1 COGNITIVE PSYCHOLOGY & HUMAN MEMORY

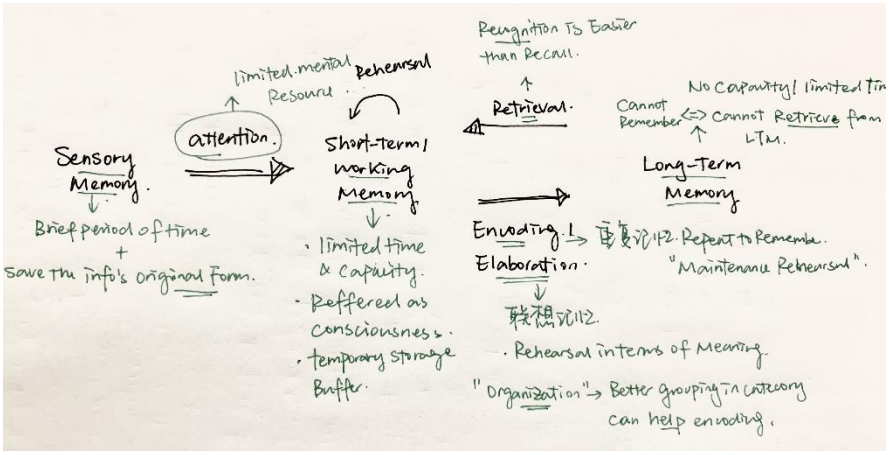
What is Cognitive Psychology:

- Cognitive Psychology is all processes by which sensory input is transformed, reduced, elaborated, stored, recovered and used.
    - Interested in how people think and cognitive process
        - Cognitive processes include perception, attention, pattern recognition, memory, visual imagery, language, reading, learning, problem solving, planning & decision making.
- Interacting with technology is cognitive, so we need to consider the cognitive limitations of users. Then we can understand what users can or cannot be expected to do. And cognitive psychology can help to identify/explain the causes/nature of problems users encountered 由于和系统互动需要使用认知(例如 search information 需要用到 cognitive load 或者需要 attention) 所以了解用户的认知极限可以让设计者更清楚用户能做什么, 不能做什么. 也可以帮助了解用户犯错的真实原因.
- Cognitive psychology can supply theories, modelling tools, guidance and methods that can make design better/easier to use.
- *Extend human capabilities & compensate for weaknesses* 帮助用户扬长避短

Three major branches of contemporary cognitive psychology:

- Experimental cognitive psychology
    - Mainly involves empirical 经验的 work on normal subject 基于实验的认知心理学
- Cognitive Science
    - Combines experimentation and computational modelling of human cognition 结合认知心理学的实验和计算机知识来得出结论, 例如神经网络之类的信息
    - Use either neural works or production system
- Cognitive neuropsychology
    - Tries to map the relationship between different parts of the brain and specific cognitive process 研究大脑中的各部分合作来得出关于认知心理学的决定

The information processing approach:



- Cognition is sometimes referred to as “acquisition of knowledge” – cognitive processes overlap and don’t occur isolation e.g. reading a book

Memory:

- *Sensory memory* 感知记忆
    - Sensory memory saves/preserves information in its original sensory form for very brief period of times.
    - Echoic or auditory memory has similar limitations
        - Sperling’s experiment 根据 tome 和 display 来记忆
    - 在感知记忆里观察到或者听到感觉到的事件会以其 original form 储存在 sensory memory 里很短时间

- *Perception* 认知
  - Perception refers to how information is acquired from the environment via different senses and transformed into experience of objects/events/sounds/tastes
  - Active Process – integrating what is in the environment with what we already know
  - Perception is heavily influenced by context. -> might cause visual illusions.
  - Gestalt Principles of perceptual organization
    - Proximity, Similarity, Closure, Symmetry, Continuity
  - Visual Illusions 有的时候大小颜色和位置可能会造成视觉上的幻觉
  - *Color* – Perceptual Tool
    - Powerful way to dividing display into separate regions
    - Useful for search tasks (but too many colors can increase search time)
    - More effective with inexperienced users
  - 例如当播放动画片时人物的嘴型和声音对上, 音频应该时很清晰的这样可以帮助用户理解. 内容应该和背景区分开这样人们可以清楚地区分他们
  - Bordering & spacing are effective visual ways of grouping information.
- *Attention*
  - Attention is a very *limited mental resource*. 相当于是选择事件来进行 further processing/ concentrate, 也可以将其比喻成 filter sensory information
  - Shadow Experiments – 给左右耳朵听不同的信息, 使倾听着说出/shadow 一边耳朵听到的东西, 结果表明倾听者有的时候会偶尔说出另一只耳朵听到的声音 -> suggests attention not tally all or non process
  - Multitasking and attention 喜欢 multitasking 的人经研究表明是比较容易分心的
  - 可以使用 attention grabbing techniques – color/bold/underlining/animation/flashing-text/reverse-video/auditory warnings 但是不要使用太多.
  - Categories/meaningful grouping 和 appropriate spacing 可以帮忙 grab attention 而不造成 too overwhelming
  - 将重要的信息放在显眼 prominent 的地方. 如果是不常使用的信息, 尽量在用户 request 了过后再 display. 当一件事情很容易被忘记时(例如保存文档), 应该有弹窗提示 Prompts 来提醒用户.
- *Automatic/Controlled Processing*
  - Automatic Processes 已经自动化了的一些动作或操作
    - Processes that are highly practiced and require little/no attention (little/no consciousness)
    - It is effortless, fast, but difficult to alter or suppress once learned 当习惯了一件事情过后很难改变过来, 但是自动化的操作可以让我们花更少的集中力来进行操作(例如开车回家的线路)
    - Requires no attention or awareness, it is parallel in nature
    - It is virtually unaffected by working memory load 并不会对 working memory load 造成大影响
    - Being an expert within a domain involves automating basic skills and processes, highly practiced skills are often difficult to suppress
    - Stroop Effect 的存在就是因为 automation, 什么时 Stroop Effect? 例如用黄色的颜色写 blue, 红色的字写 yellow, 人们就很容易念错
  - Controlled Process 还没有习惯的一些动作
    - Needs conscious attention/control
    - Is slow, easily established, altered or reversed 因为不熟练或不习惯所以很容易被改变
    - Is serial in nature, strongly dependent on working memory load
    - 例子: 当一个人刚刚开始学习语言的时候, 每说一个句子或者词语都需要思考很久
- Short-term or Working memory
  - STM
    - They often referred to as Consciousness, short-term memory is limited in both capacity and duration.
      - *Span of Attention* – the maximum elements one can recognize in a single glance
      - *Memory Span* – the maximum elements one can remember after reading a list
    - Chunking – can increase the amount of information stored in short-term memory by grouping or chunking items together into larger meaningful way
    - Limitations of short term memory must be applied with care to interface design 例如 不要让用户在这边看了信息需要在另一个页面填上 -> might overload user's memory

- WM
  - Temporary storage buffer for the processing of current information – it's a more modern conception
  - Focus on memory being an Active Process but not just a storage medium.
  - Focus on the parallel nature of information processing
  - More recent research suggests the number of unfamiliar items we can store in working memory is 4
  - 3 Subsystems:
    - *Phonological Loop* ⇔stores and rehearses speech-based or auditory information
    - *Visuospatial Sketchpad* ⇔ Allow people to temporary hold and manipulate visual imagery
    - *Central Executive Processor* ⇔ Controls the operations of Working Memory and allocates resources to the other two subsidiary system. Its an attention controlling system

- Long-term memory
  - Encoding: 重复记忆
    - *Maintenance Rehearsal* – information is rehearsed at a superficial 表面的 level, it is repeated over and over again without thinking about it. 不停地重复来记忆, 并没有联想或者采取别的技巧
    - *Elaboration* – information is rehearsed in terms of its meaning and is linked to other stimulus at the time of encoding 在不停地重复记忆的同时也想办法用以前有的记忆进行联想来帮助记忆
    - *Organization* – material that is well organized in terms of meaningful groups or categories will be better encoded 例如自己的笔记排版比上课的笔记好就会比较容易记忆
  - Retrieval – 在 heuristic evaluation 里面就有提到 recognition is easier than recall
    - *Recall* – Involves retrieve information from memory 例如简答题, Linux 系统需要使用 command
    - *Recognition* – involves selecting previously learned information from an array or options 例如选择题, GUI windows 系统可以直接选(recognition uses context which helps you to remember)
    - Use retrieval cues to aid in the recall of relevant information – help system
    - Naming conventions – use meaningful, distinguishable, consistent names across the application. 当系统的 terminology 是有意义的时候,可以唤起用户的 prior knowledge. 或者提供一些 context 也可以提醒用户. Provide users with many ways of encoding information (files/emails/images) so that it can be more easily remembers, can use color, time-stamps, icons

- Organization of Knowledge
  - Schema 我们对事物的看法, 想法, 可以用来猜测或预估事情, 可以比较轻易地被改变
    - Cognitive structure in memory that allows us to organize information according to how It will be used. It is like patterns of thoughts or organized knowledge structures, that render 致使 the environment relatively predictable
    - Schema allow us to filter, organize, process large amounts of information quickly and economically, helps to reduce burden on our limited working memory 例如今天你觉得一条狗很可爱 明天有一条狗袭击了你你可能会觉得狗很凶残, 但是当我们再一次看到狗时我们可能不再需要花时间去思考其是否可爱, 从而减少了 working memory 的压力
    - Schema aids learning, understanding and problem solving
    - Passage Title – title provides a context and activates the appropriate schema
  - Mental model 我们对事物或者事情的固有看法, 有的时候我们会用它来做 prediction 猜测
    - Internal constructions of some aspects of the external world that are manipulated enabling predictions and inferences to be made 例如想象一下家具应该怎样排放
    - Well designed interactive systems are more likely to lead to users developing an appropriate mental models of the system, so that the system should provide:
      - Useful feedback in response to input
      - Intuitive 直觉的 ways of interacting with system
      - Clear and easy to follow instructions
      - Appropriate online help and tutorials
      - Context-sensitive guidance for users, set as their level of experience

- Improving memory
  - 前面提到的 elaboration 联想记忆, organize materials 资料整理, automating skills 熟悉的技能, chunking 将信息断成有意义的组合, imagery 想象…都可以帮助人的记忆

  - External memory aids 可以帮助记忆, 例如日记, 购物清单, todo 清单, 日历, 包括不同的窗口
  - Computational offloading 使用工具或者设备来进行计算 use tool or device in conjunction with an external presentation to help us carry out a computation 例如使用笔和纸来算数学题
  - Annotation – modify the external representation 例如划掉购物清单上的已买商品 / cognitive tracing 例如将卡片进行不同顺序的排序组合
  - Summaries/stories/acronyms 首字母缩写
  - Advanced Organizers – 童工一个用户熟悉的 introductory framework, which users can use to interpret new information
  - Linking new information to previously mastered information
  - Norman's theory of action – Proposes 7 stages of an activity – but its not really realistic – it can just help designers to think about how to help users monitor their actions
    - Establish goal
    - Form intention
    - Specify action sequence
    - Execute action
    - Perceive the system state
    - Interpret the state
    - Evaluate the system state with respect to the goals and intentions
  - Gulf – explicate the gap between user and interface – try to bridge the gulfs in order to reduce the cognitive effort required to perform task
    - Gulf of execution – the distance between the user to the physical system
    - Gulf of evaluation – the distance from physical system to user
- Applications of memory research
  - Judicial System – Eyewitness Testimony
    - The constructive nature of memories may affect the accuracy of recall
      - Memory of an event can be affected by the meaning of words used to encode event
      - The terminology used during an interview can impact the answer you are given
  - Educator
    - Try to not overload the memory limitation
    - Try to use analogy, and relate it to students' prior knowledge, and try to organize material well
  - HCI Professionals
    - Relate information to prior knowledge, information need to be well structured, use meaningful subdivisions
    - Use diagrams, heading and numbering
    - The interface design can affect users way to perceive, attend, learn and remember

2 Introduction to Cognitive Psychology – Problem Solving

Relevance & Definition of Problem Solving:

- Figure out how to interact/use a system is a problem solving process, even experienced users can encounter problems -> Designer need to solve the problem of designing usable application
- Problem Solving ⇔ finding a path/solution to overcome some obstacles, permitting us to reach desired goal state
- Problem Space includes
  - *Initial state* – initial situation of problem solver
  - *Goal state* – the goal itself
  - *Problem solving operators* – transform one problem state to another problem state

General Problem Solving Strategies:

- Diagrams
  - Can help to make relationship between problem elements more concrete and explicit.
  - It can act like an external memory, help us to visualize the whole problem all at once
  - Helps to understand the problem – problem representation. E.g. flowcharts

- Creating Sub-goals
    - Involves decomposing a problem into smaller, more manageable components
- Working Backwards from the goal
    - Look at what he goal is and try to figure out how to get back to the start state
    - Use the strategy in unfamiliar domains
- Random Search ⇔ Generate & Test
    - Essentially a trial and error procedure
    - Fall-back method when others don't work or are too cognitive overloading
- Hill Climbing
    - Problem solver looks one move ahead and chooses the move that most closely resembles the goal state
- Means-End strategy
    - problem solver compares the current problem state with the desired goal state, tries to find problem solving operators that will bring them closer to goal state e.g. tower of Hanoi
    - Useful for novices
- Analogy
    - Uses structure of solution to one problem to guide the solution to another similar problem
    - Analogy Mapping 两边对比解题

Importance of Prior Knowledge to Problem Solving:

- Most everyday problems that we solve rely on a large base of domain specific knowledge, which is stored in form of schema. (cognitive structure in memory that allows people to classify information according to how will be use)
- One of the reasons a problem may be difficult to solve is that the problem may be difficult to present in a solvable form.
- Analogies and tutorial might be helpful.

Other reasons why problem may be difficult to solve:

- *Functional Fixedness* – Mental block against using an object in anew or unconventional way in order to solve particular problem.
    - Being expert can stop you from seeing things in a new/different ways. The uses of software may discover new or unintended uses.
- *Unwarranted Assumptions* – A problem may also not be properly represented because unwarranted assumptions are made about moves that are or are not legal
    - Make the instruction and explanation clear so that there is less chance for the users to misunderstood
- *Set Effect* – The set effect occurs because the biases we have in solving a problem in a certain way as result of previous experience.
    - Try to not change too many things while upgrading
- Goal state is inadequately defined
    - Well-defined ⇔ problems have clear-cut goals and solutions
    - Ill-defined ⇔ problems do not have easily agreed upon solutions (e.g. discuss)
    - Problem solving space is too large
        - Too many options, create sub-goals can reduce search space size
    - Lack of prior knowledge
    - Memory Limitation