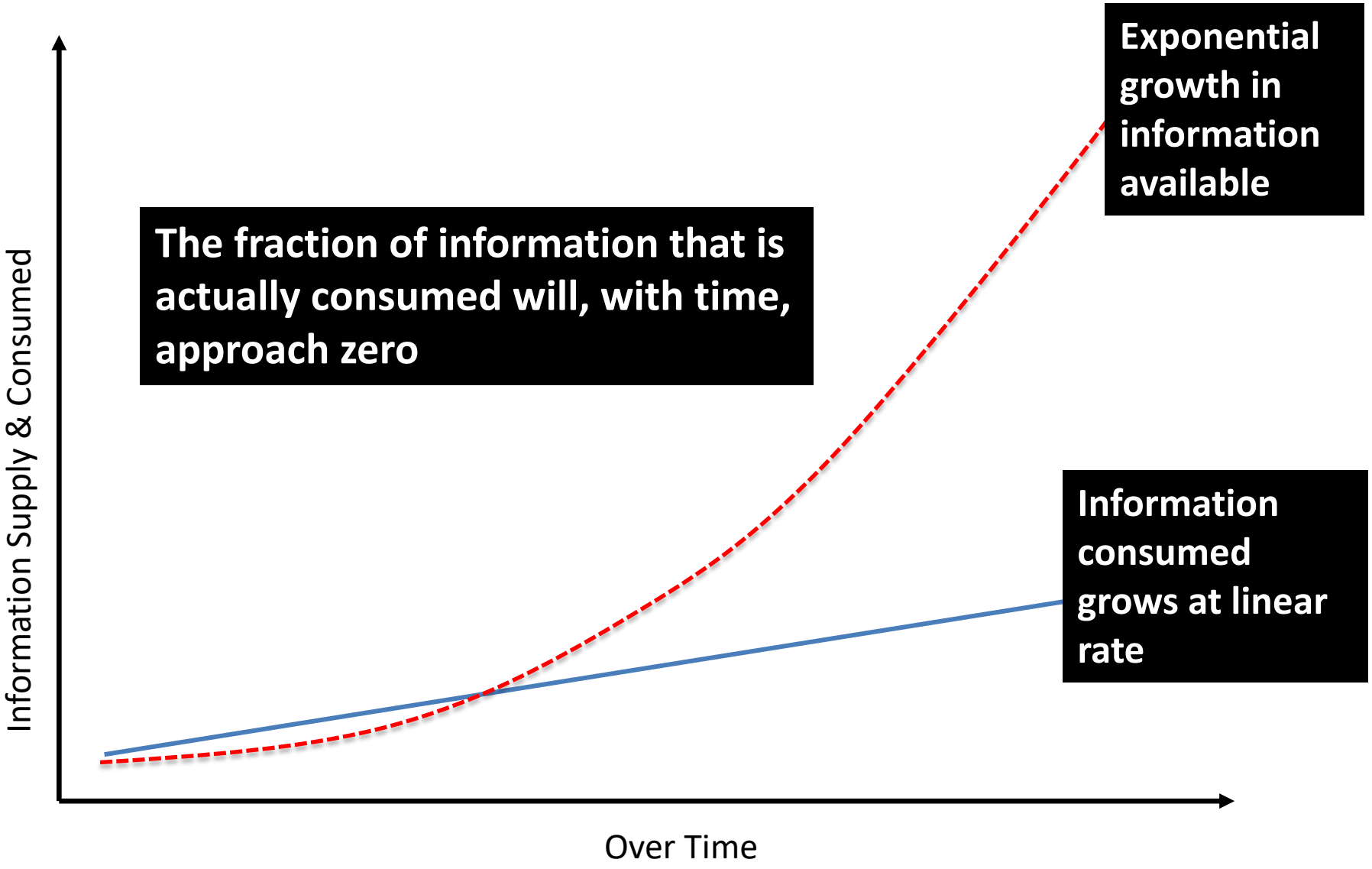
Division of Labor

- **Specialization** enables **economics of scale**
  - As the level of production increases, the average cost of producing each unit declines.
- The **division** and **specialization** of labor has been a force against the problem of scarcity.
  - Especially in collaborative environments, we need therefore to be mindful of how people/agents are specializing (or not)
  - Write a document in Word, different roles are "supported" through different views/menus/ribbons

Micro vs Macro

- **Microeconomics:** focuses on the actions of individuals
  - What determines how people allocate their budget?
  - What combination of interactions/services best fits their wants?
  - How should people and agents work together?
- **Macroeconomics:** focuses on the economy/ecosystem as a whole, i.e. the population level
  - E.g. filter bubbles, algorithmic bias, popularity bias
  - The Attention Economy

Why is Attention Scarce?



Economic Models

- **Economic Model**: a simplified version of reality that allows us to observe, understand and make predictions about behavior

- An **Economic Model** takes a complex real-world situation and boils it down to the essentials
  - it could be a narrative model, e.g. law of demand
  - here we will mostly focus on mathematical models
    - E.g. Formal Models

Perceived Problems w/ Formal Models

- a **ruthless abstraction** of **reality**
- **marginalize** the **user** & **ignore context**
- contain **math** & **equations** & **formulas**
- contain **math** & **equations** & **formulas**
- **look scary** and are **intimidating**
- **not very explained well**
- **appear complex** & are **hard to interpret**
- Often **difficult** to **operationalize** in **practice**

Benefits of Formal Models

- a **ruthless abstraction** of **reality**
- **focus** on the **salient variables**
- **precisely relate** these **variables together**
  - And so are often mathematical
- **produce testable hypotheses**
- can be **elegant**, **insightful** & **beautiful**
- **intellectually**, they are **desirable**
  - they can **ground** our **science**

Why don’t we have lots of formal models?

- Often it is **hard** to **understand** what is going on?
  - Different contexts/users, many observed behaviors
  - Same context, many observed behaviors
- **Too many variables**, **too complex**
  - Often we throw our hands up at the problem
  - Its impossible, people are unpredictable
- There is general **belief** that is **can’t be done**
  - Yet, we can model the universe, but not people?

Why don't we have lots of formal models?

- **Abstraction** is **hard**. Abstraction is really hard
- Modeling requires a **deep understanding** of the process and tasks
  - Often pre-theoretical work needs to be performed *a priori*
  - Background knowledge is needed
  - Observations are required to developed intuitions
- They are scary – **BOO**!

What is next?

- Now:
  - Formalizing intuitions – usability guidelines
- Next:
  - Building Cost Models
  - Performing Cost Benefit Analysis
  - Comparing Features/Methods
  - Defining Optimization Models to explore trade-offs
- Then:
  - Examples and the practical session

What makes a “good” interface?

1. Strive for Consistency

Designing “consistent interfaces” means using the same design patterns and the same sequences of actions for similar situations. This includes, but isn’t limited to, the right use of color, typography and terminology in prompt screens, commands, and menus throughout your user journey.

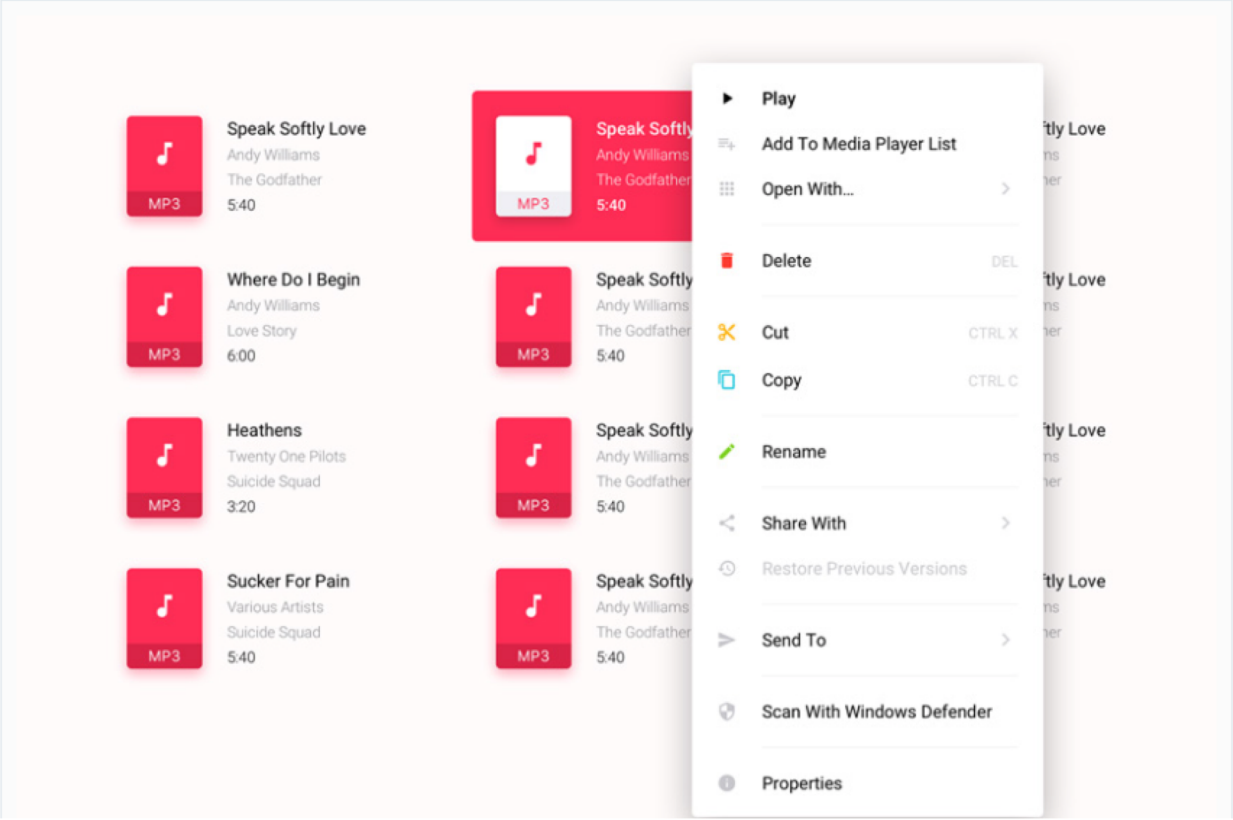
Remember: a consistent interface will allow your users to complete their tasks and goals much more easily.

2. Enable Frequent Users to Use Shortcuts

Speaking of using UI rules as shortcuts, your users will benefit from shortcuts as well, especially if they need to complete the same tasks often.

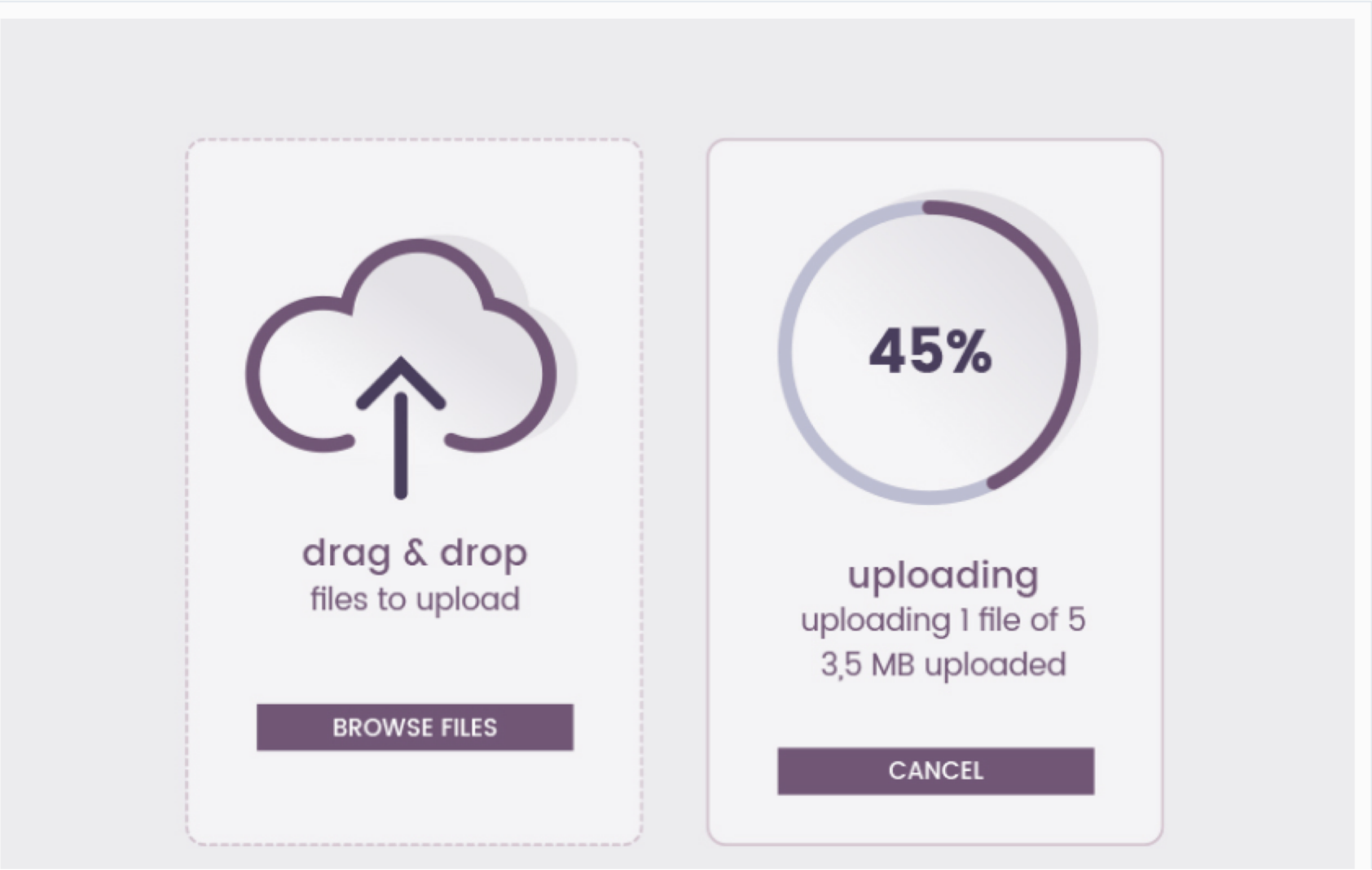
Expert users might find the following features helpful:

- Abbreviations
- Function keys
- Hidden commands
- Macro facilities



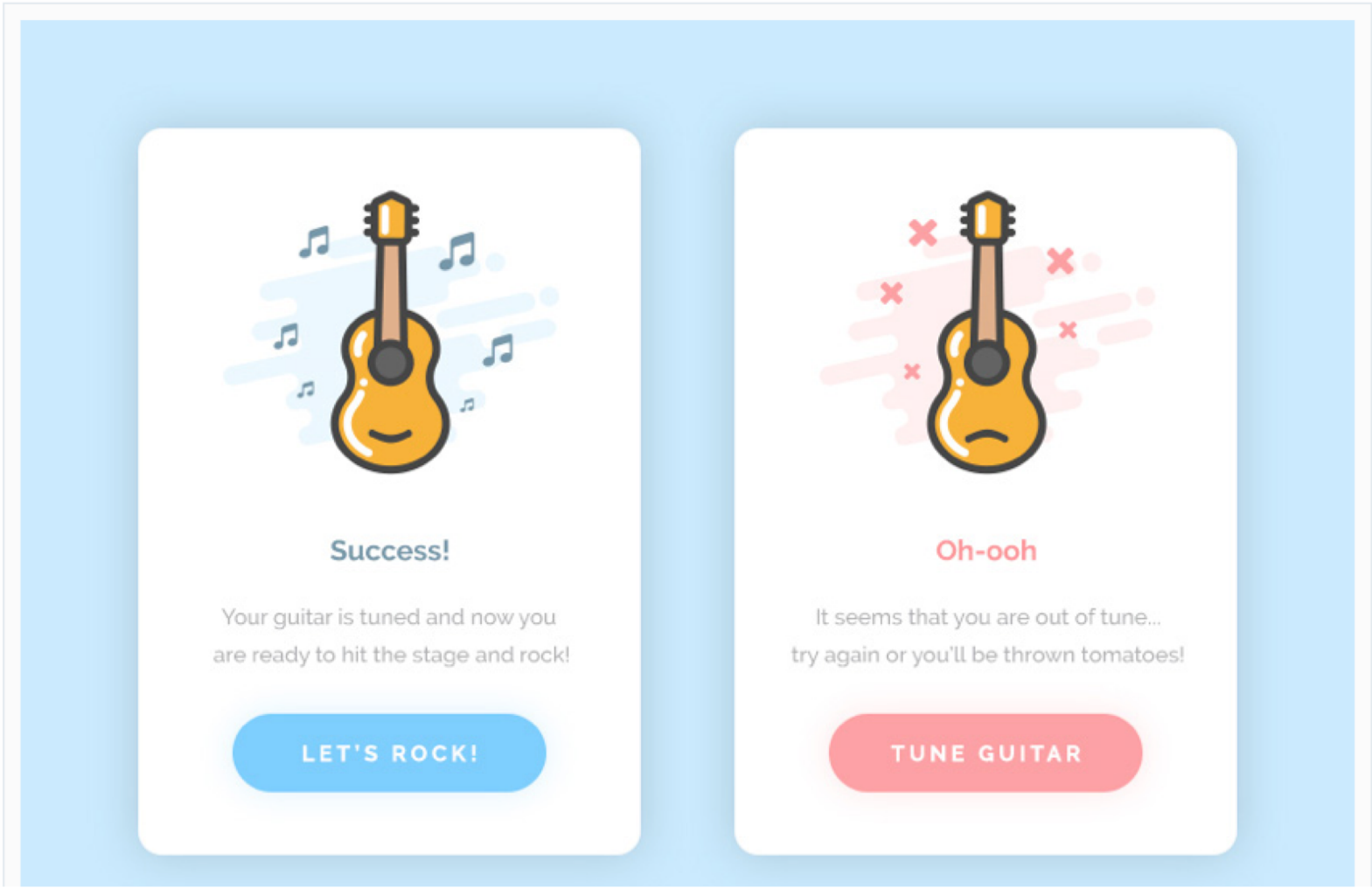
3. Offer Informative Feedback

You need to keep your users informed of what is happening at every stage of their process. This feedback needs to be meaningful, relevant, clear, and fit the context.



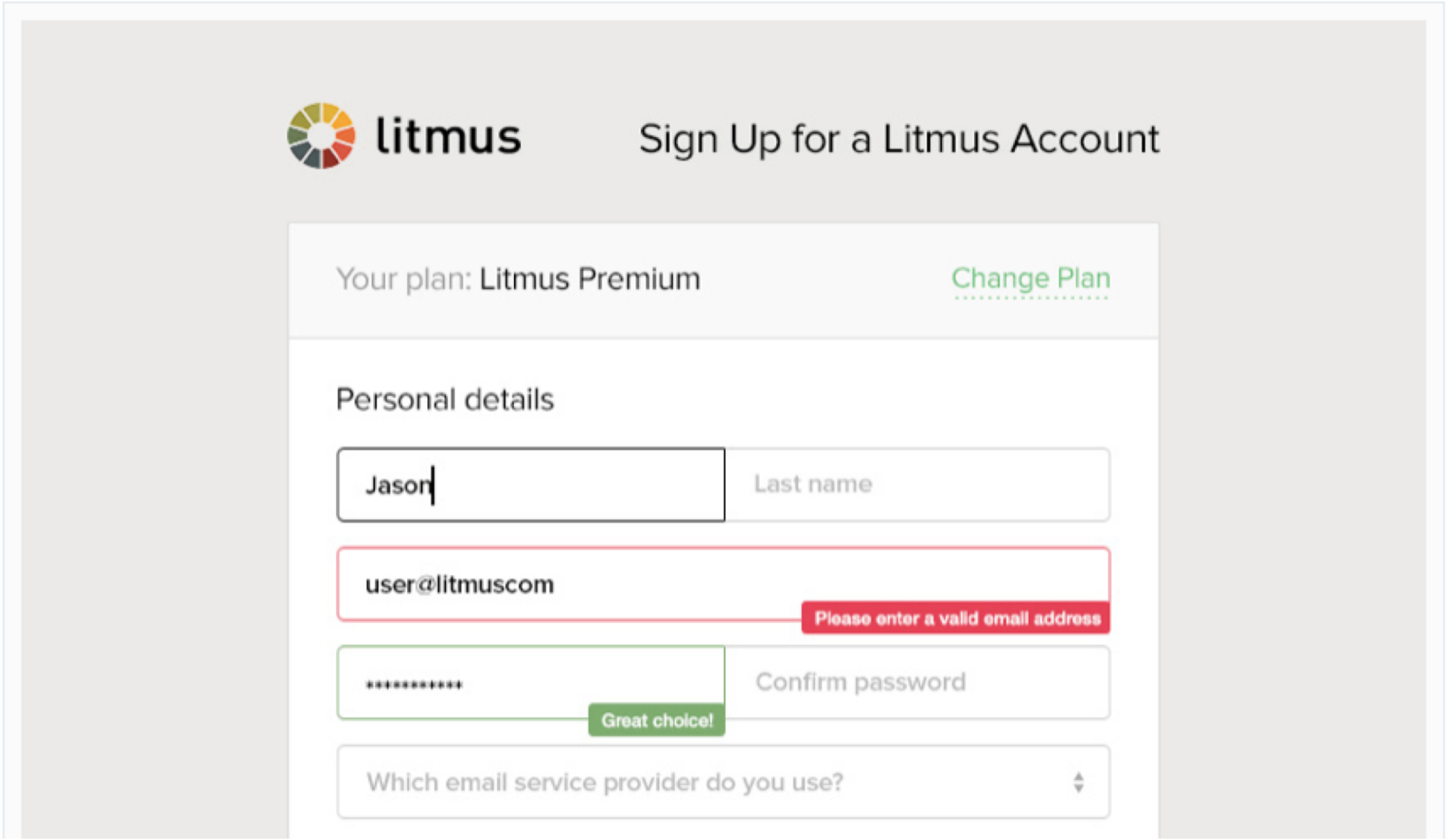
4. Design Dialog to Yield Closure

Let me explain. Sequences of actions need to have a beginning, middle and end. Once a task is completed, give some peace of mind to your user by providing them informative feedback and well-defined options for the next step if that's the case. Don't keep them wondering!



5. Offer Simple Error Handling

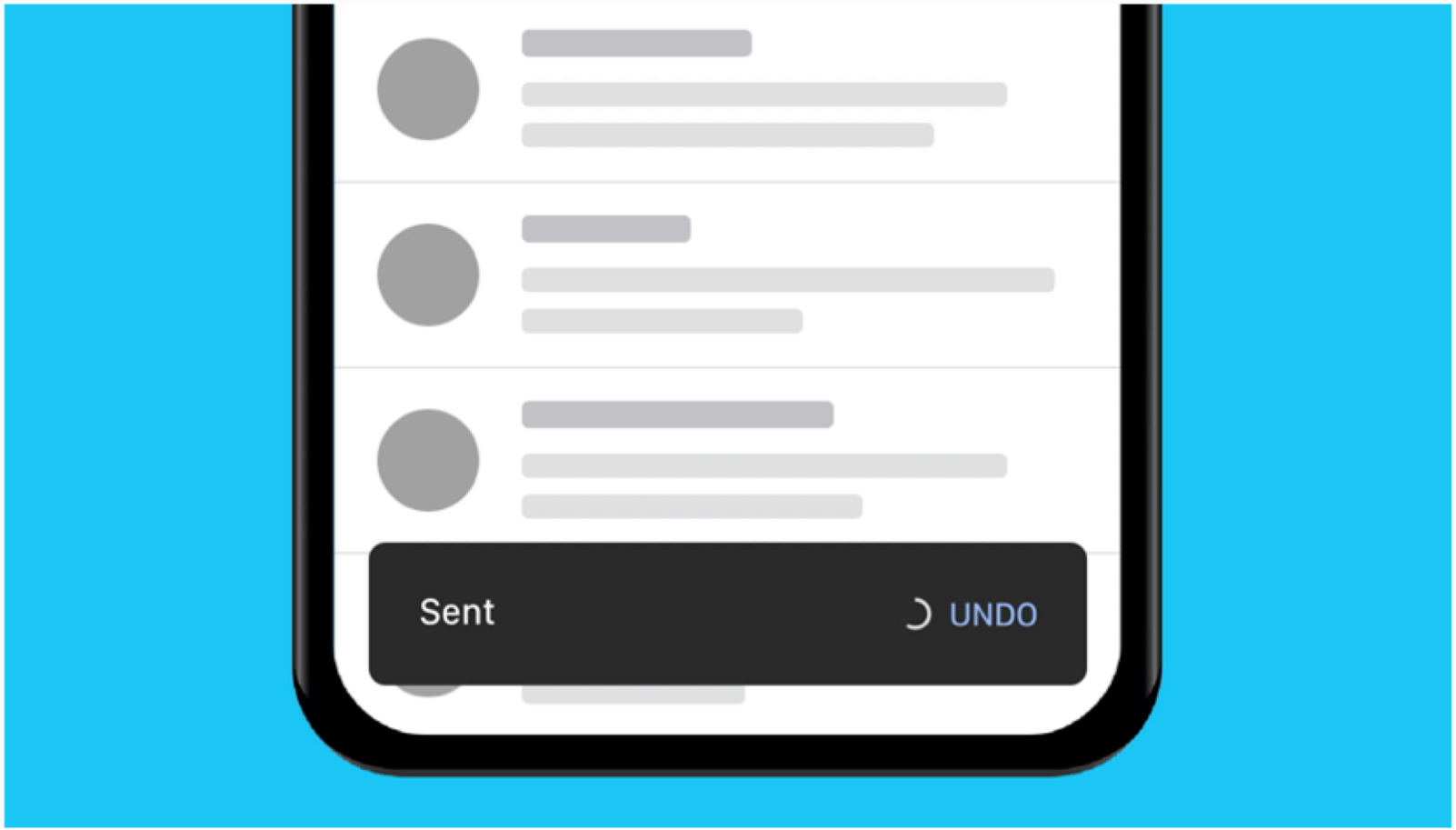
A good interface should be designed to avoid errors as much as possible. But when errors do happen, your system needs to make it easy for the user to understand the issue and know how to solve it. Simple ways to handle errors include displaying clear error notifications along with descriptive hints to solve the problem.



6. Permit Easy Reversal of Actions

It's an instant relief to find that "undo" option after a mistake is made. Your users will feel less anxious and more likely to explore options if they know there's an easy way to reverse any accidents.

This rule can be applied to any action, group of actions, or data entry. It can range from a simple button to a whole history of actions.



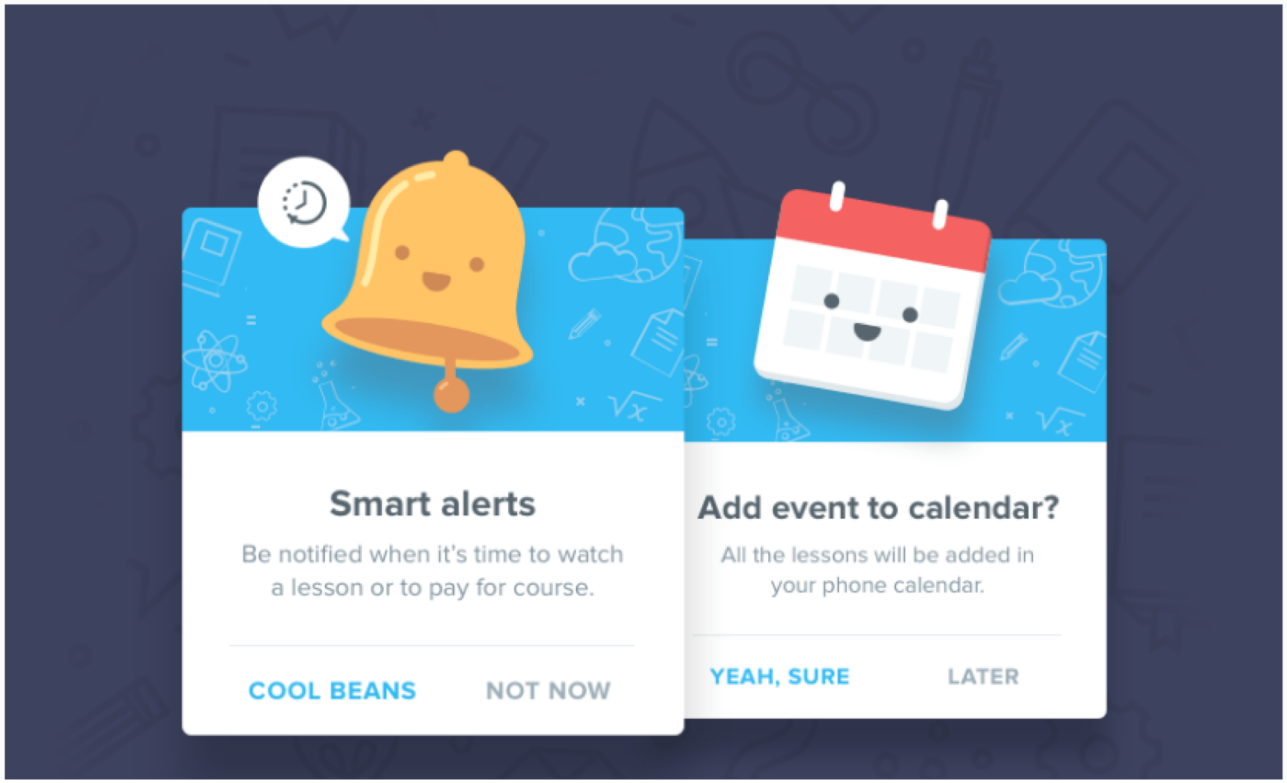
7. Support Internal Locus of Control

First, a definition:

> *"In personality psychology, locus of control is the degree to which people believe that they have control over the outcome of events" — Julian Rotter*

It's important to give control and freedom to your users so they're able to feel they're in charge of the system, not the other way round. Avoid surprises, interruptions, or anything that hasn't be prompted by the users.

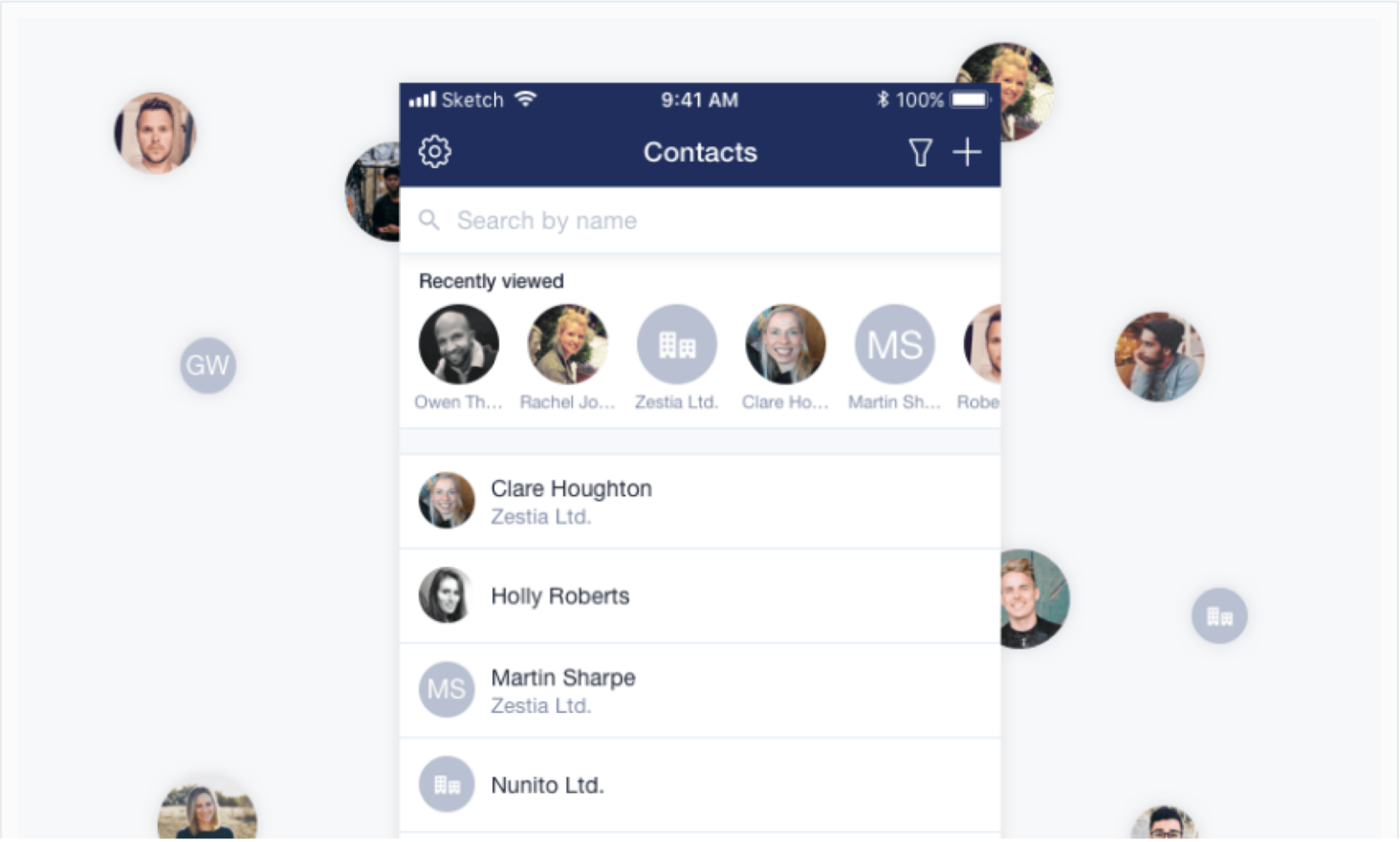
Users should be the initiators of the actions rather than the responders.



8. Reduce Short-Term Memory Load

Our attention span is limited and anything we can do to make our users' job easier, the better. It's simpler for us to recognize information rather than recall it. Here, we can refer to one of Nielsen's principles describing "recognition over recall". If we keep our interfaces simple and consistent, obeying to patterns, standards and conventions, we are already contributing to better recognition and ease of use.

There are several features we can add to aid our users depending on their goals. For example, in an ecommerce environment, a list of recently viewed or purchased items.



END OF SESSION ONE