Distributed Cognition and Social Creativity

Abstract

Anatomy and cognitive abilities are not destiny — an important intellectual or philosophical grounding of this mission is provided by Neil Postman (in his book Postman, N. (1985) *Amusing Ourselves to Death – Public Discourse in the Age of Show Business,* Penguin Books, New York, p 14):

> *"The invention of eyeglasses in the twelfth century not only made it possible to improve defective vision but suggested the idea that human beings need not accept as final either the endowments of nature nor the ravages of time. Eyeglasses refuted the belief that anatomy is destiny by putting forward the idea that our minds as well as our bodies are improvable!"*

My presentation will discuss models and illustrations to gain a deeper understanding of distributed cognition and social creativity influenced by our work in the CLever project with people with cognitive disabilities.
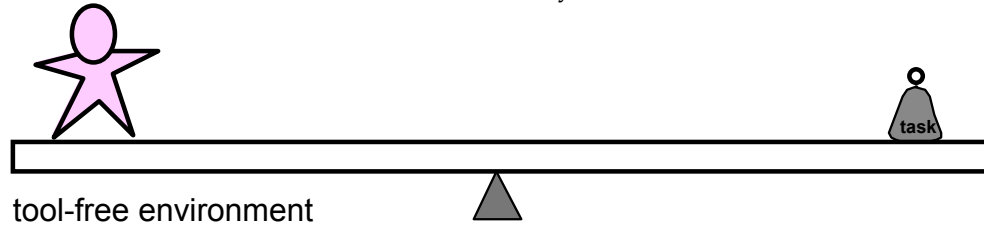
Table of Contents:

Empowering Humans with Media and Technologies

## *The Unaided, Individual Human Mind*

the unaided (with no media support such as reading and writing) and acting as individuals, humans can achieve a set of tasks of a certain difficulty

tool-free environment

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
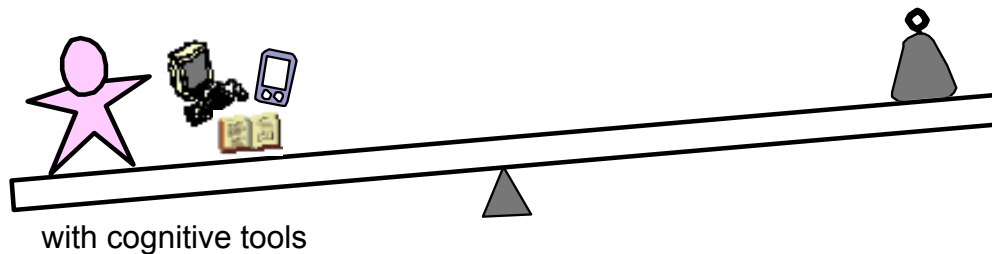
References and Quotes

1. McLuhan, M. (1964) *Understanding Media: The Extensions of Man,* The MIT Press, Cambridge, MA.
2. D. Engelbart in Apple's "Interactive Multimedia book": "the components of an augmentation system are the bundle of all things that can be added to what a human is genetically endowed with, the purpose of which is to augment these basic human capabilities in order to solve the problems of human society"
3. Einstein: "My pencil and I are cleverer than I"

Issues and Questions:

1. is the argument that tools may suppress the development of or weaken certain cognitive abilities sufficiently addressed (Socrates worried about this already in the context of writing)
2. see the discussion with critics (and spell checkers) → do they help or hinder learning of the underlying concepts?
3. more power is only provided if people are able to learn the tools and exploit their power (the "mismatch" picture below illustrates this point)

Achieving More Challenging Tasks with Media

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

with cognitive tools
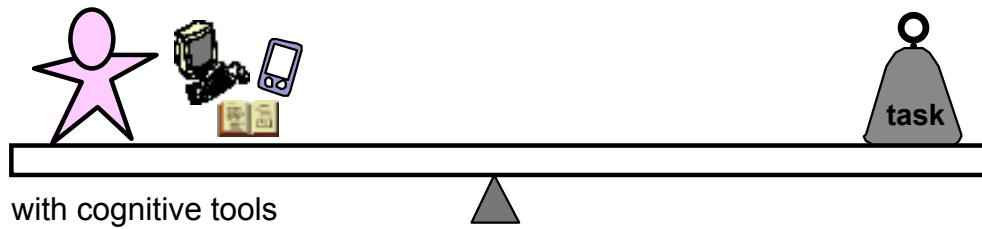
Collaborative Minds and Social Creativity

social + technical
environment
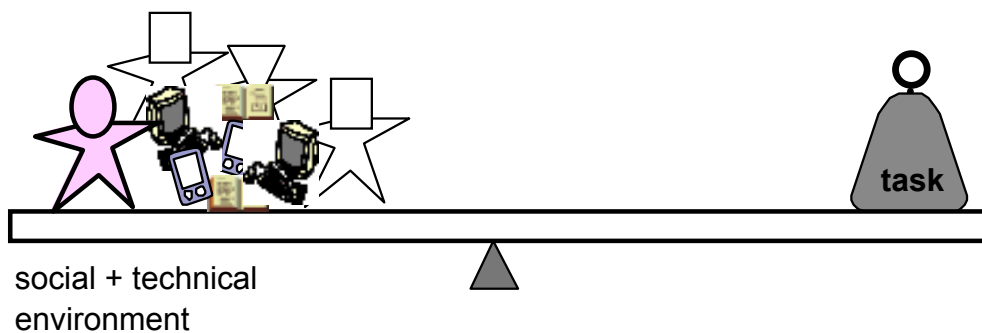
References and Quotes

- Simon, H. A. (1996) The Sciences of the Artificial, (third ed.), The MIT Press, Cambridge, MA., p 92: "When a domain reaches a point where the knowledge for skillful professional practice cannot be acquired in a decade, more or less, then several adaptive developments are likely to occur. Specialization will usually increase (as it has, for example, in medicine), and practitioners will make increasing use of books and other external reference aids in their work."
- Brown, J. S. & Duguid, P. (2000) *The Social Life of Information,* Harvard Business School Press, Boston, MA., p 86: socializing technology — "in order for people to work alone, technology may have to reinforce their access to social networks"
- Nardi, B. A. (1993) *A Small Matter of Programming,* The MIT Press, Cambridge, MA. , p 103 — collaborative work practices: consider the social matrix in which people work

Cognitive Disabilities and New Media and Technologies

Without Tools: Severe Limitations Exist

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

cognitive disabilities
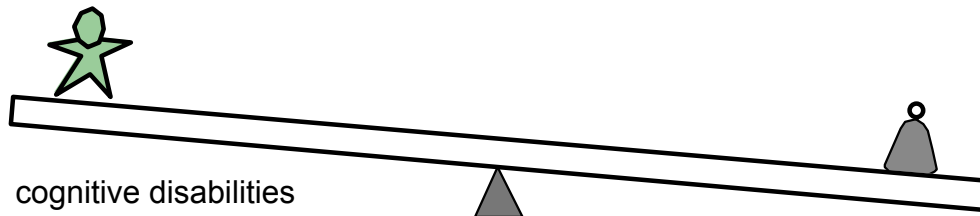
Issues and Questions:
1. in many cases: cognitive impairment is not just a "smaller" version of people without cognitive disabilities?
2. For the purpose of these diagrams, it may be okay to symbolize cognitive impairment with small (even though it is important to explicity acknowledge our point).

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

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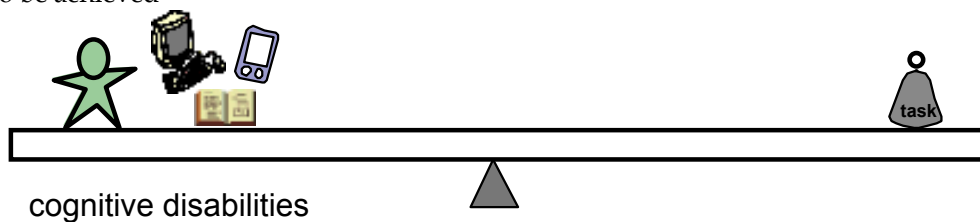
claims:
1. the "standard tool" set fails (e.g., reading and writing), because people with disabilities are lacking the cognitive requirements to use the tools)
2. we need more than "alterations" to existing tools which were developed for people without disabilities
3. we need tools explicitly developed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

Media as "Information Prosthesis"

cognitive disabilities with
greatly enriched tool set
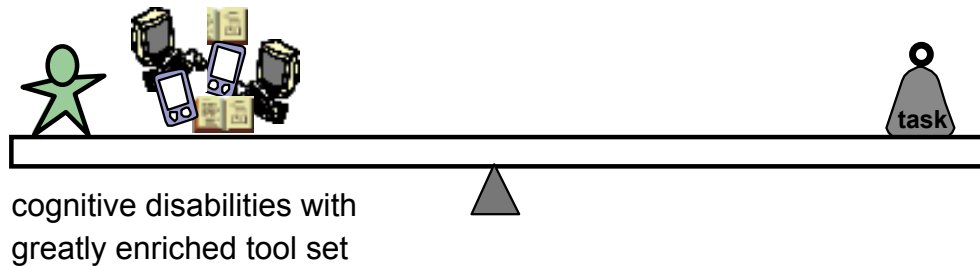
Examples of elements of the "greatly enriched toolset":
- personal prompting devices
- mobility for all
- greatly simplified interfaces
- tools with fewer prerequisites to master

Distributed Cognition: Socio-Technical Environments

Transcending the limitations of the individual human mind by embedding people with disabilities in socio-technical environments (including caregivers, technology, and the integration of the human infrastructure with the technological infrastructure)

social + technical
environment

Remarks:
1. the rationale for using different heads is to indicate different "roles", like teachers and parents
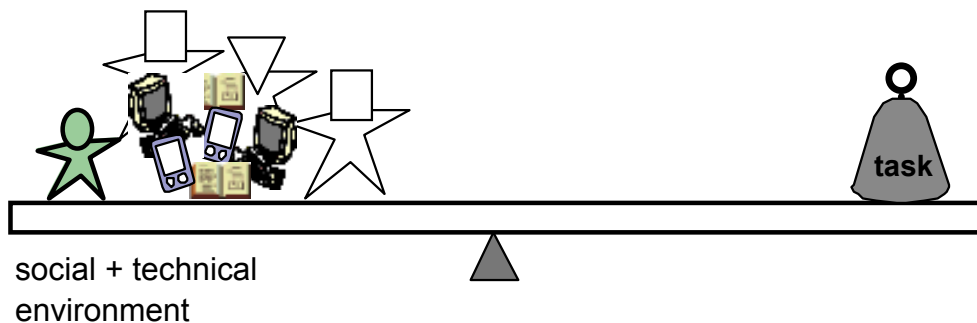2. rationale for "transparent" people was to prevent them from dominating attention. Rationale for their size is that they are the same size as "people without cognitive disabilities"
3. caregivers (parents, teachers, bus drivers in "Mobility for All") become important components in the design of the socio-technical system
4. "panic button" (of specific importance if the additional people are not co-present is critically important that people with disabilities can access the human support network when the technological support fails
   4.1. a back-up with a human infra-structure for unrelaliable tools
   4.2. but: the human infrastructure may be not always available either

Matching Humans and Tools

Mismatching between Needs and Support Tools
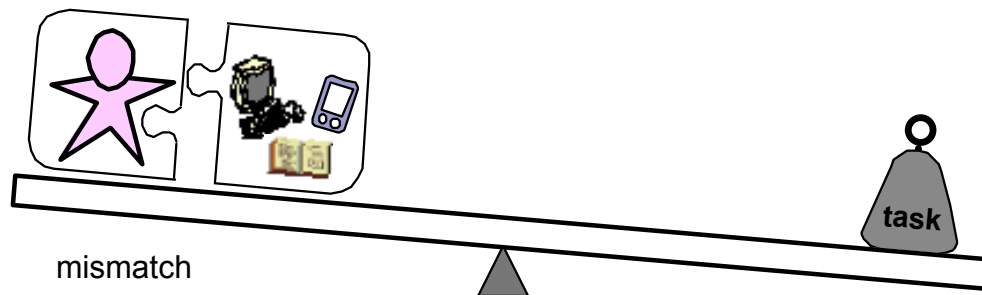
mismatch

people with cognitive disabilities represent more a **"universe of one"** than people without disabilities → the mismatch will lead to abandonment
how to avoid or eliminate mismatches:
-   find the "right" match to start with
-   adopt / customize the technology (technology changes)
-   learn the technology (human changes)

Creating a Match → Finding the "Right" Tool and Personalization and Adaptation of Tools

match between
user and tools
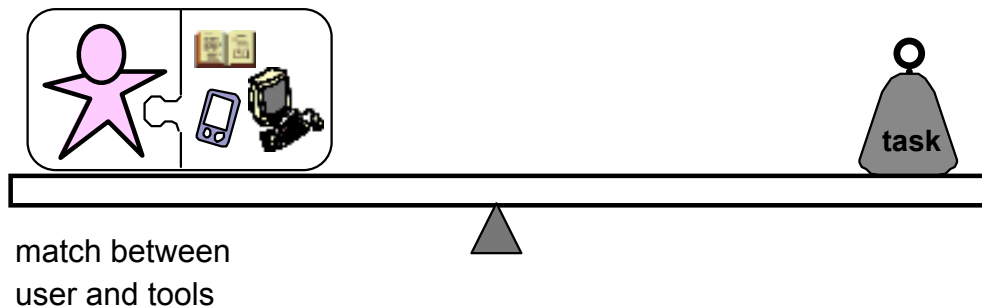
the personalization and adaptation of the tool needs to be done by the caregivers → leading to the following requirement:
-   *meta-design* by the developers including a special support environment and interface for the caregivers
-   sharing of these personalizations and adaptations using Web2gether

Reflections

Distributed Cognition

1. *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 changing tasks
2. *forms of distribution*:
    2.1.   across the members of a social group → leading to social creativity, facilitated by systems suchas EDC/PitaBoard, Web2gether
    2.2.   between internal and external structures
        2.2.1.   internal structures: memory, attention, executive function
        2.2.2.   external resources: artifacts, oeuvres, tools,
    2.3.   throughout time (design time / use time, meta-design, long-term, indirect collaboration
3. claim: working with people with cognitive disabilities
    3.1.   creates new unique challenges for our theories about distributed cognition
    3.2.   provides us with a deeper understanding of distirbuted cognition

References and Quotes

1. 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.

Unique Characteristics of Cognitive Tools/Artifacts

1. cognitive tools require some "understanding and learning" on the side of the person who use them → these people must have or acquire these cognitive skills to take advantage of these tools
2. eyeglasses and wheelchair: they can be bought and used without a great effort by their users (the creativity is on the side of the people who developed them)
    2.1.   but: Anja's comment: *"Wheelchair selection is a very complex process now. There are so many choices and customizations that are done. People often fly across the country to get fitted with the right chair. It is no longer everyone gets to one we see patients in the hospital being wheeled around in."*
3. research methodology of the CLever project to make progress: our research is grounded in three major developments: theory, empirical studies, and engineering construction.
    3.1.   *theory*: to understand how human cognition results from an interplay between mental processes and external computational and memory aids
    3.2.   *empirical research*: examines how people perform tasks and the roles of artifacts
    3.3.   *engineering design and construction*: create new classes of artifacts and test them in natural settings. Dimensions to be investigated:
        3.3.1.   the complementarity between human and artificial capabilities,
        3.3.2.   the role of availability and portablity,
        3.3.3.   interface principles (the nature of the interaction between the person and the artifact
        3.3.4.   personalization and adaptation

Tools for Living and Tools for Learning

in both cases: users need to
- understand these tools
- use the tools
- learn enough to take advantage of the tools

Tools for Living

Wheel chairs are tools that enable us to get around. They are liberating, not confining.
— a person with a physical disability

1. *definition*: do task with tools
2. *examples*:
    2.1.   eye-glasses: to compensate for poor eyesight (→ question:is the correction of eyesight with "lasik surgery" conceptually different?)
    2.2.   pencil and paper (literacy): to overcome the limitations of short-term memory
3. *opportunity*: while some people might have no problems to learn to perform the tasks without the tools (e.g., spelling, critiquing of designs), they use tools for doing these "low level" tasks and they can therefore focus on the more interesting tasks
4. *independence*:
    4.1.   people will be dependent on the tool
    4.2.   but: the availability of the tool (e.g., the tools to be developed in the "Mobility for All" project) may give them the independence to engage independently in other activities (e.g., mobility)
    4.3.   analyze how interdependence/socialization in one dimension can increase independence in another dimension?

Tools for Learning

1. *definition*: people learn to perform the tasks over time without tools (an objective of many things students learn in school)
2. *examples*:
    2.1.   hand-held calculators
    2.2.   spelling correctors
3. *opportunity*: while some people might have no problems to learn to perform the tasks without the tools (e.g., spelling, critiquing of designs), they use tools for doing these "low level" tasks and they can therefore focus on the more interesting tasks
4. *independence*: people will become independent of these tools

Issues and Questions:
1.   should the heads of the people in the diagrams drawn bigger in these cases??

Additional Perspectives

Increasing Time on Task and Creating Safe Environments

The paper Burton, R. R., Brown, J. S., & Fischer, G. (1984) "Analysis of Skiing as a Success Model of Instruction: Manipulating the Learning Environment to Enhance Skill Acquisition." In B. Rogoff & J. Lave (Eds.), Everyday Cognition: Its Development in Social Context, Harvard University Press, Cambridge, MA - London, pp. 139-150. illustrates that technology can provide:
- substantially more time on task (e.g., lifts afford this in downhill skiing, design environments in programming)
- a safer environment reducing the anxiety factor of trying new things (e.g., safety bindings in skiing, "undo"-command in programming)


Learning and Optimal Flow

the figure is based on: Csikszentmihalyi, M. (1990) Flow: The Psychology of Optimal Experience, HarperCollins Publishers, New York.:
- **anxiety:** is caused by tasks that are too difficult (the balance beam is titled to the right in the above diagrams)

- **boredom:** is caused by tasks that are too easy (the balance beam is titled to the left in the above diagrams)

claim: optimal flow leads to human development through the development and enhancement of human competencies
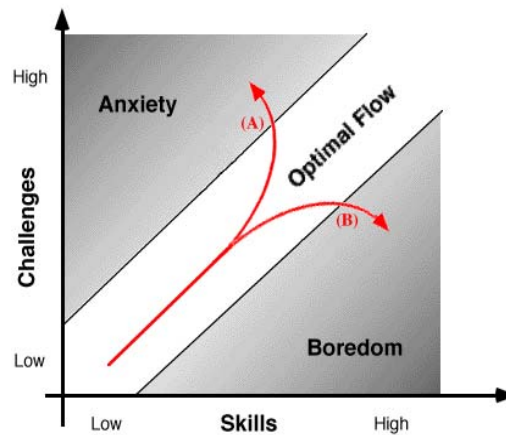
John Anderson: The Role for Basic Skills

(from Cognitive Science Conference, 1993, Panel on "Learning on Demand")

If most job-relevant knowledge must be learned on demand what is the role for basic education? In particular, I will consider the role of a traditional high school mathematics education. There is a general perception that American children are poorly prepared in mathematics and that this is part of the reason for our lack of international competitiveness. However, the kind of mathematics that American schools fail at teaching (and which other countries excel at) has increasingly little relationship to work performance. Almost all of the mathematics that students learn in traditional high school mathematics is job-irrelevant (e.g., doing proofs in geometry) or now automated (e.g., algebraic symbol manipulation). Most people's on-the-job contact with mathematics (if they have any) will be in using tables and software packages based on mathematics. Perhaps we need only teach traditional mathematics to a small minority of the population who will maintain these systems.

Perhaps the function of a high-school mathematics education is to train students to intelligently use these mathematical artifacts. I will discuss our work at building an algebra tutoring system focused on teaching students to use spreadsheet, graphing, and symbol manipulation facilities to solve "real world" problems. Intelligent use of such artifacts requires that students have some relatively traditional skills in high school mathematics. I will discuss what some of these basic skills are and how they can be tutored.

Social Creativity and Collective Collaboration

see: John-Steiner, V. (2000) *Creative Collaboration*, Oxford University Press, Oxford.

p 192: "group mind" (relate it to "group think in CoPs") — often carries a negative connotation of stifling conformity. The term does not bring to light the role of dialogue and the diversity of perspectives which, when linked to a common purpose, reveal the power of collaboration.

p 193: Hutchins "Cognition in the Wild" study of navigational systems is one of the most detailed accounts of joint activity. It has raised some interesting issues about personal agency and the site of cognitive activities. As reviewer C. Bazerman wrote: "Hutchins' project to see how much cognition can be found outside the self within the culturally ordered system{of navigation}, and in the constraints and affordances of tasks and tools helps demystify our cultural beliefs in individuality, individual intelligence, and imagination beliefs that have often found allies in the cognitive tradition."

Some Basic Objectives of L³D's CLever Project

CLever: "Building <u>C</u>ognitive <u>Lever</u>s to help people help themselves"
a research project supported by the Coleman Initiative
for details see: http://www.cs.colorado.edu/~l3d/clever/

The **mission of the CLever project** is to provide computationally enhanced environments to assist and empower people with a wide range of cognitive disabilities directly and through their support community.

Anatomy and Cognitive Abilities are not Destiny

An important intellectual or philosophical grounding of this mission is provided by Neil Postman (in his book Postman, N. (1985) *Amusing Ourselves to Death — Public Discourse in the Age of Show Business*, Penguin Books, New York, p 14):

> *"The invention of eyeglasses in the twelfth century not only made it possible to improve defective vision but suggested the idea that human beings need not accept as final either the endowments of nature nor the ravages of time. Eyeglasses refuted the belief that anatomy is destiny by putting forward the idea that our minds as well as our bodies are improvable!"*

Research Objectives for CLever

"My pencil and I are more clever than I" — A. Einstein

This observation "that our minds are improvable" through media and technologies has led to the following research objectives for CLever:

1. the assertion that the **cognitive abilities of all of us are limited** — the most convincing example is provided by the limitations of our memories that was addressed by the invention of reading and writing;

2. the development of **computational media** that provide us with unique opportunities to "improve our minds" (and especially the minds of those of us who have a cognitive disability) leading to fundamental research challenges in distributed cognition, informational prosthesis, and media as extensions of humans

   2.1. a unique property of computational media is that they have interpretive capabilities, leading to artifacts such as spelling correctors, hand-held calculators, personalized information (e.g., maps tailored to our specific trips);

   2.2. a particular challenge and opportunity for computational media is not only to create new tools for the individual mind, but new tools for the *social mind*

3. **the distinction between "tools for living" and "tools for learning"**

   3.1. *tools for living*: The goal of assistive technologies is to overcome a barrier to learning that is in place because of a misformed or damaged brain structure. Shunning such assistance places unnecessary limitations on a person's potential achievement.

   3.2. *tools for learning*: technological aids should not preempt learning when the person has the capacity to learn something

4. **assessment and acceptance:**

   4.1. while reading and writing is readily accepted to "improve our minds" (i.e. it is considered a "tool for living"), the acceptance of other tools (such as spelling correctors, hand-held calculators, …) is much more controversial (they are considered by many exclusively as "tools for learning") → in other words: many teachers and parents don't want kids to use calculators and spell correctors because they "feel" it impedes learning

4.2.   obviously we do want to create "independence of tools" where this is possible

    4.2.1.   e.g., we want to be independent of spelling correctors and hand-held calculators as much as possible

    4.2.2.   but for a person with strong dyslexia a spelling corrector (just as eyeglasses for a person with poor eyesight) is a tool for living and often a prerequisite to allow people in engage in problem solving, working, and learning (which would be impossible without the tool)

4.3.   a deeper understanding of *independence* is necessary

    4.3.1.   the major objective should be that people can live an independent, interesting, and productive life

    4.3.2.   in case this objective can be reached better with tools, these tools should be provided and become an integral part of people's life

5.   Alan Kay in Papert (Connected Family, p 30): people use the word **"technology"** only for what was invented after they were born; that's why we do not argue

    5.1.   whether the piano is corrupting music

    5.2.   reading and writing corrupts our memory

Arguments by Bruner addressing this topic:

1.   Bruner (in his essay, "Education as Social Invention" in Bruner, J. (1973) *Beyond the Information Given,* W.W. Norton and Company, New York, p 471) defines a view which he calls "evolutionary instrumentalism"):
"Human's use of mind is dependent upon his ability to develop and use tools or instruments or technologies that make it possible for him to express and amplify his powers"

2.   Bruner (in his book Bruner, J. (1996) The Culture of Education, Harvard University Press, Cambridge, MA, p2) argues:
"how the mind works is itself dependent on the tools at its disposal" (in analogy to: "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, …..")

3.   with respect to assessment, we have to understand:

    3.1.   why hand tools, eye-glasses, reading and writing (instead of memorizing) are readily accepted?

    3.2.   why spelling corrector, hand-held calculators, ….. are often associated with **"learned helplessness"?**
comment by Mark Dubin: *"it is often misplaced moral judgement that leads to the resistance to such tools. This relates to the 19th century belief that mental deficits were illnesses that reflected moral vices or immoral lifestyles. Indeed, sometimes a calculator is a "crutch" that allows a person to forgo the effort associated with true learning, that is of displaying the moral vice of laziness. However, generalizing this idea to all uses of such devices by any individual, independent of circumstances, is inappropriate."*

Issues and Questions for Discussion

1. what is the semantics of the *fulcrum point* in these representation? we can also change the power and tilt by moving the fulcrum point → what would be the semantics of doing so? (but: we should avoid overloading the semantics of the diagrams to the point where people don't understand them)

2. the weight is only getting bigger → should we use different weights to show the diversity of larger task sets?

3. in these diagrams, the technology is always bundled together with the person → but:

    3.1.   there is also technology distributed in the environment (see our design for "Mobility for All"), such as GPS systems, Query Lens, …….

    3.2.   wheelchairs are of little use if the environment is not structured that it allows their use

4. eyeglasses remains tools — how should we think about *"lasik surgery"* in the context of these diagrams? → a solution that makes us independent of an external tool

5. tools do not augment humans cognitive functions → **they change tasks and processes**; examples:

    5.1.   velcro: frees people of tying shoe laces

    5.2.   microwaves: changes the way how food is prepared

    5.3.   TV dinners: frees people from learning to cook → but: a prompting tool that prompts a person how to cook a can of condensed soup on the stove does not change the physical task, it only changes the memory requirement

6. should we stress that cognitive tools can increase the cognitive abilities of the *combined* human/tool system

    6.1.   The cognitive scientist is more of a "naturalist" (in Simon's sense), and is concerned with the cognitive abilities of the unaided human mind.

    6.2.   Our perspective should be more on the human/artifact system

7. *examples* to think about:

    7.1.   Calculators - if we believe that humans have limited attention, then calculators increase the amount of attention that can be paid to the implications of calculations, rather than performing the calculations.

    7.2.   calculators do not change the "natural" cognitive abilities (natural in Simon's sense of the basic cognitive processing) but they do increase our ability to solve complex problems, and in this sense, they can be said to augment our natural abilities.

    7.3.   External (including computational) Memories - humans "natural" memory is limited, and like calculators, external memories increase our ability to perform cognitive tasks.

    7.4.   in the illustrations: this is in part realized, because the "head" of the people do not get bigger, but the tasks which can be tackled/achieved get larger

8. the diagrams in this write-up should be thought of as *depicting general relations* between cognitive abilities, tools, and tasks → more specific diagrams should be developed to depict these relationships in more specific situations.

    8.1.   similar to the "smoke signal" argument, a general diagram cannot be used to completely represent a specific (complex) situation)

    8.2.   to do: illustrate how tasks and processes will change in the "Mobility for All" environment when our technologies will be in place

9. our arguments providing a useful perspective: *we all have disabilities* → example: invention of reading and writing to address limitations of short term memory

10. criticism for schools: tool-free environments in which students cope as individuals

A "Modern" Prize?

source: New Yorker; courtesy of Stefan Carmien

"I won the spell-check bee."