HUMAN-COMPUTER INTERACTION (IS252) CHAPTER THREE

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CHAPTER 3
# UNDERSTANDING USERS

INTRODUCTION

- IN THIS CHAPTER WE EXAMINE SOME OF THE CORE COGNITIVE ASPECTS OF INTERACTION DESIGN. SPECIFICALLY, WE CONSIDER WHAT HUMANS ARE GOOD AND BAD AT AND SHOW HOW THIS KNOWLEDGE CAN BE USED TO INFORM THE DESIGN OF TECHNOLOGIES THAT BOTH EXTEND HUMAN CAPABILITIES AND COMPENSATE FOR THEIR WEAKNESSES. WE ALSO LOOK AT SOME OF THE INFLUENTIAL COGNITIVELY BASED CONCEPTUAL FRAMEWORKS THAT HAVE BEEN DEVELOPED FOR EXPLAINING THE WAY HUMANS INTERACT WITH COMPUTERS. (OTHER WAYS OF CONCEPTUALIZING HUMAN BEHAVIOR THAT FOCUS ON THE SOCIAL AND AFFECTIVE ASPECTS OF INTERACTION DESIGN ARE PRESENTED IN THE FOLLOWING TWO CHAPTERS.) THE MAIN AIMS OF THIS CHAPTER:

- EXPLAIN WHAT COGNITION IS AND WHY IT IS IMPORTANT FOR INTERACTION DESIGN.

- DESCRIBE THE MAIN WAYS COGNITION HAS BEEN APPLIED TO INTERACTION DESIGN.

- PROVIDE A NUMBER OF EXAMPLES IN WHICH COGNITIVE RESEARCH HAS LED TO THE DESIGN OF MORE EFFECTIVE INTERACTIVE PRODUCTS.

- EXPLAIN WHAT MENTAL MODELS.

- GIVE EXAMPLES OF CONCEPTUAL FRAMEWORKS THAT ARE USEFUL FOR INTERACTION DESIGN.

- ENABLE YOU TO TRY TO ELICIT A MENTAL MODEL AND BE ABLE TO UNDERSTAND WHAT IT MEANS.

WHAT IS COGNITION?

- *"COGNITION IS WHAT GOES ON IN OUR HEADS WHEN WE CARRY OUT OUR EVERYDAY ACTIVITIES".*

- IT INVOLVES COGNITIVE PROCESSES, LIKE THINKING, REMEMBERING, LEARNING, DAYDREAMING, DECISION MAKING, SEEING, READING, WRITING AND TALKING. AS FIGURE 3.1 INDICATES, THERE ARE MANY DIFFERENT KINDS OF COGNITION. NORMAN (1993) DISTINGUISHES BETWEEN TWO GENERAL MODES: EXPERIENTIAL AND REFLECTIVE COGNITION. THE FORMER IS A STATE OF MIND IN WHICH WE PERCEIVE, ACT, AND REACT TO EVENTS AROUND US EFFECTIVELY AND EFFORTLESSLY. IT REQUIRES REACHING A CERTAIN LEVEL OF EXPERTISE AND ENGAGEMENT. EXAMPLES INCLUDE DRIVING A CAR, READING A BOOK, HAVING A CONVERSATION, AND PLAYING A VIDEO GAME. IN CONTRAST, REFLECTIVE COGNITION INVOLVES THINKING, COMPARING, AND DECISION-MAKING. THIS KIND OF COGNITION IS WHAT LEADS TO NEW IDEAS AND CREATIVITY. EXAMPLES INCLUDE DESIGNING, LEARNING, AND WRITING A BOOK. NORMAN POINTS OUT THAT BOTH MODES ARE ESSENTIAL FOR EVERYDAY LIFE BUT THAT EACH REQUIRES DIFFERENT KINDS OF TECHNOLOGICAL SUPPORT.

COGNITION HAS ALSO BEEN DESCRIBED IN TERMS OF SPECIFIC KINDS OF PROCESSES. THESE INCLUDE:

- ATTENTION

- PERCEPTION AND RECOGNITION

- MEMORY

- LEARNING

- READING, SPEAKING, AND LISTENING

- PROBLEM SOLVING, PLANNING, REASONING, DECISION MAKING
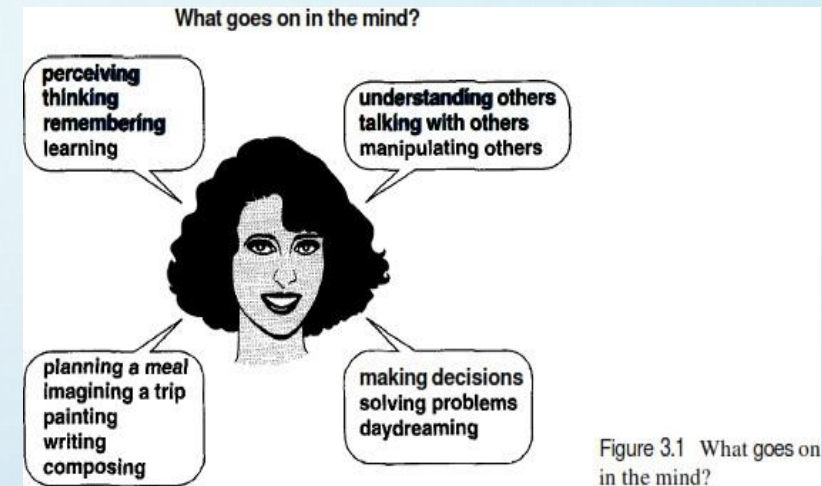
❖ *ATTENTION* IS THE PROCESS OF SELECTING THINGS TO CONCENTRATE ON, AT A POINT IN TIME, FROM THE RANGE OF POSSIBILITIES AVAILABLE. ATTENTION INVOLVES OUR AUDITORY AND/OR VISUAL SENSES. AN EXAMPLE OF AUDITORY ATTENTION IS WAITING IN THE DENTIST'S WAITING ROOM FOR OUR NAME TO BE CALLED OUT TO KNOW WHEN IT IS OUR TIME TO GO IN. AN EXAMPLE OF ATTENTION INVOLVING THE VISUAL SENSES IS SCANNING THE FOOTBALL RESULTS IN A NEWSPAPER TO ATTEND TO INFORMATION ABOUT HOW OUR TEAM HAS DONE. ATTENTION ALLOWS US FOCUS ON INFORMATION THAT IS RELEVANT TO WHAT WE ARE DOING. THE EXTENT TO WHICH THIS PROCESS IS EASY OR DIFFICULT DEPENDS ON (I) WHETHER WE HAVE CLEAR GOALS AND (II) WHETHER THE INFORMATION WE NEED IS SALIENT IN THE ENVIRONMENT:

I. *OUR GOALS* IF WE KNOW EXACTLY WHAT WE WANT TO FIND OUT, WE TRY TO MATCH THIS WITH THE INFORMATION THAT IS AVAILABLE.

II. *INFORMATION PRESENTATION* THE WAY INFORMATION IS DISPLAYED CAN ALSO GREATLY INFLUENCE HOW EASY OR DIFFICULT IT IS TO ATTEND TO APPROPRIATE PIECES OF INFORMATION.

❖ *PERCEPTION* REFERS TO HOW INFORMATION IS ACQUIRED FROM THE ENVIRONMENT, VIA THE DIFFERENT SENSE ORGANS (E.G., EYES, EARS, FINGERS) AND TRANSFORMED INTO EXPERIENCES OF OBJECTS, EVENTS, SOUNDS, AND TASTES (ROTH, 1986). IT IS A COMPLEX PROCESS, INVOLVING OTHER COGNITIVE PROCESSES SUCH AS MEMORY, ATTENTION, AND LANGUAGE. VISION IS THE MOST DOMINANT SENSE FOR SIGHTED INDIVIDUALS, FOLLOWED BY HEARING AND TOUCH. WITH RESPECT TO INTERACTION DESIGN, IT IS IMPORTANT TO PRESENT INFORMATION IN A WAY THAT CAN BE READILY PERCEIVED IN THE MANNER INTENDED. FOR EXAMPLE, THERE ARE MANY WAYS TO DESIGN ICONS. THE KEY IS TO MAKE THEM EASILY DISTINGUISHABLE FROM ONE ANOTHER AND TO MAKE IT SIMPLE TO RECOGNIZE WHAT THEY ARE INTENDED TO REPRESENT.

❖ *MEMORY* INVOLVES RECALLING VARIOUS KINDS OF KNOWLEDGE THAT ALLOW US TO ACT APPROPRIATELY. IT IS VERY VERSATILE, ENABLING US TO DO MANY THINGS. FOR EXAMPLE, IT ALLOWS US TO RECOGNIZE SOMEONE'S FACE, REMEMBER SOMEONE'S NAME, RECALL WHEN WE LAST MET THEM AND KNOW WHAT WE SAID TO THEM LAST. SIMPLY, WITHOUT MEMORY WE WOULD NOT BE ABLE TO FUNCTION.

❖ *LEARNING* CAN BE CONSIDERED IN TERMS OF (I) HOW TO USE A COMPUTER-BASED APPLICATION OR (II) USING A COMPUTER-BASED APPLICATION TO UNDERSTAND A GIVEN TOPIC. JACK CARROLL (1990) AND HIS COLLEAGUES HAVE WRITTEN EXTENSIVELY ABOUT HOW TO DESIGN INTERFACES TO HELP LEARNERS DEVELOP COMPUTER-BASED SKILLS.

• A MAIN OBSERVATION IS THAT PEOPLE FIND IT VERY HARD TO LEARN BY FOLLOWING SETS OF INSTRUCTIONS IN A MANUAL. INSTEAD, THEY MUCH PREFER TO "LEARN THROUGH DOING." GUIS AND DIRECT MANIPULATION INTERFACES ARE GOOD ENVIRONMENTS FOR SUPPORTING THIS KIND OF LEARNING BY SUPPORTING EXPLORATORY INTERACTION AND IMPORTANTLY ALLOWING USERS TO "UNDO" THEIR ACTIONS, I.E., RETURN TO PREVIOUS STATE IF THEY MAKE A MISTAKE BY CLICKING ON THE WRONG OPTION. CARROLL HAS ALSO SUGGESTED THAT ANOTHER WAY OF HELPING LEARNERS IS BY USING A "TRAINING-WHEELS APPROACH. THIS INVOLVES RESTRICTING THE POSSIBLE FUNCTIONS THAT CAN BE CARRIED OUT BY A NOVICE TO THE BASICS AND THEN EXTENDING THESE AS THE NOVICE BECOMES MORE EXPERIENCED. THE UNDERLYING RATIONALE IS TO MAKE INITIAL LEARNING MORE TRACTABLE, HELPING THE LEARNER FOCUS ON SIMPLE OPERATIONS BEFORE MOVING ON TO MORE COMPLEX ONES.

- ❖ ***READING, SPEAKING AND LISTENING:*** THESE THREE FORMS OF LANGUAGE PROCESSING HAVE BOTH SIMILAR AND DIFFERENT PROPERTIES. ONE SIMILARITY IS THAT THE MEANING OF SENTENCES OR PHRASES IS THE SAME REGARDLESS OF THE MODE IN WHICH IT IS CONVEYED. FOR EXAMPLE, THE SENTENCE "COMPUTERS ARE A WONDERFUL INVENTION" ESSENTIALLY HAS THE SAME MEANING WHETHER ONE READS IT, SPEAKS IT, OR HEARS IT. HOWEVER, THE EASE WITH WHICH PEOPLE CAN READ, LISTEN, OR SPEAK DIFFERS DEPENDING ON THE PERSON, TASK, AND CONTEXT. FOR EXAMPLE, MANY PEOPLE FIND LISTENING MUCH EASIER THAN READING. SPECIFIC DIFFERENCES BETWEEN THE THREE MODELS INCLUDE:

- WRITTEN LANGUAGE IS PERMANENT WHILE LISTENING IS TRANSIENT. IT IS POSSIBLE TO REREAD INFORMATION IF NOT UNDERSTOOD THE FIRST-TIME ROUND. THIS IS NOT POSSIBLE WITH SPOKEN INFORMATION THAT IS BEING BROADCAST.

- READING CAN BE QUICKER THAN SPEAKING OR LISTENING, AS WRITTEN TEXT CAN BE RAPIDLY SCANNED IN WAYS NOT POSSIBLE WHEN LISTENING TO SERIALLY PRESENTED SPOKEN WORDS.

- LISTENING REQUIRES LESS COGNITIVE EFFORT THAN READING OR SPEAKING. CHILDREN, ESPECIALLY, OFTEN PREFER TO LISTEN TO NARRATIVES PROVIDED IN MULTIMEDIA OR

- WEB-BASED LEARNING MATERIAL THAN TO READ THE EQUIVALENT TEXT ONLINE.

- WRITTEN LANGUAGE TENDS TO BE GRAMMATICAL WHILE SPOKEN LANGUAGE IS OFTEN UNGRAMMATICAL. FOR EXAMPLE, PEOPLE OFTEN START A SENTENCE AND STOP IN

- MID-SENTENCE, LETTING SOMEONE ELSE START SPEAKING.

- THERE ARE MARKED DIFFERENCES BETWEEN PEOPLE IN THEIR ABILITY TO USE LANGUAGE. SOME PEOPLE PREFER READING TO LISTENING, WHILE OTHERS PREFER LISTENING. LIKEWISE, SOME PEOPLE PREFER SPEAKING TO WRITING AND VICE VERSA.

- DYSLEXICS HAVE DIFFICULTIES UNDERSTANDING AND RECOGNIZING WRITTEN WORDS, MAKING IT HARD FOR THEM TO WRITE GRAMMATICAL SENTENCES AND SPELL CORRECTLY.

- PEOPLE WHO ARE HARD OF HEARING OR HARD OF SEEING ARE ALSO RESTRICTED IN THE WAY THEY CAN PROCESS LANGUAGE.

❖ **PROBLEM-SOLVING, PLANNING, REASONING AND DECISION-MAKING** ARE ALL COGNITIVE PROCESSES INVOLVING REFLECTIVE COGNITION. THEY INCLUDE THINKING ABOUT WHAT TO DO, WHAT THE OPTIONS ARE, AND WHAT THE CONSEQUENCES MIGHT BE OF CARRYING OUT A GIVEN ACTION. THEY OFTEN INVOLVE CONSCIOUS PROCESSES (BEING AWARE OF WHAT ONE IS THINKING ABOUT), DISCUSSION WITH OTHERS (OR ONESELF), AND THE USE OF VARIOUS KINDS OF ARTIFACTS, (E.G., MAPS, BOOKS, AND PEN AND PAPER).

• COMPARING DIFFERENT SOURCES OF INFORMATION IS ALSO COMMON PRACTICE WHEN SEEKING INFORMATION ON THE WEB. FOR EXAMPLE, JUST AS PEOPLE WILL PHONE AROUND FOR A RANGE OF QUOTES, SO TOO, WILL THEY USE DIFFERENT SEARCH ENGINES TO FIND SITES THAT GIVE THE BEST DEAL OR BEST INFORMATION. IF PEOPLE HAVE KNOWLEDGE OF THE PROS AND CONS OF DIFFERENT SEARCH ENGINES, THEY MAY ALSO SELECT DIFFERENT ONES FOR DIFFERENT KINDS OF QUERIES. FOR EXAMPLE, A STUDENT MAY USE A MORE ACADEMICALLY ORIENTED ONE WHEN LOOKING FOR INFORMATION FOR WRITING AN ESSAY, AND A MORE COMMERCIALLY BASED ONE WHEN TRYING TO FIND OUT WHAT'S HAPPENING IN TOWN.

3.3 CONCEPTUAL FRAMEWORKS FOR COGNITION

IN THIS SECTION WE EXAMINE THREE OF PEOPLE'S COPING STRATEGIES IN THE PHYSICAL WORLD TO THE DIGITAL WORLD., WHICH EACH HAVE A DIFFERENT PERSPECTIVE ON COGNITION:

- MENTAL MODELS

- INFORMATION PROCESSING

- EXTERNAL COGNITION

3.3.1 MENTAL MODELS

- WHAT HAPPENS WHEN PEOPLE ARE LEARNING AND USING A SYSTEM IS THAT THEY DEVELOP KNOWLEDGE OF HOW TO USE THE SYSTEM AND, TO A LESSER EXTENT, HOW THE SYSTEM WORKS. THESE TWO KINDS OF KNOWLEDGE ARE OFTEN REFERRED TO AS A USER'S MENTAL MODEL.

- HAVING DEVELOPED A MENTAL MODEL OF AN INTERACTIVE PRODUCT, IT IS ASSUMED THAT PEOPLE WILL USE IT TO MAKE INFERENCES ABOUT HOW TO CARRY OUT TASKS WHEN USING THE INTERACTIVE PRODUCT. MENTAL MODELS ARE ALSO USED TO FATHOM WHAT TO DO WHEN SOMETHING UNEXPECTED HAPPENS WITH A SYSTEM AND WHEN ENCOUNTERING UNFAMILIAR SYSTEMS. THE MORE SOMEONE LEARNS ABOUT A SYSTEM AND HOW IT FUNCTIONS, THE MORE THEIR MENTAL MODEL DEVELOPS. FOR EXAMPLE, TV ENGINEERS HAVE A "DEEP" MENTAL MODEL OF HOW TVS WORK THAT ALLOWS THEM TO WORK OUT HOW TO FIX THEM.

3.3.2 INFORMATION PROCESSING:-

- ANOTHER APPROACH TO CONCEPTUALIZING HOW THE MIND WORKS HAS BEEN TO USE METAPHORS AND ANALOGIES. A NUMBER OF COMPARISONS HAVE BEEN MADE, INCLUDING CONCEPTUALIZING THE MIND AS A RESERVOIR, A TELEPHONE NETWORK, AND A DIGITAL COMPUTER. ONE PREVALENT METAPHOR FROM COGNITIVE PSYCHOLOGY IS THE IDEA THAT THE MIND IS AN INFORMATION PROCESSOR. INFORMATION IS THOUGHT TO ENTER AND EXIT THE MIND THROUGH A SERIES OF ORDERED PROCESSING STAGES (SEE FIGURE 3.11). WITHIN THESE STAGES, VARIOUS PROCESSES ARE ASSUMED TO ACT UPON MENTAL REPRESENTATIONS. PROCESSES INCLUDE COMPARING AND MATCHING. MENTAL REPRESENTATIONS ARE ASSUMED TO COMPRISE IMAGES, MENTAL MODELS, RULES, AND OTHER FORMS OF KNOWLEDGE.
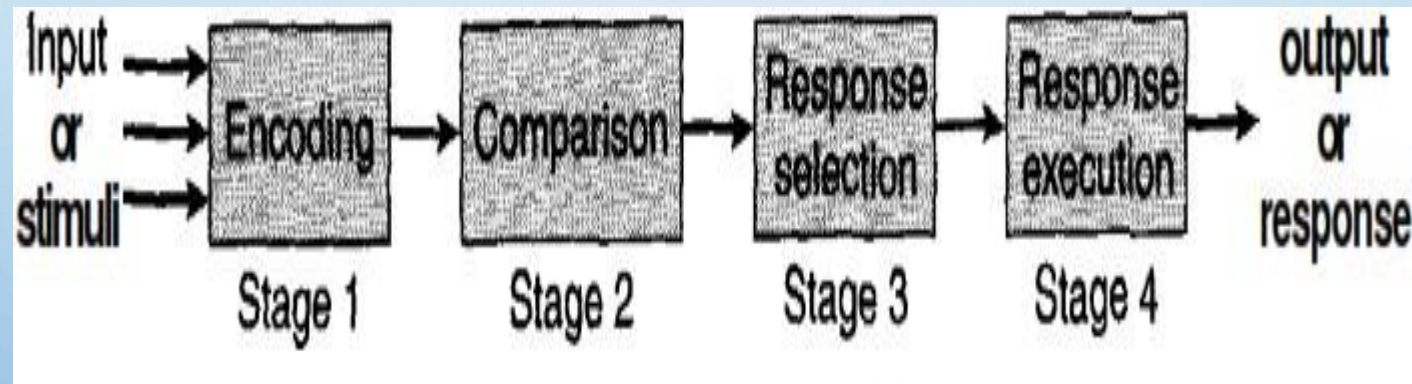

FIGURE (3.2) HUMAN INFORMATION PROCESSING MODEL

SEVERAL RESEARCHERS HAVE ARGUED THAT EXISTING INFORMATION PROCESSING APPROACHES ARE TOO IMPOVERISHED.

3.3.3 EXTERNAL COGNITION

PEOPLE INTERACT WITH OR CREATE INFORMATION THROUGH USING A VARIETY OF EXTERNAL REPRESENTATIONS, E.G., BOOKS, MULTIMEDIA, NEWSPAPERS, WEB PAGES, MAPS, DIAGRAMS, NOTES, DRAWINGS, AND SO ON. FURTHERMORE, AN IMPRESSIVE RANGE OF TOOLS HAS BEEN DEVELOPED THROUGHOUT HISTORY TO AID COGNITION, INCLUDING PENS, CALCULATORS, AND COMPUTER-BASED TECHNOLOGIES. THE COMBINATION OF EXTERNAL REPRESENTATIONS AND PHYSICAL TOOLS HAVE GREATLY EXTENDED AND SUPPORTED PEOPLE'S ABILITY TO CARRY OUT COGNITIVE ACTIVITIES (NORMAN, 1993). INDEED, THEY ARE SUCH AN INTEGRAL PART THAT IT IS DIFFICULT TO IMAGINE HOW WE WOULD GO ABOUT MUCH OF OUR EVERYDAY LIFE WITHOUT THEM

- **EXTERNAL** COGNITION IS CONCERNED WITH EXPLAINING THE COGNITIVE PROCESSES INVOLVED WHEN WE INTERACT WITH DIFFERENT EXTERNAL REPRESENTATIONS (SCAIFE AND ROGERS, 1996). A MAIN GOAL IS TO EXPLICATE THE COGNITIVE BENEFITS OF USING DIFFERENT REPRESENTATIONS FOR DIFFERENT COGNITIVE ACTIVITIES AND THE PROCESSES INVOLVED. THE MAIN ONES INCLUDE:

1. EXTERNALIZING TO REDUCE MEMORY LOAD

2. COMPUTATIONAL OFFLOADING

3. ANNOTATING AND COGNITIVE TRACING

1- EXTERNALIZING TO REDUCE MEMORY LOAD

- A NUMBER OF STRATEGIES HAVE BEEN DEVELOPED FOR TRANSFORMING KNOWLEDGE INTO EXTERNAL REPRESENTATIONS TO REDUCE MEMORY LOAD. ONE SUCH STRATEGY IS EXTERNALIZING THINGS WE FIND DIFFICULT TO REMEMBER, SUCH AS BIRTHDAYS, APPOINTMENTS, AND ADDRESSES. DIARIES, PERSONAL REMINDERS AND CALENDARS ARE EXAMPLES OF COGNITIVE ARTIFACTS THAT ARE COMMONLY USED FOR THIS PURPOSE, ACTING AS EXTERNAL REMINDERS OF WHAT WE NEED TO DO AT A GIVEN TIME (E.G., BUY A CARD FOR A RELATIVE'S BIRTHDAY).

- EXTERNALIZING, THEREFORE, CAN HELP REDUCE PEOPLE'S MEMORY BURDEN BY:

- REMINDING THEM TO DO SOMETHING (E.G., TO GET SOMETHING FOR THEIR MOTHER'S BIRTHDAY)

- REMINDING THEM OF WHAT TO DO (E.G., TO BUY A CARD)

- REMINDING THEM OF WHEN TO DO SOMETHING (SEND IT BY A CERTAIN DATE)

2- COMPUTATIONAL OFFLOADING

- COMPUTATIONAL OFFLOADING OCCURS WHEN WE USE A TOOL OR DEVICE IN CONJUNCTION WITH AN EXTERNAL REPRESENTATION TO HELP US CARRY OUT A COMPUTATION. AN EXAMPLE IS USING PEN AND PAPER TO SOLVE A MATH PROBLEM.

3- ANNOTATING AND COGNITIVE TRACING

- ANOTHER WAY IN WHICH WE EXTERNALIZE OUR COGNITION IS BY MODIFYING REPRESENTATIONS TO REFLECT CHANGES THAT ARE TAKING PLACE THAT WE WISH TO MARK. FOR EXAMPLE, PEOPLE OFTEN CROSS THINGS OFF IN A TO-DO LIST TO SHOW THAT THEY HAVE BEEN COMPLETED. THEY MAY ALSO REORDER OBJECTS IN THE ENVIRONMENT, SAY BY CREATING DIFFERENT PILES AS THE NATURE OF THE WORK TO BE DONE CHANGES. THESE TWO KINDS OF MODIFICATION ARE CALLED ANNOTATING AND COGNITIVE TRACING:

- ANNOTATING INVOLVES MODIFYING EXTERNAL REPRESENTATIONS, SUCH AS CROSSING OFF OR UNDERLINING ITEMS

3.4 INFORMING DESIGN: FROM THEORY TO PRACTICE

- THEORIES, MODELS, AND CONCEPTUAL FRAMEWORKS PROVIDE ABSTRACTIONS FOR THINKING ABOUT PHENOMENA. IN PARTICULAR, THEY ENABLE GENERALIZATIONS TO BE MADE ABOUT COGNITION ACROSS DIFFERENT SITUATIONS. FOR EXAMPLE, THE CONCEPT OF MENTAL MODELS PROVIDES A MEANS OF EXPLAINING WHY AND HOW PEOPLE INTERACT WITH INTERACTIVE PRODUCTS IN THE WAY THEY DO ACROSS A RANGE OF SITUATIONS. THE INFORMATION PROCESSING MODEL HAS BEEN USED TO PREDICT THE USABILITY OF A RANGE OF DIFFERENT INTERFACES.

- THEORY IN ITS PURE FORM, HOWEVER, CAN BE DIFFICULT TO DIGEST. THE ARCANE TERMINOLOGY AND JARGON USED CAN BE QUITE OFF-PUTTING TO THOSE NOT FAMILIAR WITH IT. IT ALSO REQUIRES MUCH TIME TO BECOME FAMILIAR WITH IT-SOMETHING THAT DESIGNERS AND ENGINEERS CAN'T AFFORD WHEN WORKING TO MEET DEADLINES.

- RESEARCHERS HAVE TRIED TO HELP OUT BY MAKING THEORY MORE ACCESSIBLE AND PRACTICAL. THIS HAS INCLUDED TRANSLATING IT INTO:

- DESIGN PRINCIPLES AND CONCEPTS

- DESIGN RULES

- ANALYTIC METHODS

- DESIGN AND EVALUATION METHODS