NAME: Giacomo Bartoli
STUDENT ID: 930130T538

QUESTION 1:

Visual perception can be distinguished in two phases. The first one is the early phase. During the early phase our sight recollects shapes and objects from the visual scene. Thereafter, during the late phase, shapes are join together so we can be able to recognize objects.

The way we process information through sight can be summarized in 3 steps:
- Information coding in visual cells
- Perceiving depth and surfaces
- Object Perception

According to Hubel & Wiesel's representation of the primary visual cortex, the organization of the visual cortex is topographic, meaning that areas closed to each other represent similar objects and adjacent regions represent similar orientation. A huge amount of information has been taken from the visual signal. But this is not at all, we can also perceive the colors of objects and whether they are moving. Livingstone and Hubel's theory affirms that our visual system process forms, colors and movements separately. For instance, if a colourful object is moving in a specific space these features (form, color, movement) belong to different visual area of the brain.
The next step is to locate the object in the space. Here, the main issue is that the information on the retina is two dimensional, while we want to reconstruct a three dimensional object. A lot of factors are taken into account in order to infer distance. Texture gradient is a factor which represents the tendency of items to appear more close and packed together as they are more far from the viewer. Another important factor is stereopsis, meaning that each eye has a slightly different view of the world and this gives to objects a third dimension. Motion Parallax is a cue used by our visual perception system for placing, rendering and visualizing 3D objects. In fact, objects that are more distant will tend to move in the retina more slowly than closer ones. As soon as we move our head, the 3D structure of an object becomes clear.
Another important study in the field was done by David Mar. He proved that a generic representation is far from the actual perception of the world by a factor of 2.5D sketch. 2.5D is inherently the ability to perceive the physical environment, which allows for the understanding of relationships between objects and ourselves within an environment.

However, what we have already mentioned is not sufficient: we still need to understand how shapes in our visual perception system go together to form the objects we see.
Amongst all our senses, visual perception is the best one.
We are constantly bombarded by million of information that consciously or unconsciously we handle all the time. What are the principles to handle this information?
Gestalt psychologists have been extremely influential and they found four principles that explain how we structured information. The principle of proximity is the one that recognize elements close together as units. The principle of similarity tend to group objects depending on their form and shape, while the principle of good continuation make it easy to see things that are "naturally" connected. This is why when we draw a simple cross we just draw before a diagonal line, then the other diagonal line. These two lines follow a sort of natural continuation. In the end, the principle of closure can be exemplified just by taking two pictures of overlapped circles, where the first circle is not closed at all we tend to see the circle even if it's not closed. It's just like our perception needs to see the complete figure before recognizing that it is a circle.
Principles like this govern our perception of the world.
It is perfectly unconscious because if we have to think about it every time there will be too many questions. Some processes just happen, they are automatic.
Still David Marr, as a researcher, started asked questions to AI scientists like: *what is perception? What characterise an object?*
Saying what characterise an object isn't that easy. The size, the shape and the context are important. Marr suggests a bottom-up process: you start recognising shapes, then size, then colours before realising it's a bottle. On the other hand, he received some criticism: can this be the case that our perception is always bottom-up?
He died young, but he showed to the world that the perception make some raw pictures that we interpret in our mind.
At the same time, James Gibson had a completely different perspective. He said that it's the information outside that give all we need to interpret the world. When we are infants our perception system is not completely developed yet, this is why we need to use other senses: touch, eat, smell. But then we understand objects because they are shaped in a way we are suppose to use them. Gibson introduced also the concept of 'effectivity'. Objects have 'affordance' and 'effectivity', they present to us and we learn them how to use them. Information is presented to us and picked up.
Gibson and Marr have a completely different perspective, but there is also a middle way: Neisser. It's interesting to find a threshold between what is automatic and comes from the inner perception and what comes from the external world. They come up with a theory called 'Sensory stores': we need to pay attention to

information if we want to stick them to our memory. When there are many things that come to our mind we need to prioritise, we need to make choices.
For instance, let's suppose a scenario where a person is driving and doing other things like staying on the phone. If staying on the phone requires many attention then it can affects other actions.
The example that was brought at lesson was taken directly from Robert's daily life: he was driving because kids had to go to the football training. Kids were screaming, while his wife called him for asking to go to the grocery later on. Moreover, the radio was on with some random music. Things are getting confusing, too many information to elaborate. Our brain has a sort of threshold, after that information are discarded because mental load work should be balance.
This lead us to a fundamental rule for designing our user interface for air traffic control system: we must not provide too many information, but we have to provide the right one. It's a trade-off between too much information and usability. This can guarantee situation awareness and mental control.
Further considerations are about automatic processes. Some processes require our attention, while other not. To be more specific, control processes and high order cognitive process require conscious control like problem solving, reading and understanding. There are still some process that are automatic. Repeating a behaviour so many times makes it automatic. Reading as well, became such an automatic process to we can't stop reading ("the strip effect").
In general, processes that we do all the time are become automatic and there's nothing we can do to stop them.
Hence, for designing a good user interface for air traffic monitoring we should consider as well that many repetitive tasks will not increase for sure the complexity of the system, because pilots will be immediately get used to some actions like press some buttons with certain icons, in the same way we get familiar with a new smartphone after few hours.
Going back to the principle of proximity, reported by Gestalt psychologists, I would definitely say that grouping icons, buttons or knobs according to their functions will make the user experience something meaningful and this shrewdness can easily speed up the learning process for the new pilots.
Moreover, we should consider worst case scenarios where pilots have to take quick decisions in a context of emergency. They have a lot information and the design of the air traffic control system must help them in prioritize things. We need to design tools that help make priorities. Some examples can be design the icons of special buttons bigger than others, with colors that make them clear enough to be recognized or identified as different.
Finally, the training phase can be considered part of the design. Using latest technologies, flight simulation can become almost a real experience. Virtual reality and real world are mixed in a uniform environment. But we need to define measures

about how to check performances and efficiency in a specific context. If you really want to learn something you need valuable feedback on what you did.

Kolb's experiential learning style is an interesting theory made of four stages, structured as a loop. The first one is the concrete experience, a new experience is encountered. Then, it comes the reflective observation phase, reviewing and reflecting what happened during the previous step. The third phase is the abstract conceptualisation, meaning that reflective give us a new idea and we have to learn from experience. The last phase is the active experimentation where what we learnt has to be applied to the real world.

One final consideration regarding the training: it would a good idea to put everything in the same scenario and that pilots could be able to communicate in real time. This would make the simulation an experience close to what they are going to encounter in the real world.

References:

1. *Cognitive Psychology and its implication*, J.R. Anderson, chapter 2
2. *Visual Perception*, Wikipedia, https://en.wikipedia.org/wiki/2.5D_(visual_perception)
3. *Kolb's experiential learning*, Wikipedia, https://en.wikipedia.org/wiki/Kolbs_experiential_learning
3. *Personal notes taken during the course of Cognitive Psychology*, held by Robert Ramberg at Stockholm University, DSV dept. academic year 2017-18.

QUESTION 2:

How is knowledge represented in our mind? Do we represent all types of information in the same way or there are differences?
Cognitive psychology tried to answer these questions, aiming to understand how human processes represent information.
Data becomes information, information becomes knowledge. A piece of information is not turned into knowledge until a person knows how to use it. This is why knowledge comes from earlier experience and it varies depending on the context or the domain.
It is important to distinguish between declarative knowledge and procedural knowledge. The first one is just simply know things. For instance, what's the capital of Sweden? Stockholm. We can point at it. The latter kind of knowledge, procedural, is knowing how to do certain things.
Next question is: how knowledge is represented? Here, there are two main researches. Perception-based research is focused on representations that preserve the structure. On the other hand, meaning-based research is focused on representation that preserve the meaning, splitting the representation and its meaning. This is how we remember the core of the concepts.
Concerning the investigation of memory for meaningful interpretations of events, Wanner (1968) shown how important is the meaning, the main concept instead of just remembering a sequence of words that express the concept. People normally tend to extract the meaning from a message, they will rarely remember the exact sequence of words. The only way to retain information about specific wording is to be warned. Otherwise, we will not pay attention to it.
Later on, this theory was confirmed by a study conducted by Mandler and Ritchey (1977). While Wanner found out that participants were much more sensitive to meaning-significant changes in a sentence, Mandler and Ritchey proved that participants were more sensitive to meaning-significant changes in a picture.
Further observations can be done regarding memory visualization, for example: what does a Swedish 100SEK banknote look like? No one knows it, what we know is what it represents. We focus on the meaning. Researchers think that the meaning is represented in our mind.
Thus, they came out with a propositional representation theory: the smallest entity which is relevant in terms of being true or false. We try to get to the meaning of what we communicate.
Let's consider for instance the sentence: "the salesman sold a tasty sandwich to the stingy customer".
What does it mean?

- the salesman sold a sandwich
- the sandwich was tasty
- the customer was stingy

The order doesn't matter, what counts is the meaning.
This way of thinking has become extremely influencer in how human memory works.
We define meaning elements through relations.
In long term memory structures like that become extremely interesting. It seems that some concepts are close each other. According to these reasons, a theory called Propositional Networks was proposed. Propositions are represented in a network form. This network is done by nodes, which represent the arguments, and links, used to connect different nodes.
An important aspect of propositional network is the spatial location: we really do not care about the location of an element because the whole network can be seen as a tangle of marbles connected by strings. Marbles are nodes, strings are the links between nodes.
Studies confirm that it is helpful to think of the nodes in such networks as ideas and to think of the links between the nodes as associations amongst these ideas.
Semantic Networks, designed by Quillian (1966), are a sort of extension of Proposition Network that considers as key factor categories and hierarchy. Hence, information is stored and retrieved through a hierarchical network, where each layer represents the most general category. Each layer or node can be deepened and split into different subcategories. When our brain is looking for an information it walks through this network, this is why, as proven by Collins and Quillian, information stored into high layers are retrieved quicker than the ones in the sub-layers. However, as Conrad (1972) pointed out, there is another factor that can vary the retrieving time: when facts are experienced then the retrieval time is minor. It seems that if a fact about a concept is encountered frequently, it will be stored and retrieved quicker. A computer system does the same when it activates the cache for reducing the loading time of an application, web page.
It is a good practice to consider both semantic networks (meaning the hierarchical organization, the categorization) and experience as a key factors to estimate the time needed to retrieve a specific information.
There's still a lack in the idea behind semantic networks. In fact, even if they categorize properties and concepts, cannot capture the nature of our general knowledge about such concepts. Rumelhart & Ortony (1976) comes out with a representational structure called schema. A schema represents categorical knowledge according to a slot structure, in which slots specify values of various attributes. There is a strong parallelism with most famous programming languages that were introduced 20 years later, especially within the inheritance mechanism. Basically, a concept inherits the features of its superset.
Schemas are extremely functional for us! As soon as someone refers to something we have a schema for that. In fact, a good way to learn is to organise a material in a hierarchical structure.
I would like to focus on a theory that was not directly reported at classes, but we faced it through seminars. In the latest trends for learning athwart the support of

multimedia systems, there is the gamification theory: rules, concepts and their applications are learnt as playing a videogame. What is interesting is that we can encourage players to apply their knowledge to solve problems in order to unlock a character or pass to the next level. Supposing the main character has to face a dragon and beat it before going to the next level. The player needs a special sword for killing the dragon and the process that let to the player to get this sword requires the application of a task that agrees with the specific learning outcomes. So, it is not sufficient to know the rule, the concept but the player is forced to apply it. This is a concrete example of procedural learning, knowing how to apply theory to concrete cases.

To sum up, it would be a good practice to apply all these principles and theories to the design of a multimedia support system for learning. The system should be devised taking into account the importance of connections between different concepts, taking inspiration from semantic and proposition networks. After that, information should be structured, ordered in a hierarchical way: which concepts are more general and which one are subcategories? Then, concepts not only should be categorized but also fulfilled with their properties, according to their hierarchical structure.

Applying these principles to a concrete case is not so easy. Multimedia ICT support systems for learning can be anythings: an app, a videogame, a totem placed in a public place like a museum, etc. However we should remember that when an user interface is not clear enough, the user will tend to abandon our application. This is true for any object, with any interface and requiring any interaction: from a door to a tap, from a remote control to a mobile phone, from a car to a computer.

Effective learning can be achieved in a variety of ways; for example, by using a range of different approaches in the learning platform that will allow the user to pick the one that suits him, or that can be personalised to him, or by satisfying a number of the characteristics of good learning.

For sure, combining multimedia elements for learning something new seems to be the best way.

References:

1. *Cognitive Psychology and its implication*, J.R. Anderson, chapter 5

2. *Personal notes taken during the course of Cognitive Psychology*, held by Robert Ramberg at Stockholm University, DSV dept academic year 2017-18.

3. *The design of everyday things*, Donald Norma