Wisdom is not the product of schooling but the lifelong attempt to acquire it.
- Albert Einstein

Distributed Cognition: Toward a New Foundation for Human-Computer Interaction Research

Gerhard Fischer and Hal Eden

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paper: Hollan, J., Hutchins, E., & Kirsch, D. (2001) "Distributed Cognition: Toward a New Foundation for Human-Computer Interaction Research." In J. M. Carroll (Ed.) Human-Computer Interaction in the New Millennium, ACM Press, New York, pp. 75-94.

Core Issues of Human-Computer Interaction (HCI)

- "reality is **not** user-friendly"
- the user interface is **not** the major problem for HCI research
- most users are not interested in computers per se, but in their **tasks**
- **"high-tech scribes"** and "**complete idiots**" are not the primary computer users
- experts (= users who know everything about a domain or a tool) do not exist → complex systems can and will not be completely learned and **learning on demand** is a necessity

Beyond Human-Computer Interaction

- **human-computer interaction is more than user interfaces**
  Applying the Macintosh style to poorly designed applications and machines is like trying to put Béarnaise sauce on a hot-dog! (A. Kay)

- **make systems useful and usable**
  If ease of use was the only valid criterion, people would stick to tricycles and never try bicycles. (D. Engelbart)

- **the human mind is limited**
  Humans have a bounded rationality. (H. Simon)

- **support human problem-domain interaction**
  Interfaces get into the way. I don't want to focus my energies on an interface. I want to focus on the job. (D. Norman)

Useful versus Usable

- **usable (as main objective):**
  - novices
  - limited functionality
  - low threshold to get started
  - walk-up and use
  - “experts” exist
  - understandable model of the complete system can be developed
  - examples: original MacIntosh, ATMs, VCRs

- **useful (as main objective):**
  - skilled users
  - broad functionality
  - high ceiling for skilled users
  - no “experts” (→learning on demand is a necessity rather than a luxury)
  - no complete models
  - end-user modifiability, programmability
  - examples: Unix, application programs (e.g., MS-Word, Excel, Mathematica)

goal: useful and usable

Success Stories of Useful and Usable:
A Large Hardware Store with Knowledgeable Sales Agents

- empirical study: McGuckin Hardware in Boulder, Colorado — more than 350,000 different line items
- problem setting and problem solving are intertwined
- queries are articulated incrementally, situations talk back, examples are critical
- to determine the relevance of a found object requires domain knowledge (e.g., “simulation of use” — the plumber story)
- a shared understanding is incrementally achieved between customer and sales agent
- summary: “computer systems have the same functionality as McGuckin, but are operated like K-Mart”

Missing from HCI Research

- **a motivation perspective**
  - intrinsically motivating computational environments
  - what will make users want to share? (e.g., design rationale: who is the beneficiary and has to do the work?)
  - making information relevant to the task at hand
  - example: good computer games

- **a learning perspective**
  - life-long learning and learning on demand
  - integration of working and learning
  - example: high-functionality applications (HFAs)

- **a change and evolution perspective**
  - users change
  - artifacts change tasks, work, organizations
  - media/technology changes
  - organizations change
  - examples: co-adaptive systems, evolutionary design of complex systems, design-in-use

Going BEYOND

- novice → skilled domain worker
- direct manipulation → programmability, end-user modifiability
- information overload → saying the "right" thing at the "right" time in the "right" way
- system creation → system evolution
- tools → human-centered agents (goal sharing, information delivery)
- solving "given" problems → integration of problem framing and problem solving
- HCI → human problem-domain communication (HPDC)

Distributed Cognition

Einstein: "My pencil and I are more clever than I"

- **traditional view:** *"human cognition has been seen as existing solely 'inside' a person's head, and studies on cognition have by and large disregarded the social, physical, and artifactual surroundings in which cognition takes place"*

- **claim*:*** **distributed cognition** provides an effective theoretical framework for understanding what humans can achieve and how artifacts, tools, and socio-technical environments can be designed and evaluated to empower humans beings and to change tasks

Internal and External Cognition

- **anatomy is not destiny**

- **claim:** "the story of the human race is one of ever-increasing intellectual capability. Since our early cave-dwelling ancestors, our brain have gotten no bigger, our hands no more nimble, but there has been a steady accretion of new tools for physical and intellectual work"

- **Jerome Bruner**
  - "Human's use of mind is dependent upon her/his ability to develop and use tools or instruments or technologies that make it possible for him to express and amplify her/his powers" — p 471 in Education as Social Invention
  - "'how the mind works is itself dependent on the tools at its disposal" (compare: "'how the hand works cannot be fully appreciated unless one also takes into account whether it is equipped with a screwdriver, a pair of scissors, …..") — p 8 in Culture of Education
  - Bruner, Culture of Ed, p 8: "if a theory of mind is to be interesting educationally, it should contain some specifications for (or at least implications bearing on) how its functioning can be improved or altered in some significant way" — p 8 in Culture of Education

Ethnography

- cognition in the wild → data from “beyond the laboratory”
- interviewing
- surveys
- participant observation
- video and auto recording
- automated recording of histories of interaction (in HCI)
- examples:
    - ship navigation
    - airline cockpit automation
    - beyond direct manipulation

Active Representations

- dynamic forms
- dynamic menus
- official airline guide
- history-enriched digital objects (“read and edit wear”)
- PAD++: Zoomable Multiscale Interfaces

Forms of Distribution

- **forms of distribution**:
  - across the members of a social group leading to social creativity, facilitated by systems suchas Web2gether
  - between internal and external structures
  - throughout time (long-term, indirect collaboration)

- **advantage of humans:** shared understanding and shared background knowledge

- **advantage of things** (Illich, p 125)**:** → the "Nobel Prize Winner" fallacy

  "a thing is available at the bidding of the user - or could be - whereas persons formally become a skill resource only when they consent to do so, and they can also restrict time, place, and methods as they choose."

- claim: working with people with **cognitive disabilities**
  - creates new unique challenges for our theories about distributed cognition
  - provides us with a deeper understanding of distributed cognition

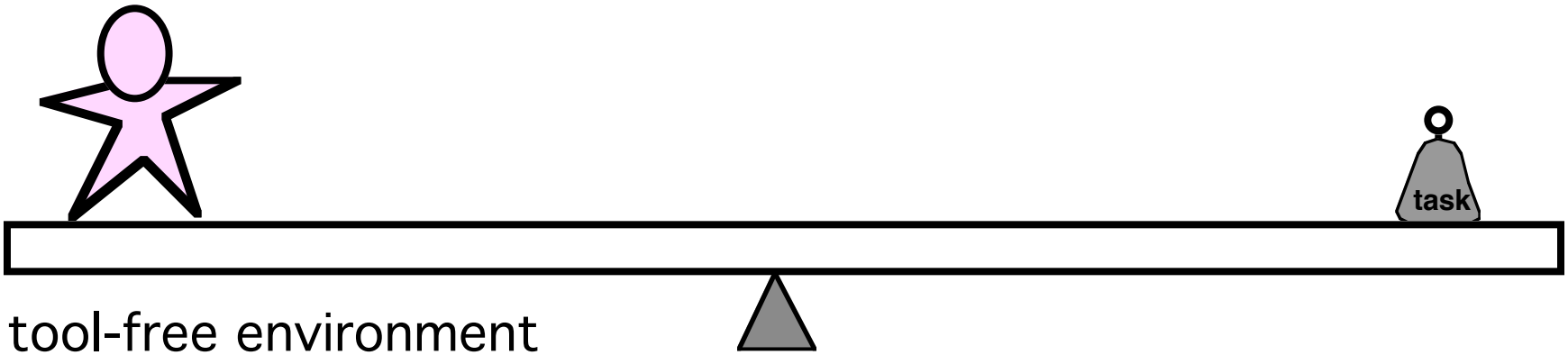
Distributed Cognition and HCI

Bands of Cognition: Biological, Cognitive, Rational, and Social

	TIME	ACTION	MEMORY	THEORY
sec	common units			
10^9	(decades)	Technology	Culture	
10^8	(years)	System	Development	Social and
10^7	(months)	Design	Education	Organizational
10^6	(weeks)	Task	Education	
10^5	(days)	Task	Skill	
10^4	(hours)	Task	Skill	Bounded
10^3	(ten mins)	Task	LTM	Rationality
10^2	(minutes)	Task	LTM	
10	(ten secs)	Unit task	LTM	Cognitive and
1	(secs)	Operator	STM	Psychological
10^{-1}	(tenths)	Cycle time	Buffers	
10^{-2}	(centisecs)	Signal	Integration	Neural and
10^{-3}	(millisecs)	Pulse	Summation	Biochemical

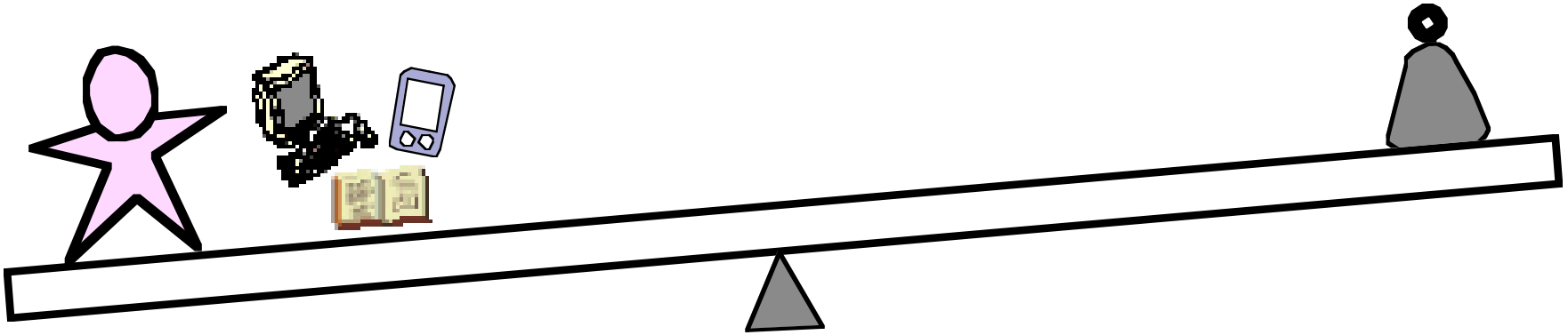
The Unaided, Individual Human Mind

humans can achieve tasks restricted to a certain difficulty by relying only on the unaided mind and acting as individuals



Media as Extensions of Humans Missed Opportunities

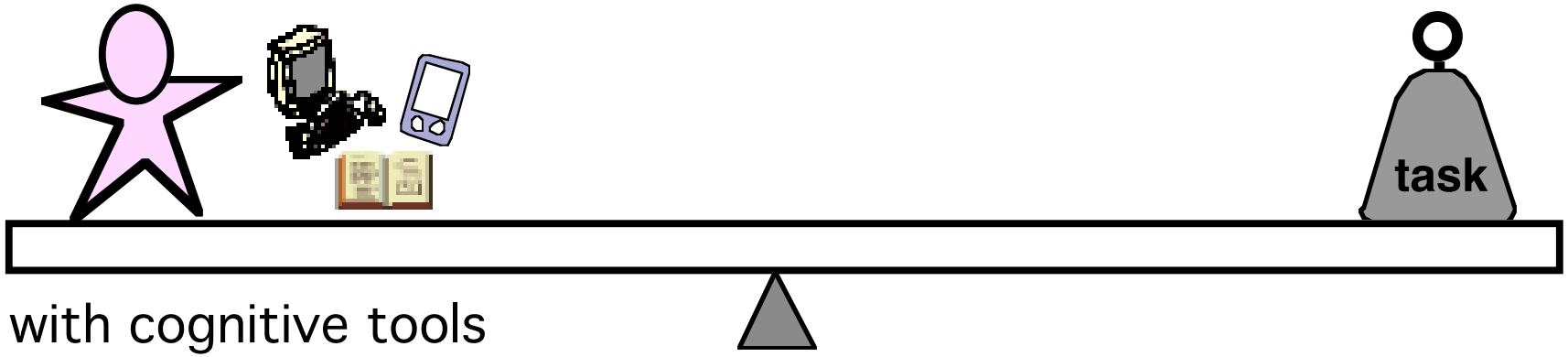
with tools/media, humans have more power attempting the same set of tasks with tools will provide no challenges and will lead to missed opportunities



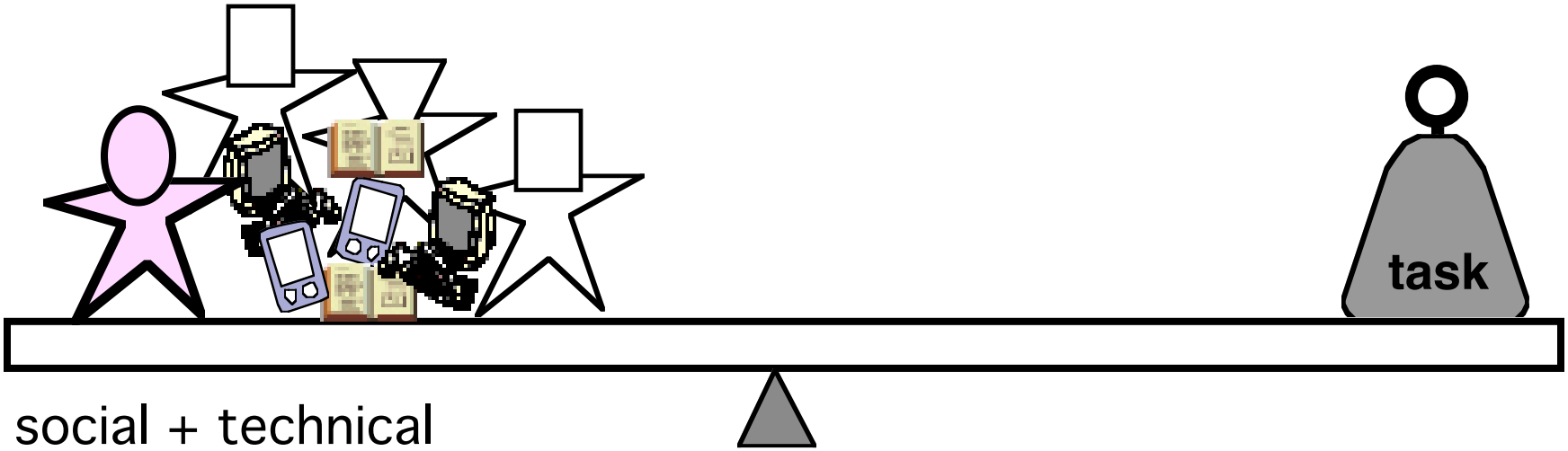
with cognitive tools

Achieving More Challenging Tasks with Media

with tools/media, humans have more power ⇒ more difficult tasks can be undertaken



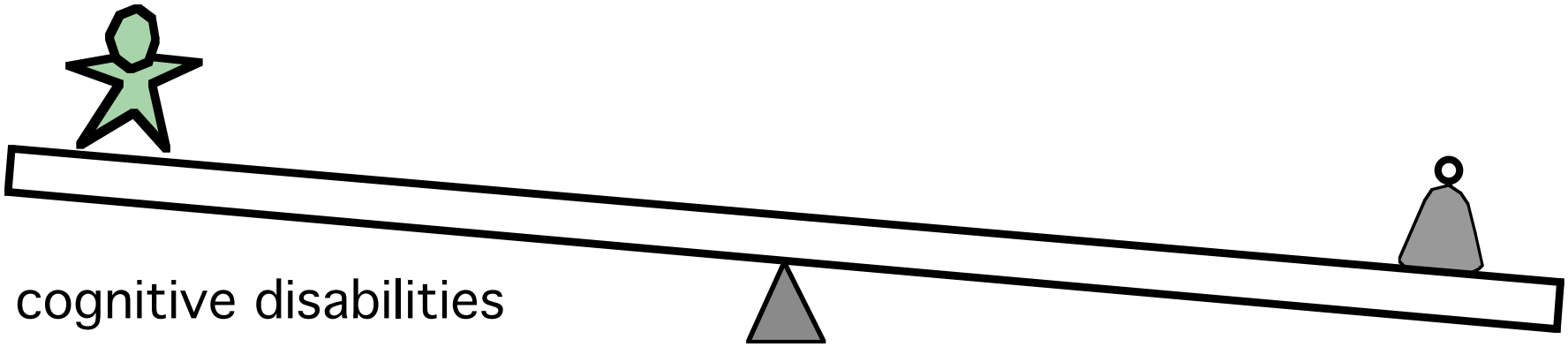
Collaborative Minds and Social Creativity



Cognitive Disabilities and New Media and Technologies

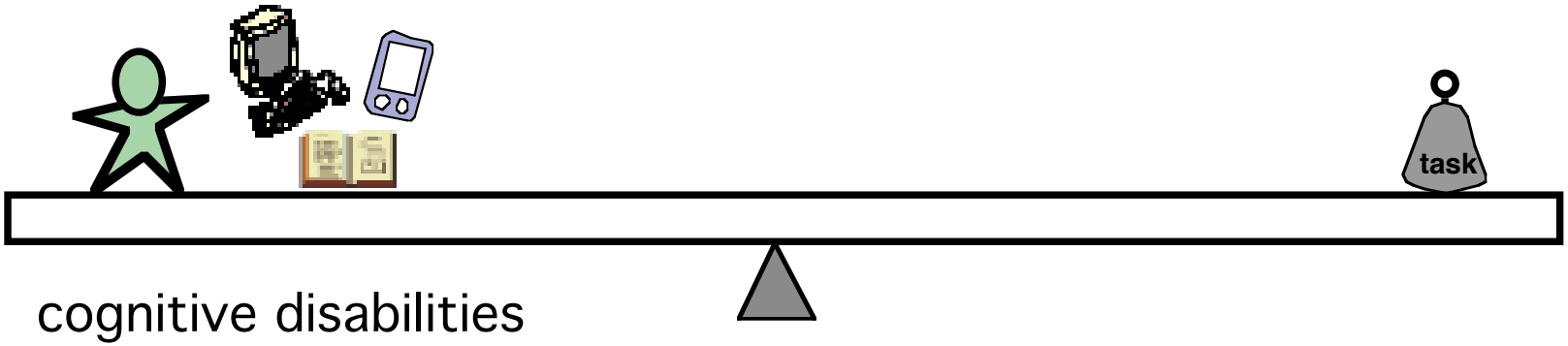
Without Tools: Severe Limitations Exist

even simple tasks are hard to achieve (e.g., simple plans can not be maintained)



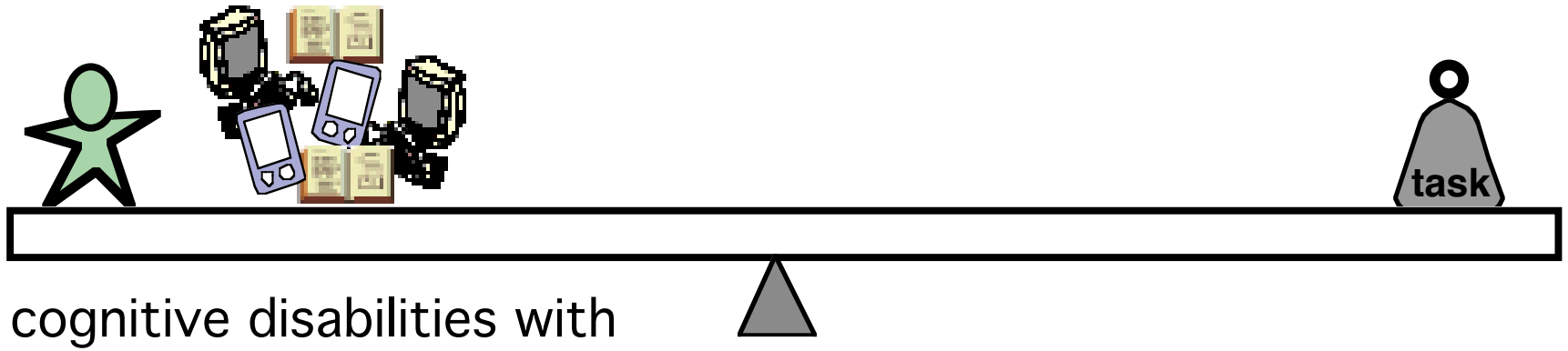
Cognitive Disabilities and Media and Technologies: the "standard tool" set is not good enough

while the "standard tool" set gives some empowerment, it allows only moderately challenging tasks to be achieved



- **claims:**
  - the "standard tool" set fails (e.g., reading and writing), because people with disabilities are lacking the cognitive requirements to use the tools)
  - we need more than "alterations" to existing tools which were developed for people without disabilities
  - we need tools **explicitly** developed for people with cognitive disabilities

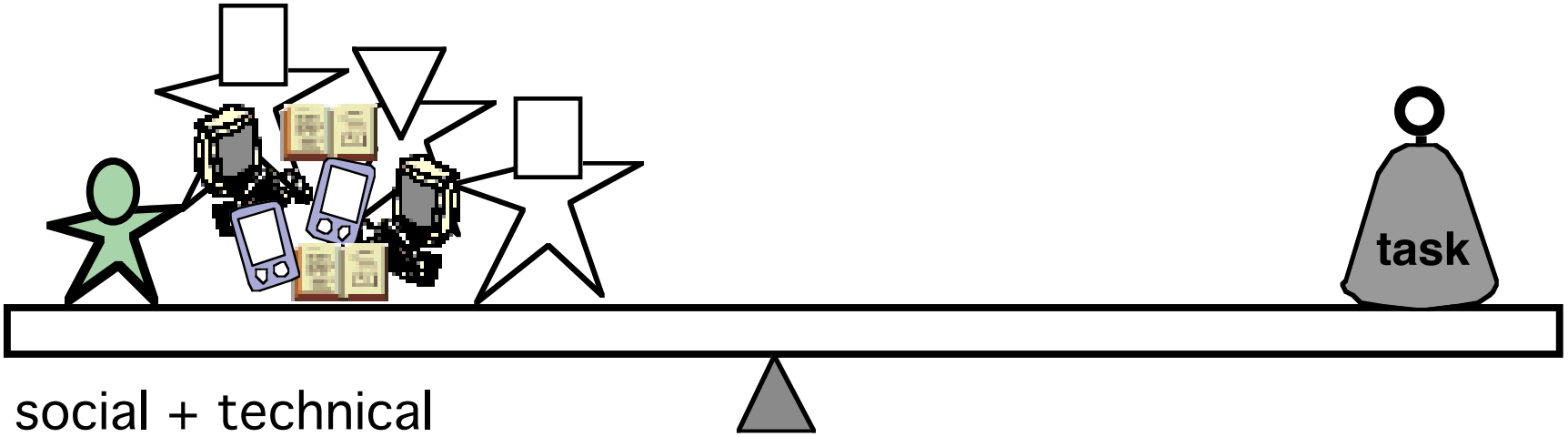
Media as “Information Prosthesis”



- **examples of elements of the “greatly enriched toolset”:**
  - personal prompting devices (MAPS)
  - mobility-for-all
  - greatly simplified interfaces
  - tools with fewer prerequisites to master

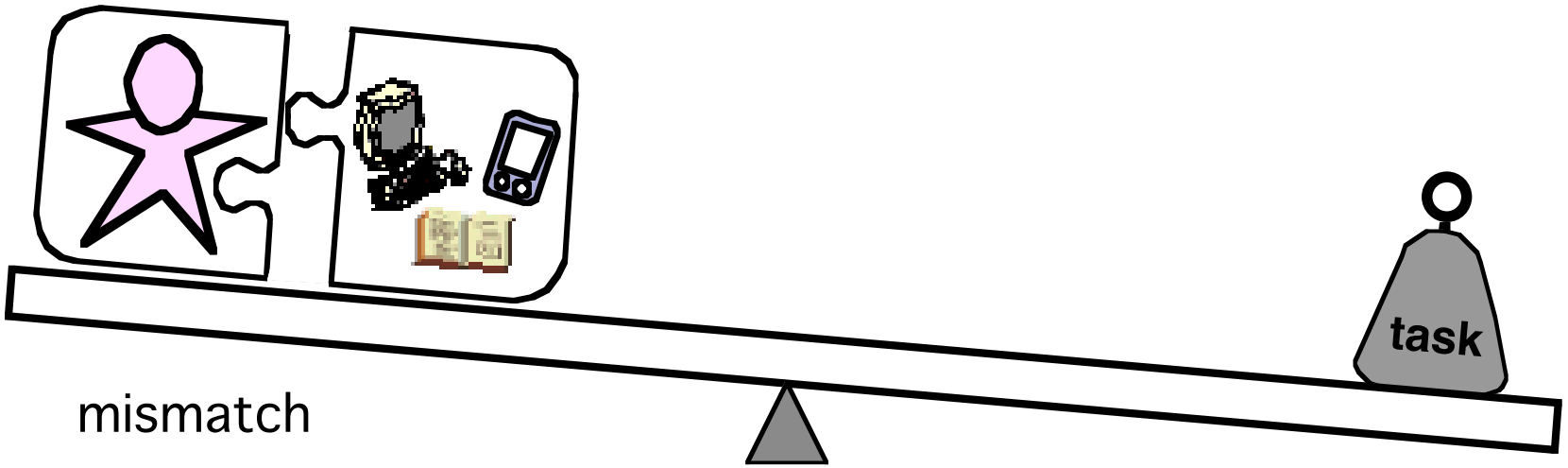
Distributed Cognition: Socio-Technical Environments

- **objective:** transcending the limitations of the individual human mind by embedding people with disabilities in socio-technical environments (including caregivers, bus drivers in “Mobility for All”, technology, and the integration of the human infrastructure with the technological infrastructure)

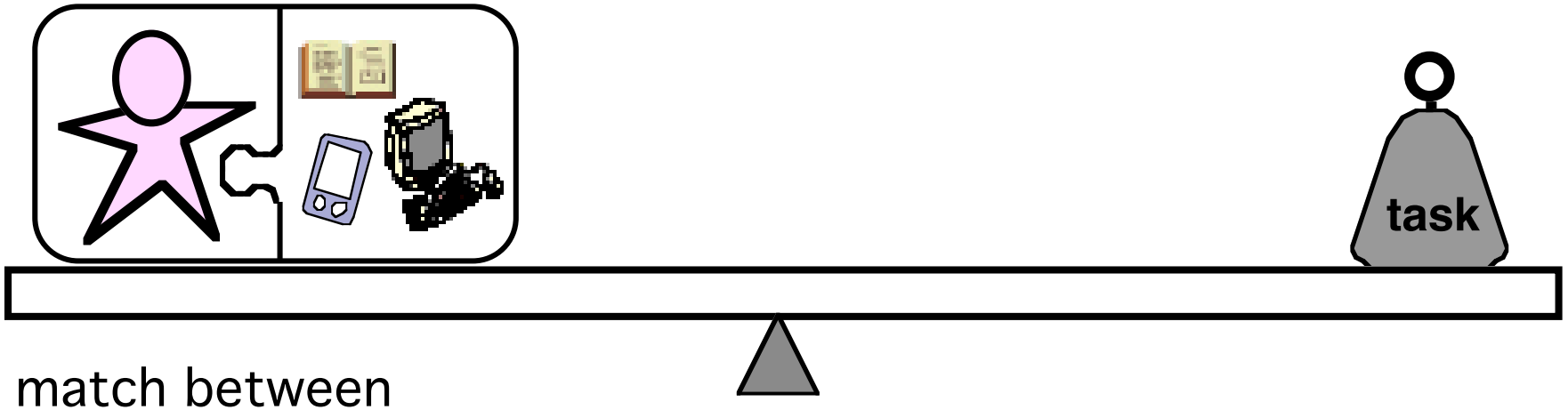


Mismatch between Needs and Support Tools:

Lack of Adoption and High Level of Abandonment



Creating a Match Finding the “Right” Tool and Supporting Personalization and Adaptation of Tools



match between
user and tools

Distributed Cognition: A Conceptual Framework for Design-for-All

- working with humans with special needs and with different cognitive abilities can help to understand the **thinking of humans in general**

- exploit the **dual use strategy** (or “space program effect”)

- **distributed cognition** → differentiate between
  - tools for living (do task **with** tools; dependency on tool)
  - tools for learning (people learn to perform the tasks over time **without** tools)

- an argument providing a useful perspective: ***we all have disabilities*** → example: invention of reading and writing to address limitations of short term memory

- ***our objective in the CLever project:*** creating cognitive levers to help people help themselves