Cognitive Psychology in HMI

Individual exam, 3hp.

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QUESTION 1:

Think of yourself as being a member of a design team having designed a decision support system for a customer. The system is meant to assist air traffic controllers in proficiently carrying out their work. You are responsible for the design of the user interface of the system which is meant to support the air traffic controllers. Now, in a discussion with the customer you are asked to explain the basic theories behind your suggested design for a decision support system to be used by the air controllers, as follows:

QUESTION 2:

The driving school "Honk-the-horn" in Stockholm, has renewed its teaching and is in particular stuck for ideas of "learning by doing" and that learning is best done in contexts where knowledge is used. The result is that students are literally thrown out into the Stockholm traffic. Teachers at the driving school marvel, however, that their students, despite the new pedagogy, seems to have severe difficulties to learn to deal with e.g. the gear in a car, steering the car with the steering wheel, problems with the clutch, gas and brake – i.e. driving the car. It has been particularly noticed that these problems seem to escalate in traffic situations involving the interpretation of traffic signs, there being pedestrians and cyclists to look out for, etc., i.e. situations that are more intense.

The traffic school has now called you in as an expert and advisor on the subject. The traffic school wants to do an evaluation of the new pedagogy and therefore demands that a document is written that they can have as a basis for evaluation of their new pedagogy. What is pictured is a document related to the problems they have experienced (described above) and that deals with relevant cognitive processes and concepts in cognitive psychology, and more specifically processes of attention, memory, and perception.

Write the document that is asked for, base and anchor your writing on the facts from the course book Anderson, in particular;

-perception, attention, and

- memory.

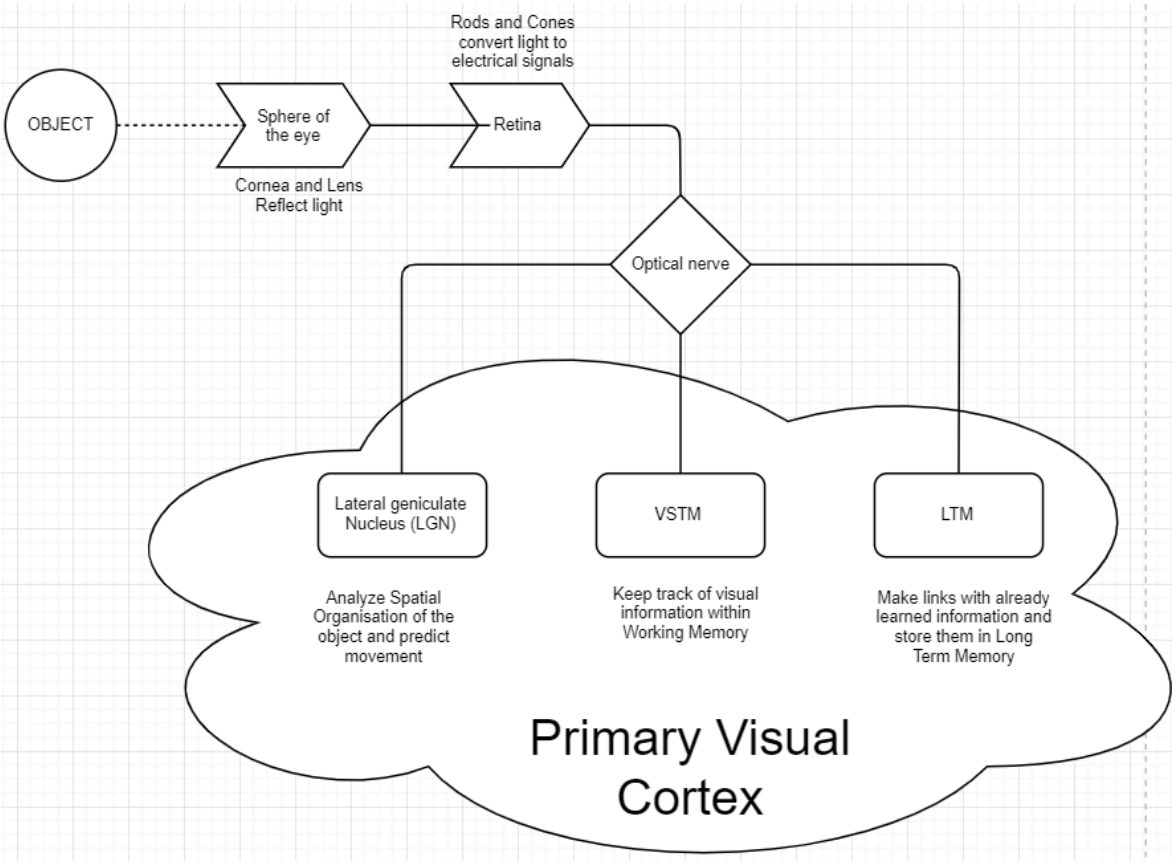
MY ANSWER TO QUESTION 1 – write your answer below

I- Visual system and how information travel in the brain :

Visual processing takes an important part of our brain. We receive information through our eyes, this information is processed and then organized in some way. To be able to do something with it and in order to remember it, we have to associate this information with information already learned. Advance in neuroscience shows that Information travels all the way back to the primary visual cortex, located on the occipital lobe.

In order to make better sense of Early and Late visual information processing, we need to understand how the visual system works.

At first, All the information coming from the right visual field (right eye) goes to the left side of the brain, and all information coming from the left visual field (left eye) goes to the right side of the brain. They cross at the "optic chiasm" (Figure 2.5 Page 30 from John Anderson Book), and travel through the optic nerve, that decides, depending on the type of information perceived, what part of the brain should process it.



The primary visual cortex is the first cortical area to receive visual input, after that, there are two pathways (Visual streams) that pass the information.

1- Dorsal Visual Stream : Determine **HOW** action is guided toward objects ?
   - *Originates in the occipital cortex and projects to the parietal cortex*

2- Vental Visual Stream : Identify WHAT object it is
   - *Originates in the occipital cortex and projects to the temporal cortex.*

On one hand, we can look at early visual processing as what enables us to sharpen the image of the object presented. When we show a subject a particular object and ask him to draw it back, the ability to draw back accurate details depends on the performance of his early visual processing.

The late visual processing, on the other hand, deals with pattern recognition. That's what enables us for example to understand many different writing of the same letter, to distinguish between forms, and interpret what is being presented.

II - Bottleneck phenomenon and Interface Design:

There are many different information that need to be processed. It can be an information about feedback to coordinate movement, mapping ; Spatial relations like reading maps, finding places, judging time (predict how long something will take) ; Visual closure : facial recognition, looking at missing parts, identify what that missing part is and link it to memory.

Neurobiological literatures and theories on mental workload affirm that, where there are too many information, a part of them might not be processed as we wanted to. When we present a subject with too much information, the subject has difficulties to remember all of them.

However they agreed on a loss of information, one question that has occupied psychologists and neuroscientist is : how early do the bottlenecks occur ? Before we perceive the stimulus, after we perceive the stimulus but before we think about it, or only just before motor action is required ?

In order to counter this bottleneck phenomenon, we need to think of a design that already filters the most relevant information.

We focused mainly on presenting few details on the interface, each details containing all the important information regarding a specific issue. We think that organizing information by their relevance will help the air controllers spend more time about "what decision can I make, according to the information presented", rather than, "What information do I need to look at, in order to make a decision".

We tried to group the objects presented in the interface following the Gestalt principles. These principles take into account the complexity of the objects perceived and enable us to present information as groups of united forms for specific problems. The Interface aims to organize and assign forms for all the different situation an air controller may encounter, and the gestalt principles makes it easier for the user to identify and recognize patterns.

You can also find in Red, the information related to "Aircrafts landing", information about "Aircrafts departures" is in Blue and information concerning "Sky traffic" in Green. According to J. Ridley Stroop (1935), the first psychologist to work on the Stroop effect, the brain identifies colors more readily than words. So by linking specific colors to specific problem an aircraft controller deals with, we hope to reduce the delay in the reaction and decision time.

So, by focusing on the structure of the interface and the relevance of the information presented, we believe users will better interpret the encountered problems and take the best decision accordingly, thus avoiding consequential errors in such a critical area of work.

MY ANSWER TO QUESTION 2 - write your answer below

1-How attention and memory are implicated in a Learning task

According to (Dewey, 1938; Piaget, 1964; Vygotsky, 1986), Learning is an active process, a process of engaging and manipulating objects (involving cognitive processes such as perception and attention), conversations and experiences (involving memory), in order to build mental models of the world.

This process consists of absorbing and generating knowledge (combination of data and information) in order to improve our performance in a task.

There is two types of Knowledge :

- Declarative knowledge : Things we remember, we can report on it when asked for
- Procedural Knowledge : When some process becomes automatic, we repeat a task so much that it is embodied in ourselves. With time and practice, we build experience and the task become easier.

In order to understand how we improve ourselves on a learning task, we first need to understand how memory processes information :

According to Baddeley's first model (1974), Working Memory consists of three components: the visuospatial sketchpad, the phonological loop, and the central executive, that work together to process incoming information. The **visuospatial sketchpad** governs the processing of visual information, the **phonological loop** deals with auditory and written information and the **central executive,** allocates information to the correct component.
The addition of the **episodic buffer** (25 years later) allowed a clearer connection to be made between working memory and long-term memory. The episodic buffer is also controlled by the central executive, it transfers information into and out of the long term store.

Neuro psychologist agreed that **the type of information perceived** impacts the way this information is processed by our brain. However, **the way we perceive information** also impacts and triggers our attention, which is according to Nelson Cowan (Cowan et al, 2005, 2006; Gold et al, 2006), a core vehicle of working memory.

Attention can be split into 2 parts :

- Active attention: Active attention is the determined directing of concentration, it is triggered when we perform a specific task. In a driving task, the information related to the gears, steering wheel and all other information that help execute the task, are processed by active attention

- Passive attention : Passive attention is the unconscious or semi-conscious reactive mode of perceptual awareness. It is what processes the background information while performing a task. In Driving task, the passive attention focus on the road signs, pedestrian and all external information.

II-Issues while driving

a- Mental workload

When the driver is presented with too much information, he find it difficult to memorize them all at once.

Leino, Leppaluoto, Ruokonen, and Kuronen (1999) studied psychophysiological performance under high workload flying conditions. They found out that : "*A certain level of neuroendocrine activation in response to a psychological workload evidently increases a pilot's ability to perform….However, very high anticipatory levels of ACTH have been shown to correlate negatively with psychomotor performance*."

A lot of information needs to be processed while driving: Lansdown (2001) explored drivers visual workload and argued that visual inputs are the primary source of information for drivers. Sabey and Staughton (1975) estimated that over 90% of information received while driving is visual.

Lansdown differentiated performance of novice and expert drivers, citing that experts tended to be more efficient in their attentive processing. Specifically the author cited that experts relied more on peripheral visual cues to maintain lane position as compared to novices who relied heavily on foveal fixations. This finding suggest that experts have more attentional resources to devote to other events or situations than novices. And that beginners are more likely to process a single task into step by step chunks. Beginners are most principally focused on the driving task, rather than the external environment. It is therefore really problematic for a novice driver to "handle" and decide what action to do according to what external information he is exposed to (Road signs, pedestrians, slippery roads etc ..).

It is therefore suggested that beginner drivers are more likely to perform poorly on a driving task when there is too much information, or when they get stressed by distracting factors.

b- Breakdown of attention under stress

Matthews and Desmond (1995) postulated that within the context of driving abilities and use of automation systems, stress tends to have three effects: it overloads attentional capacity, disrupts executive control over selective attention, and disrupts adaptive mobilization of effort. A novice driver thinks about what he is doing too much and when this happens, he inadvertently replaces highly effective automatic execution of his driving skills with deliberate, mentally taxing processes that are poorly designed for driving.

Al'Absi, Hugdahl, and Lovallo (2002) measured cortisol (physiological measure of stress) levels in subjects after they completed stressful tasks. These investigators concluded that cortisol disrupts working memory but enhances selective attention.

Also, Diamond, Fleshner, Ingersoll, and Rose (1996) examined the relationship between stress, hippocampal impairment, and memory, Diamond and it indicated that extended exposure to stress results in damage to the hippocampus (neural loss) and impairment in learning.

Thereby, it is suggested that performing a driving task under stress results in a disruption of the active attention and working memory cognitive processes, therefore slowing down the learning task of driving.