

Week 6-3

HCI Research and Design Trends

SFWRENG 4HC3/6HC3 Human Computer Interfaces

** Slides adapted from previous instructors of COMPSCI/SFWRENG 4HC3/6HC3*

Week 6 Overview

- Monday
 - Task Analysis and HTA
- Wednesday
 - Perception and Vision
- Friday
 - HCI Research
 - Design Trends

What is HCI Research

Human-Computer Interaction (HCI) is the study of how people interact with computers and digital systems, focusing on designing better, more intuitive interfaces and experiences.

HCI combines computer science, psychology, design, cognitive science, sociology, and engineering to create human-centered technology.

What is HCI Research

Core Questions HCI Researchers Ask:

- How can we make technology more intuitive and accessible?
- What new ways can humans input information and control devices?
- How do we design for emerging technologies (AI, VR, autonomous vehicles)?
- How can technology enhance human capabilities rather than replace them?

Overview of Areas

1. Input & Interaction Techniques

- Novel input methods beyond keyboard/mouse/touch
- Gestural interfaces, voice, eye-tracking, brain-computer interfaces
- Haptic feedback and tangible interfaces

2. Human-AI Interaction (HAI)

- Designing transparent, trustworthy AI systems
- Co-creative AI tools and AI assistants
- Explainable AI and human-AI collaboration

3. Automotive & Mobility Interfaces

- Autonomous vehicle interfaces and trust
- Driver attention and distraction management
- In-vehicle experiences and handoff protocols

4. Accessibility & Inclusive Design

- Assistive technologies for disabilities
- Universal design principles
- Age-inclusive interfaces

■ Overview of Areas

5. Virtual/Augmented/Mixed Reality (XR)

- Spatial computing and 3D interfaces
- Presence and embodiment in virtual spaces
- Social VR and telepresence

6. Playful & Gameful Design

- Games as research platforms
- Gamification for behavior change
- Play in serious contexts (health, education, work)

7. Social Computing & CSCW

- Computer-Supported Cooperative Work
- Online communities and social media
- Remote collaboration tools

8. Ubiquitous & Mobile Computing

- Context-aware systems
- Internet of Things (IoT) interfaces
- Wearable computing

Novel Input Techniques: Mid-Air Haptic Feedback

The Challenge: Traditional touchscreens and interfaces lack physical feedback, requiring constant visual attention and reducing interaction accuracy and satisfaction.

Mid-Air Haptics Innovation: Ultrasonic haptic systems create tactile sensations in 3D space without physical contact by using focused ultrasound waves to generate pressure on skin.

Key Applications:

- **Eyes-free interaction** - Drivers can feel virtual controls without looking away from the road
- **AR/VR enhancement** - Users can "touch" and feel virtual objects with realistic feedback
- **Accessibility** - Provides tactile information for visually impaired users
- **Multimodal experiences** - Combining haptics with audio and visual feedback
- **Research Questions:** How do users perceive different haptic patterns? How can we create realistic textures? What combinations of modalities work best?

Novel Input Techniques: Mid-Air Haptic Feedback

FabSound: Audio-Tactile Fabric Experiences,
<https://dl.acm.org/doi/10.1145/3613904.3642533>

Can we create realistic fabric sensations in virtual environments by combining ultrasonic haptics with sound?

Method:

- Created digital haptic textures for 9 different fabrics (cotton, silk, wool, etc.)
- Generated corresponding fabric rubbing sounds with varied frequency and volume
- Tested how audio-tactile combinations affect perception of texture qualities

Automotive UI: Designing for Autonomous Vehicles

As vehicles become more autonomous, the human-machine relationship fundamentally changes. Drivers become supervisors, passengers, or collaborators depending on automation level.

Key Research Challenges:

- **Takeover scenarios** - When and how should vehicles request human control?
- **Trust calibration** - Building appropriate (not excessive or insufficient) trust in automation
- **External communication** - How should AVs communicate intent to pedestrians and other road users?
- **Non-driving activities** - What can/should passengers do during automated driving?
- **Transparency** - Showing what the vehicle "sees" and why it makes decisions
- **Design Tensions:** Balancing automation benefits with human agency, safety with usability, innovation with user acceptance.
- **Real-World Impact:** These interfaces directly affect safety, adoption rates, and public acceptance of autonomous vehicles.

Automotive UI: Designing for Autonomous Vehicles

External Interfaces for Pedestrian Safety

Exploring the Impact of Interconnected External Interfaces in Autonomous Vehicle, <https://dl.acm.org/doi/10.1145/3613904.3642118>

- How should autonomous vehicles communicate with pedestrians at crossings, especially when multiple AVs are present? Do coordinated displays work better than independent ones?

Method:

- VR experiment with 32 participants in realistic crossing scenarios
- Tested three conditions: no eHMI, independent vehicle displays, interconnected coordinated displays
- Measured crossing decisions, confidence, safety perception, and gaze behavior

Human-AI Interaction: From Tools to Collaborators

The Paradigm Shift: AI is evolving from a tool that executes commands to a collaborative partner that suggests, creates, and co-authors with humans.

Key Research Areas:

Co-Creation & Collaboration:

- How much should AI contribute vs. human?
- What collaboration patterns emerge in creative work?
- How do teams adapt when AI joins the process?

Explainability & Trust:

- Making AI decisions transparent and understandable
- Building appropriate reliance (not over- or under-trust)
- Showing uncertainty and confidence levels

Control & Agency:

- Mixed-initiative interaction (both human and AI can take initiative)
- Contestability - users should be able to override AI
- Avoiding automation bias and skill degradation

Human-AI Interaction: From Tools to Collaborators

Shaping Human-AI Collaboration: Varied Scaffolding Levels in Co-writing with Language Models, <https://dl.acm.org/doi/10.1145/3613904.3642134>

- How does the level of AI assistance (low vs. high scaffolding) affect writing quality and productivity?

Method:

- Within-subjects experiment with 131 participants
- Three conditions: no AI, next-sentence suggestions (low), next-paragraph suggestions (high)
- Argumentative writing tasks, measured quality (expert ratings) and productivity (words/time)

Playful Interaction: Serious Applications of Games

Play is a fundamental human activity that drives motivation, learning, and social connection. Games provide rich contexts for studying engagement, behavior change, and interaction design.

Research Directions:

Games for Health:

- Physical fitness (exergames, VR fitness)
- Mental health (anxiety reduction, PTSD therapy, emotional regulation)
- Cognitive training for elderly populations
- Rehabilitation and physical therapy

Serious Games & Gamification:

- Educational games that don't feel like "edutainment"
- Behavior change (sustainability, health habits)
- Citizen science (players contributing to real research)
- When does gamification work vs. backfire?

Social & Emotional Impact:

- How games facilitate connection (especially post-pandemic)
- Designing for positive social interactions
- Games for empathy building and perspective-taking

How can we design playful experiences that achieve serious goals without feeling manipulative?

Playful Interaction: Serious Applications of Games

MindTerior: A Mental Healthcare Game with Metaphoric Gamespace,
<https://doi.org/10.1145/3544549.3583831>

- Uses interior design as a metaphor for mental/emotional states—players "decorate" rooms representing their feelings while engaging in evidence-based psychological activities.

Approach:

- Translates clinical interventions (cognitive restructuring, emotion regulation) into playful mechanics
- Players choose furniture, colors, and decorations that reflect their emotional journey
- Activities embedded naturally in gameplay rather than feeling like exercises
- Progress visualized through increasingly comfortable, personalized living spaces

General Themes in HCI Research

Ethics & Values:

- Algorithmic fairness and bias mitigation
- Privacy-preserving design
- Dark patterns and manipulative interfaces
- Digital wellbeing and attention economy
- Consent and agency in AI systems

Sustainability:

- Green computing and energy-efficient interfaces
- Technology for climate action
- E-waste and circular design
- Sustainable interaction patterns

Inclusivity & Justice:

- Participatory design with marginalized communities
- Decolonizing HCI methods and assumptions
- Global South perspectives
- Intersectional approaches to accessibility

Transparency & Control:

- Explainable AI and algorithmic transparency
- User control over data and automation
- Contestability, ability to challenge system decisions

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Why Design Trends Matter

- Design trends reflect technological capabilities and user expectations
- Each trend solves specific problems of its era
- Understanding evolution helps predict future directions
- Modern design often combines multiple trend elements

Example: Apple iOS

iOS 6 (2012) - Skeuomorphism Peak:

- Yellow lined notepad paper in Notes
- Bookshelf interface in Newsstand
- Metallic microphone in Voice Memos
- Glossy, button-like icons with depth and shadows
- Leather textures, wood grain, realistic materials

Why it worked: Helped new smartphone users understand unfamiliar digital interfaces through familiar real-world metaphors



Example: Apple iOS

iOS 7 (2013) - The Flat Design Revolution

- "There is a profound and enduring beauty in simplicity, in clarity, in efficiency"

Changes:

- Removed all textures and realistic materials
- Flat, two-dimensional icons
- Thin fonts and minimal colors
- Translucent "frosted glass" effects for layering
- Focus on content over decoration

Impact: Most influential design change in mobile history, set standards for entire industry

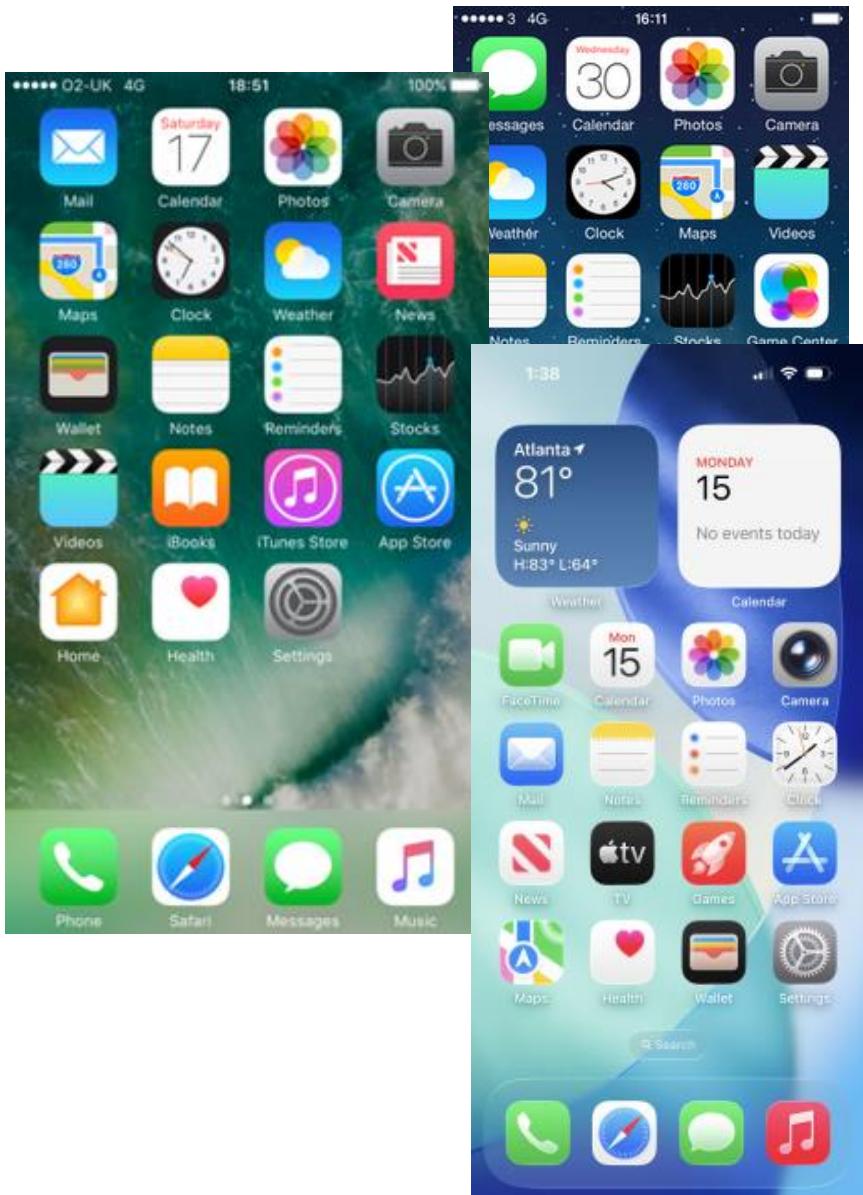


Example: Apple iOS

iOS Today - Hybrid Approach

Evolution Since 2013:

- Gradually reintroduced subtle shadows (iOS 9+)
- Thickened fonts for better accessibility
- Maintained flat aesthetic with selective depth cues
- Recent "Liquid Glass" design (iOS 26) brings back semi-transparent, layered elements
- Balance between minimalism and usability

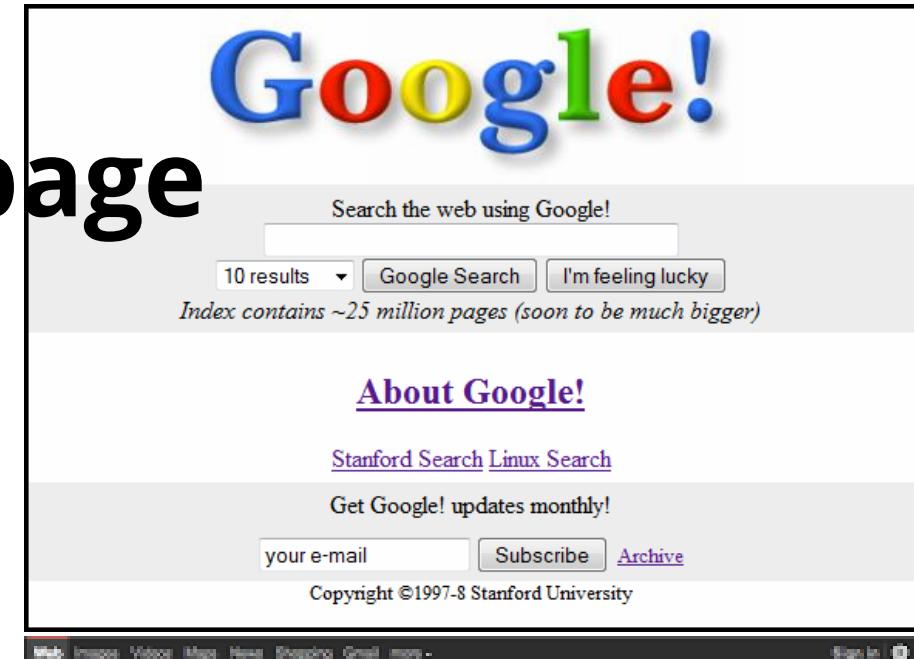


Example: Google Homepage

1998 - Original Design:

- Simple search box and colorful logo
- "I'm Feeling Lucky" button (still there today!)
- Minimal links and clean layout
- Stark contrast to competitors like Yahoo, AltaVista

Strategy: Focus users on ONE action, searching



[Advertising Programs](#) | [Business Solutions](#) | [About Google](#) | [Privacy](#)

[Change background image](#)

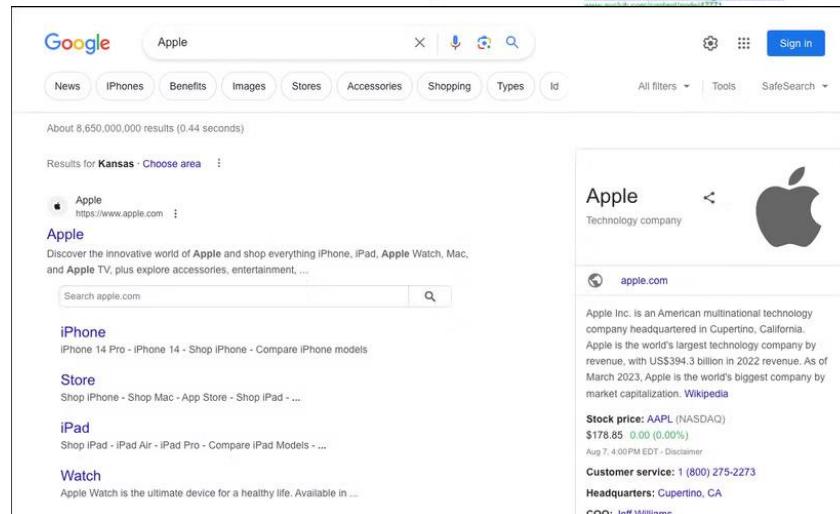
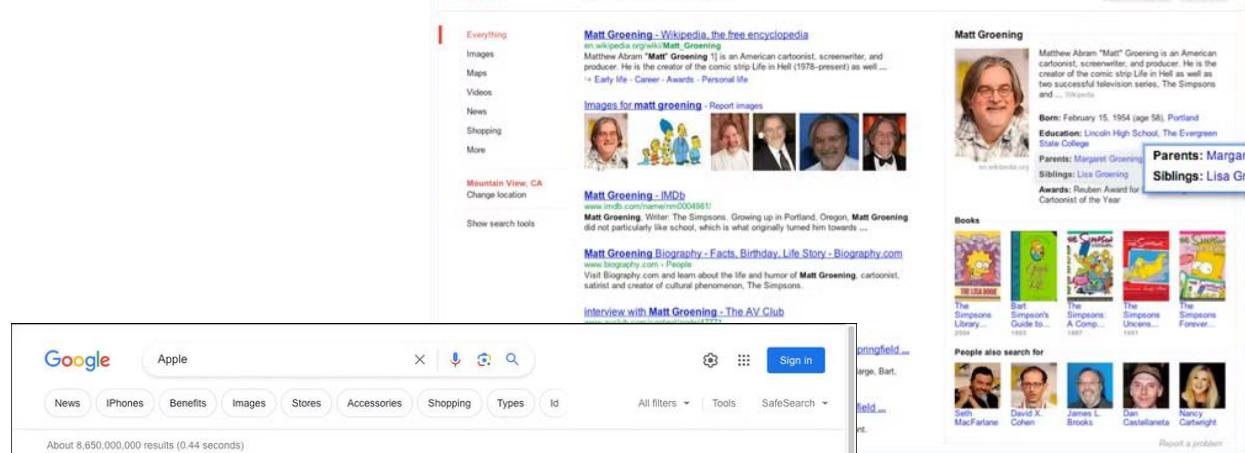
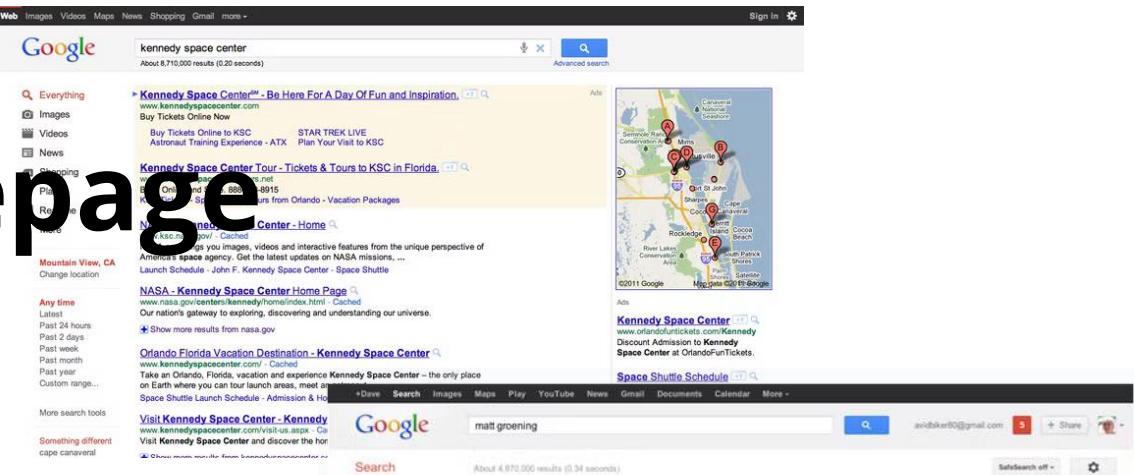
Example: Google Homepage

Key Evolution Points:

- **2000:** Added language options, kept clean design
- **2001:** Introduced tabbed interface for images/groups
- **2009-Present:** Even MORE minimal—removed unnecessary elements

Competitive Advantage:

- Competitors cluttered homepages with news, links, ads
- Google's minimalism made it faster and easier to use
- Design philosophy: "Less is more" from day one



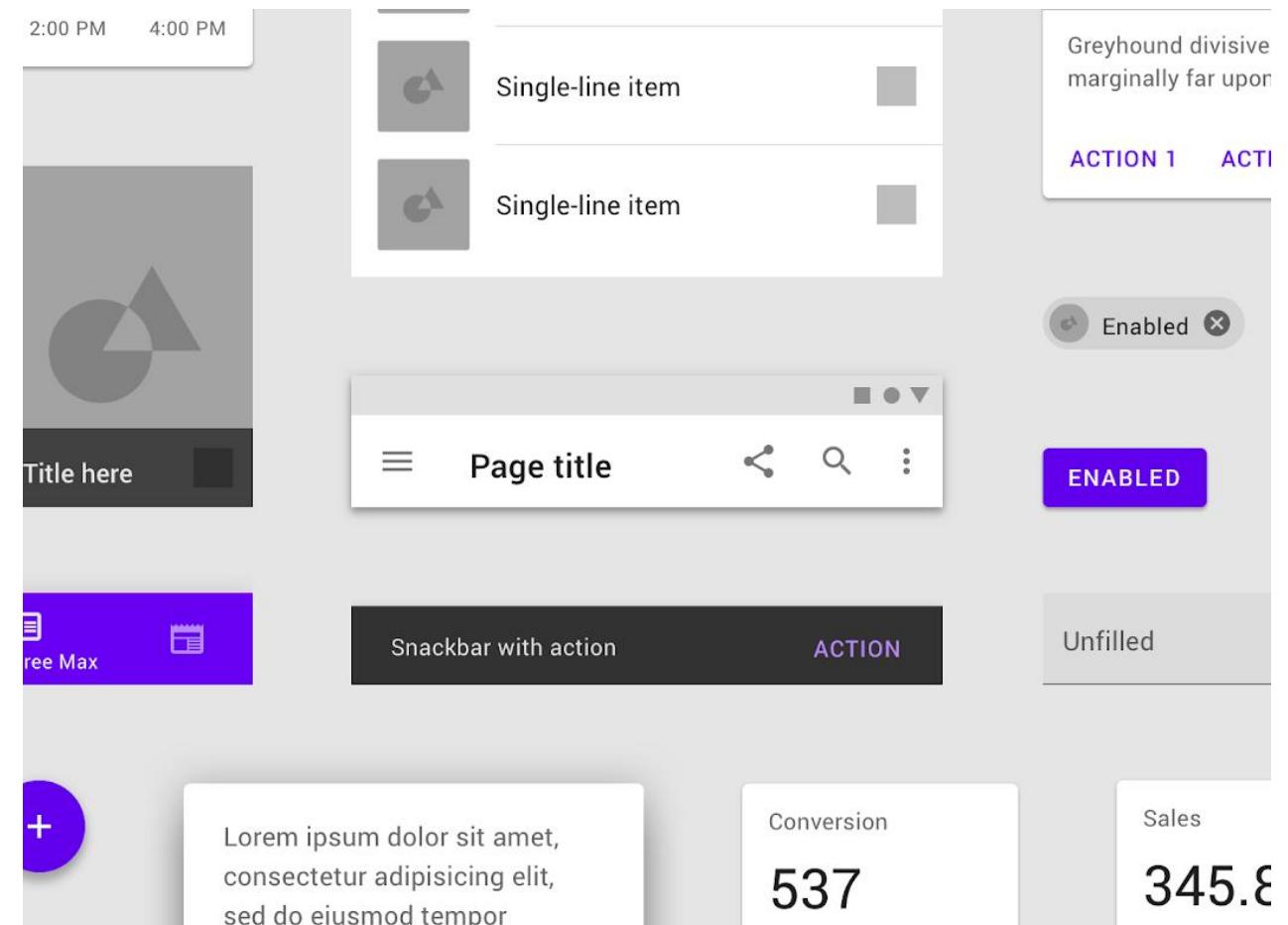
Example: Material Design

Launched 2014:

- Inspired by paper and ink (physical metaphor)
- But executed with flat, clean aesthetics
- Uses "elevation" and subtle shadows to show hierarchy
- Animation shows spatial relationships

Strict Guidelines:

- No two elements can overlap
- All materials are opaque
- Nothing folds or bends
- Grid-based layouts with crisp edges



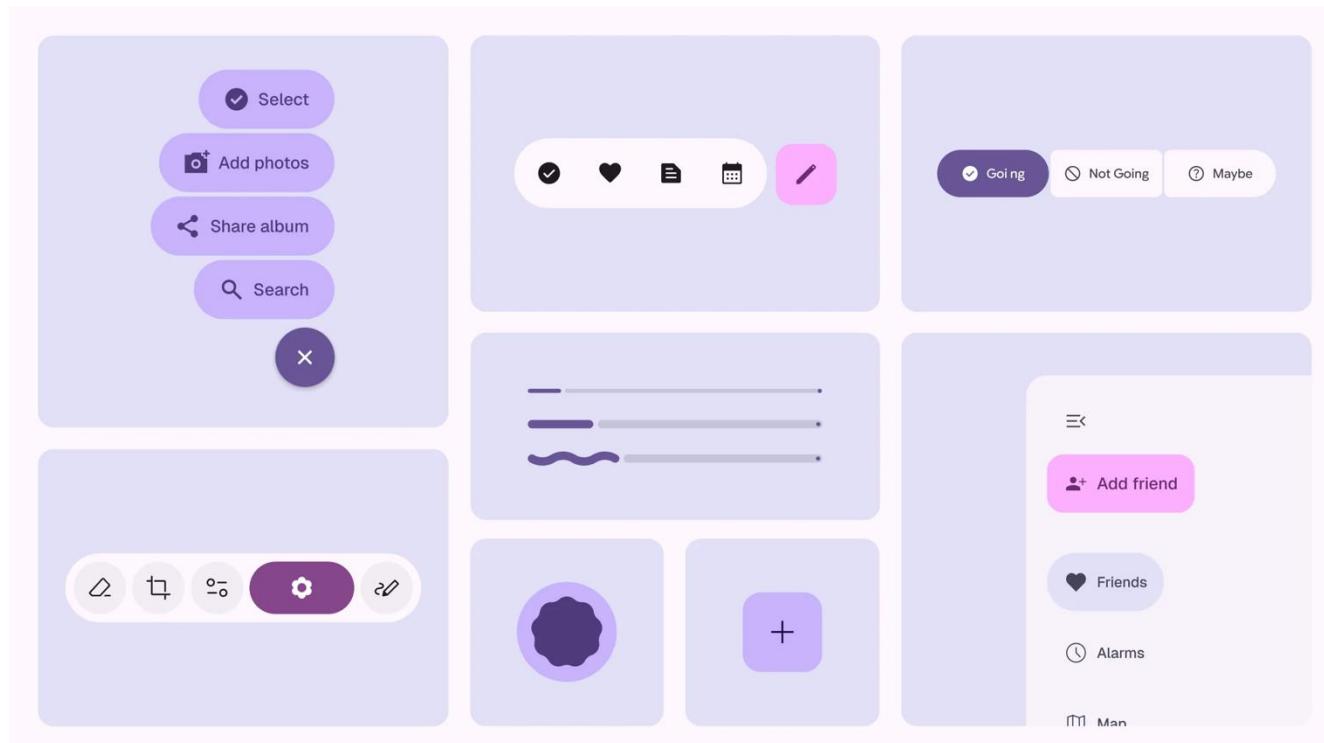
Example: Material Design

Why It Matters:

- Solved the "which side are you on" debate
- Combined best of both worlds
- Provided comprehensive design system
- Evolution continues (Material Design 3 adds more depth)

Influence:

- Adopted beyond Google products
- Inspired Microsoft Fluent Design
- Popularized "design systems" approach
- Made skeuomorphism vs. flat a false choice



Example: Conversational UI

What Changed:

- Voice assistants: Siri (2011), Alexa (2014), Google Assistant (2016)
- Chatbots and messaging interfaces
- AI-powered assistants like ChatGPT (2022), Claude (2023)
- Shift from buttons/menus to natural language

Why Now:

- Natural Language Processing breakthroughs
- Users comfortable "talking" to devices
- Mobile-first world makes typing tedious
- AI can understand context and intent

Example: Conversational UI

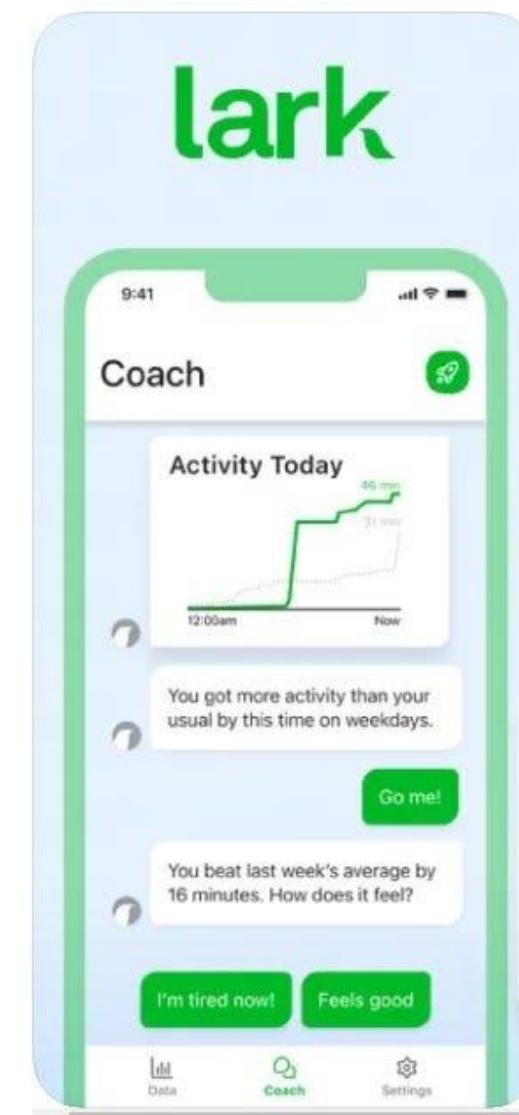
Chat-Based Interfaces:

- Customer service chatbots
- Banking apps with conversational flows
- Health apps that "interview" users
- E-commerce shopping assistants

Multimodal Experiences:

- Voice + visual results
- Text input + rich media responses
- Conversational search (Google, Perplexity)
- AI coding assistants (GitHub Copilot)

When to use conversation vs. traditional UI?



Resources

<https://www.webdesignmuseum.org/>

Most technology companies have blogs just for their design:

- <https://design.google/>
- <https://medium.com/uber-design>
- <https://design.facebook.com/blog/>