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UNITED STATES PROGRAM FOR TECHNICAL ASSISTANCE TO IAEA SAFEGUARDS

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DEPARTMENT OF STATE
DEPARTMENT OF ENERGY
ARMS CONTROL AND DISARMAMENT AGENCY
NUCLEAR REGULATORY COMMISSION

Final Report
Basic Visual Observation
Skills Training Course
Appendix A

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Visual Observation Skills Training for IAEA Inspectors

IAEA Headquarters, Vienna

May 15-18, 1995

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Background

This course on Visual Observation Skills is part of the IAEA's effort to strengthen the safeguards system.

Developed by Pacific Northwest Laboratory and provided through the United States Program for Technical Assistance to IAEA Safeguards (POTAS).

Basis

- ◆ Conducted interviews with 24 IAEA inspectors and Section Heads to identify skills training needed for enhanced inspections.
- ◆ Concluded that observational skills training should encompass three modules – Visual Observation Skills, Communication Skills, and Organizing Skills.
- ◆ This course focuses on developing Visual Observation Skills.

Approach

- ◆ The course is intended to help inspectors evaluate and improve their skills in making observations during an inspection and in evaluating and interpreting this information.
- ◆ Provides theoretical basis for skills, recommended techniques, and practical applications.

Scope

- ◆ The course emphasizes **basic** skills: what skills are relevant in the observation process, how these skills come into play during an inspection, what are individual inspectors' skill development needs.
- ◆ Does **not** focus on what to observe or on IAEA policy or procedures.

Course Logistics

Meet: 4 days, 4 hours per day

You will be asked to:

- ◆ work together in small group activities
- ◆ complete individual exercises that help to identify skill development needs
- ◆ provide examples based on your own inspection experiences
- ◆ provide course evaluations

Course Topics

- ◆ Perception/Recognition
- ◆ Attention and Attention to Detail
- ◆ Memory
- ◆ Mental Imaging/Mental Models
- ◆ Judgment and Decision Making
- ◆ Visual Observation of Physical Surroundings:
Integration
- ◆ Conclusions and Summary

General Outline for Course Topics

- ◆ Basic rules or principles that guide skill development and applications
- ◆ Examples and exercises to demonstrate these rules
- ◆ Application of skills in inspections

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Course Overview

The course focuses on five visual observation skills with the final skill integrating the five skills to perform in a simulated inspection exercise.

These skills include Perception and Recognition, Attention and Attention to Detail, Memory, Mental Imaging and Mental Models, and Judgment and Decision Making.

Note that these skills are really cognitive processes. Thus, this course focuses on thinking about thinking. That is, the course is designed to help you identify the skills needed to enhance your observational skills and to identify which skills, in particular, you should focus on.

In general, you should be asking the following questions for each skills area:

- ◆ How do you currently observe during an inspection – what changes do you need to make to enhance your observational skills and use these skills during an inspection?
- ◆ What is your current skill level in these areas?
- ◆ How do you prepare yourself to use visual observation skills in an inspection?

Session 1: Perception and Recognition Skills

Perception

Perception processes are used to organize, interpret, and selectively extract sensory information. These processes allow us to make sense of the complex stimuli that comprise our environment.

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There are a wide range of perceptual abilities that are not just limited to the visual. Examples include:

- ◆ reading a road map
- ◆ identifying the melody in an unfamiliar piano piece
- ◆ recognizing the face of a friend or acquaintance
- ◆ seeing various animal shapes in clouds

- ◆ The perception process map demonstrates the variety of sensory input that triggers perception.
- ◆ These include visual, audio, olfactory, tactile, and gustatory. Although all senses contribute to perception, this session focuses on visual and audio.
- ◆ Also, note that the filtering process influences the final perception. The factors that contribute to this filter include level of perceptual awareness, expectations, perceived pay-offs, economy of thinking, and knowledge.
- ◆ Finally, several innate and one learned rule contribute to the perceptual process.

Role of Perception and Recognition Skills in Safeguards Inspections

- ◆ Aware of factors that influence perception and recognition
- ◆ Understand distortions that may occur
- ◆ Skills used to organize and identify features and events in a facility

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- ◆ Each cognitive skill area contributes to making observations.
- ◆ The areas of perception and recognition represent the entry point for making observations.
- ◆ Perception and recognition are used extensively in the observation process. This session identifies the mechanisms that control these processes and indicates how these might be distorted or altered.

Features that Influence Perception

- ◆ Threshold for perceptual awareness: subliminal messages
- ◆ Expectancies influence which sensory input is processed further
- ◆ Relative and perceived “pay-offs” for observations/perceptions
- ◆ Economy of thinking – Limited number of cues can be selected for further processing
- ◆ Knowledge about the situation

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- ◆ A threshold for perceptual awareness refers to the amount of stimulus energy required to generate a perception. It was thought that stimulus energy is either above or below a threshold and perception occurs or does not occur. Subliminal messages, however, have altered that strict interpretation.
- ◆ Research has shown that one’s expectations of a given situation alter what is perceived and reported.
- ◆ Perception of a stimulus is influenced by stimulus energy (signal strength) and the knowledge of results or what pay offs one receives as a result of perceiving the stimulus.
- ◆ Perceptual processes are geared toward economy or simplicity in processing and interpreting stimuli.
- ◆ One’s knowledge of the situation in terms of prior experiences and formal education also influence what is perceived and how that is interpreted.

Innate Perception Rules

- ◆ Figure Ground Perception – Initial response to an event or object
- ◆ Law of Simplicity – Interpreting and organizing sensory input
- ◆ Closure – Extrapolation from limited perceptions
- ◆ Similarity and Proximity – Mechanisms for organizing sensory input
- ◆ Constancy – Environmental factors do not alter perceptions

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- ◆ Along with these characteristics of the perceptual process, there are also certain rules that guide the perceptual process.
- ◆ We are all subject to these rules and as a result, these can influence what is perceived.
- ◆ Although we cannot change or modify the perceptual process, by understanding how we see what we see, interpretation of our observations can be improved.

Rules: Figure-Ground

We identify part of the environment as the target of perception (figure) and view the target in relation to the surrounding environment (ground)

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Figure-ground perception indicates that we identify part of the environment as the target of perception and view the target image in relation to the surrounding stimuli.

Note in the figure that the vase would be considered the target, whereas the surrounding stimuli is the ground (or background). We tend to focus primarily on the vase. If you look at the background as the target image, you will see two profiles. People typically see the vase first, but most can see the two profiles. This is a common perception (vase) which has been demonstrated across several cultures. Notice that the vase is non-symmetrical and contains profiles of two persons that are easily recognized.

Rules: Law of Simplicity

We have a tendency to see things in the simplest form possible. Certain elements are seen as belonging together because they provide better continuity of the target object.

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This rule corresponds with the general rule of economy of thinking. It is easiest to perceive an object as a complete whole, as opposed to an object with unusual parts or components. That information is more difficult to process and retain.

Look at Part A, what do you see?

Most would say a circle and a rectangle. But, look at Part B. What you are really seeing is this.

Our perceptual system has a difficult time perceiving these parts, but instead perceives these as complete objects. This reflects the need for economy and simplicity in the perception process.

Rules: Closure

This refers to the tendency to fill in information that is missing from the perceptual array.

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- ◆ The closure rule indicates that we can take partial information to create or determine the whole.
- ◆ All types of stimulus inputs can be interpreted using only partial information, visual and audio are the most relevant examples.

This represents an example of closure.

- ◆ The structure of this picture leads you to see a white borderless triangle lying on top of another triangle outlined in by pac-man figures. When the white triangle is seen as the figure, people generally claim that it looks lighter and is set off from the background.
- ◆ If the pac-man figures are blocked off, the effect is that the white triangle disappears.
- ◆ Thus, the appearance of the white triangle is formed by partial information.

Rules: Similarity and Proximity

These rules refer to ways in which perceptual elements are organized. Those that are similar are viewed as belonging together, or those that are close, are viewed as belonging together.

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- ◆ The simplicity and proximity rule reflects our need to organize information.
- ◆ A considerable number of experimental reports, some based on cross-cultural research, suggests that this process of organization is directly tied to the perceptual history of the observer.

- ◆ Elements in figures A, B, and C demonstrate the simplicity and proximity rule.
- ◆ In part A, all elements appear to be the same. Thus, there is no obvious or meaningful way to organize these elements, and similarity and proximity are of no use.
- ◆ In Part B, there is a tendency to view the elements as columns of information based on similarity.
- ◆ In Part C, there is a tendency to view the elements based on proximity as appearing in rows.

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Rules: Perceptual Constancy

This is a learned skill that allows us to perceive an object as constant even though the environment may suggest the object has changed in size (distance), color (lighting).

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- ◆ This particular rule differs from the others because this reflects a learned, rather than innate skill.
- ◆ At an early age, we fail to understand that changes in distance and lighting do not alter the perceived object.
- ◆ As we age, we develop the capacity to perceive the object as constant even if we are a short or long distance away or if lighting changes occur.

This represents an example of employing the constancy rule.

- ◆ Note that the two boys shown in the drawing might otherwise be perceived as one very large boy and one very small boy. Instead, this drawing depicts distance between the two boys.
- ◆ Therefore, we would describe the two boys as of equal in size.

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Closure Exercise

Example:

I am perceiving

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- ◆ The purpose of this exercise is to provide you with the opportunity to assess your skills at perceiving only partially provided information.
- ◆ You will complete two different types of closure tasks to assess how well you can perceive words or objects from only partial information.
- ◆ After completing the task, you will compute your score and you will be provided with information about how you have done relative to others.

Perceptual Illusions

- ◆ Demonstrate instances where perception and reality disagree
- ◆ Assess the likelihood of “true” illusions in the facility inspection environment

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- ◆ There are some perceptual illusions that appear in our natural environment, such the perceived size difference between the horizon and zenith moon.
- ◆ In general, however, most illusions must be crafted, such as those presented by a magician.
- ◆ Other more well-known perceptual illusions can be demonstrated when depicting three-dimensional objects in two-dimensional space.

Muller-Lyer Illusion

- ◆ Compare the first two lines in this drawing. In general, observers will report that the first line is shorter than the second, even after careful measurement.
- ◆ The next two figures demonstrate that this illusion may be a function of perception constancy. Hence, the first line appears closer than the second.
- ◆ As a result, it appears that it is closer and we conclude that it is shorter.

- ◆ Although both horizontal lines are the same length, we perceive the top line as being longer than the bottom line. Why?
- ◆ If this were a picture of a three-dimensional scene, such as railroad tracks receding in the distance, the top line would be seen as more distant.
- ◆ As with the Müller-Lyer illusion, our unconscious knowledge of perspective tells us that the top line must be longer than the bottom line, so we automatically compensate and perceive it that way, even though, in a two-dimensional drawing there is no difference in the lines.

Realistic Illusion Example

This drawing demonstrates how one might craft a true perceptual illusion.

- ◆ The drawing depicts a large compound. There is only one entry point. Based on the design of the compound, observers brought into this compound might very well assume that it covers a much smaller area.
- ◆ According to the drawing, there are a few opportunities for detecting the illusion. These include the entry from the road which might suggest the compound is larger, or detecting the structure behind the foliage.

Recognition

How do we recognize objects or define information after it is perceived? What internal mechanisms do we use to bring past experiences and knowledge to bear on this type of processing?

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- ◆ Recognition represents the ability of the observer to process complex stimuli to identify it as a member of a class of objects.
- ◆ Thus, when you see a friend's face, hear a Bach cantata, or taste sweet-and-sour pork, you can recognize each as something previously experienced.
- ◆ This section examines the process by which we combine stimulus information and previous experience to produce a recognition.

- ◆ As the process map indicates, perceptions feed into the recognition process.
- ◆ In this section, we examine two key features of recognition. These include form perception and the recognition process.

Form Recognition

- ◆ Template matching
- ◆ Prototype matching
- ◆ Recognition by components

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- Form recognition occurs when you identify or recognize shapes, faces, melodies, words, pictures, objects, and so on. Examples are reading a diverse set of handwritten notes, even though the letters are written in a very different style.
- ◆ Several theories have been postulated to explain how the recognition process occurs.
- ◆ Each theory is described and the potential problems with each is discussed.

Template Matching

- ◆ Consists of an internal construct or template that, when matched by sensory stimuli, leads to the recognition of an object.
- ◆ This theory holds that a great number of templates have been created by one's life experiences. Each template is associated with a meaning.

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- ◆ Template matching is a simple pattern recognition procedure based on fitting the exact configuration of sensory information to a corresponding configuration in the brain.
- ◆ An analogy of template matching occurs when we operate a computer. Data are converted into electronic impulses and the computer program identifies the pattern of impulses by matching it with an analogue in its memory.

- ◆ To identify a letter, say A, the visual system must take the sensory output and compare it to information stored in long-term memory. When an object is detected, the recognition system quickly compares the sensory information to each of the stored templates.
- ◆ Consider the letter A. How many ways can that letter appear in written or print form? This figure demonstrates that for a single letter there are a large number of possibilities.
- ◆ Strict interpretation of the model dictates that millions of separate templates need to be formed, each corresponding to a specific stimulus pattern.

Prototype Matching

Rather than specific forms or templates, an abstraction of patterns is stored in memory. This abstraction serves as the prototype for recognition purposes.

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- ◆ Using the abstraction or prototype developed, the stimulus input is checked against the prototype.
- ◆ This theory allows for the recognition of “unusual” but in some way related to the prototype.
- ◆ As an example, reflect on the process you use to recognize equipment in facilities. It is clear that equipment, although serving the same function, varies from facility to facility. How do you recognize equipment that you have not seen before?

Recognition by Components: Geons

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- ◆ This theory by Irving Biederman (1987), suggests that complex objects can be represented by a relatively small set of simple shapes called geons (short for geometrical ions).
- ◆ Biederman estimates that the average individual may be familiar with as many as 30,000 objects and that these are recognized by combining no more than 36 geons.
- ◆ The figure contains five geons that can be used to define several types of objects.

Example of Recognition by Components: Objects

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- ◆ Using this theory, object perception begins by the perceiver segmenting the object, usually at regions where edges join or where curves markedly change.
- ◆ These segmented components are then compared against geons to determine a best match.
- ◆ This figure demonstrates objects can be segmented into geons and these used to recognize an object. The numbers in these objects are linked with the numbered geons.

Circle for
Closure Ring

Cylinders for Drums

Recognition Process

- ◆ Bottom up: Data-driven
- ◆ Top down: Concept-driven
- ◆ Examples

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- ◆ An additional component of recognition concerns the context in which we recognize objects.
- ◆ Bottom-up – Data driven: this suggests that the observer recognizes information using no other cues from the environment. Thus, the data are limited to the object itself.
- ◆ Top-down – Concept driven: This suggests that the observer uses prior information and cues from the environment to recognize objects. Concept driven implies that the observer integrates previous knowledge and knowledge of the context to recognize objects or stimuli.

My phone number is area
code 81-15-342968. Please call!

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- ◆ This figure demonstrates the Top-Down approach in interpreting information. We have some expectations about the letters and the words they form.
- ◆ For example, we do not confuse the “is” with “15” and the letter “h” in phone is not confused with the letter “b” in number, even though the two appear very similar.

Conclusions

- ◆ Perception requires organization
- ◆ Perceptions are formed by prior experiences, knowledge, and expectations
- ◆ Recognition is generally a top-down process based on prior knowledge

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- ◆ The inspection process involves observing and recognizing stimuli in a facility. Although much of this has focused on visual stimuli, similar conclusions can be drawn for other types of sensory stimuli.
- ◆ Perceptions are organized based on prior experiences, knowledge, expectations, and perceived pay-offs.
- ◆ Rules guiding our perceptual system are constant for all observers, it is the differences in expectations and knowledge that contribute to differences in perception.
- ◆ In the recognition process, form is a critical feature in identifying stimuli. In addition, we generally rely on a top-down process to recognize stimuli. During inspections, taking a bottom-up approach may be more useful.

Techniques for Accurate Perceptions and Recognition

- ◆ Determine expectations and assumptions before conducting the inspection
- ◆ Observe – do not just see (process the information you perceive)
- ◆ Explore – do not just go with your first impression

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- ◆ Inspectors are encouraged to examine the general expectations and assumptions they rely on when conducting an inspection. Further, inspectors may formulate expectations and assumptions specific to a facility – identify these.
- ◆ Observe – during the inspection process, focus on all sensory input. Recognize potential cues in all aspects of the inspection process.
- ◆ Explore – identify stimuli that require closer inspection or clearer focus. Although the inspector cannot attend to all stimuli, determine which stimuli demand your attention.

Session 2: Attention and Attention to Detail

- ◆ The skills map shows that attention and attention to detail skills come into play directly following the perception and recognition process.
- ◆ These skills are composed of three levels of attention – focused attention or vigilance, selective attention, and divided attention.
- ◆ Information derived from attentional processing becomes encoded and enters into memory.

Role of Attention and Attention to Detail Skills in Safeguards Inspections

- ◆ Filter multiple inputs to determine focus of attention
- ◆ Identify inputs that warrant attention
- ◆ Identify inputs that distract or reduce attention
- ◆ Determine expectations and evaluate the accuracy of these during the course of the inspection
- ◆ Utilize inputs from all available sources

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- ◆ In the inspection process, the focus of a visual search is based on the expectation of where the most useful information is likely to be found.
- ◆ These areas tend to be fixed first and most frequently. Thus, attention is directed based on one's expectations.
- ◆ Attention may, however, be diverted by usual events, multiple inputs, and so on.
- ◆ It is important for the observer to determine which sensory input is relevant and warrants further attention.

Features of Attention

- ◆ Processing Capacity (Resource Limitations)
- ◆ Signal Detection
- ◆ Control of Attention (Automatic versus Controlled Processing)

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- ◆ Processing Capacity: We are unable to process all sensory cues simultaneously. Therefore, it is necessary to selectively focus on a limited set of sensory cues.
- ◆ Signal Detection: Signal detection research suggests that detection of a sensory cue (signal) is a function of probability of occurrence, the observer's bias in detection, and expected pay-offs from a correct or missed response.
- ◆ Control of Attention: Attention to sensory cues is at the control of the observer. Research has shown, however, that with highly practiced and routine tasks, attention can be automaticized (performed with little conscious awareness).

Factors That Influence Attention

- ◆ Novel Stimuli
- ◆ Habituation
- ◆ Stress

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- ◆ Novel Stimuli: Our attention can quickly be redirected toward novel stimuli presented in the environment. Such response may be appropriate or may serve to distract the observer from focusing on a key stimulus input.
- ◆ Habituation: If a stimulus is repeated frequently, the observer no longer reacts to it.
- ◆ Stress: Stressors have a phenomenological and physiological influence, and have an impact on information processing efficiency.

The Yerkes-Dodson law

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- ◆ Two researchers initially examined the relationship between stress and performance (Yerkes and Dodson, 1907).
- ◆ Results from more recent studies indicate that initial levels of stress **energize** the observer to expand the amount of resources available, including attention. High levels of stress **narrow** the amount of attentional resources available.
- ◆ This figure also demonstrates the differences in available attention resources based on task difficulty.

Types of Attention

- ◆ Focused Attention
- ◆ Selective Attention
- ◆ Divided Attention

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- ◆ Inspection activities require the observer to perform several tasks; some require focused attention, some selective, and some divided attention.
- ◆ These attention skills are described in detail on the following pages, along with research that defines general capabilities.

Focused Attention

- ◆ Ability to concentrate on only one source of input and avoid being distracted by all other inputs
- ◆ Resource Intensive
- ◆ Modifiable by automatic processing

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- ◆ Focused attention is a function of the task requirements. That is, if the task demands a single source of sensory input and processing, then any other sensory cues serve to distract and reduce performance on the task.
- ◆ This is described as a resource-intensive task, because attention must be focused on a single source of input. At the extreme, this represents a vigilance task in which focused attention must be maintained for hours.
- ◆ Attention resource demands can be reduced by automaticity. The task must provide consistent cues with the same or similar response.

Focused Attention Exercise

Materials Inspection Form

Review form to identify specific materials codes

Part 1: Perform with one source of input

Part 2: Perform with multiple inputs

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- ◆ The purpose of the focused attention task is to demonstrate this form of attention.
- ◆ Participants will also have the opportunity to assess their skill level in situations with competing and non-competing attentional demands.

Selective Attention

- ◆ Ability to process co-existing inputs
- ◆ Includes multiple inputs from a single modality or cross-modality processing
- ◆ The same response is required for all inputs
- ◆ Capacity and limits

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- ◆ The selective attention task differs from focused attention in that multiple inputs are processed.
- ◆ These multiple inputs can come from a single modality (all visual) or from multiple sources.
- ◆ Even though the inputs may differ, all require the same response.

Divided Attention

- ◆ Ability to monitor two sources of input presented simultaneously and to produce two different responses
- ◆ Capacity and limitations
- ◆ Impact on focused attention

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- ◆ Divided attention differs from Focused and Selective attention by the presence of multiple stimuli presented simultaneously, with each stimulus requiring a different response.
- ◆ Capacity and limitations: Concerning multiple cues – same modality, resource limitations are great. Concerning multiple cues – cross modality, a multiple resource model suggests that information processing efficiency is greater here than above.
- ◆ Refining one's divided attention skills may modify one's ability to focus attention.

Divided Attention Task

- ◆ Use two different sources of input to perform two different tasks

Part 1: Perform the primary task alone

Part 2: Perform both the primary and secondary tasks

- ◆ Compare results for both

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- ◆ The purpose of these exercises is to give participants the opportunity to gauge their skills in performing a divided attention task.
- ◆ The divided attention task involves processing information presented in visual and audio modalities.

Attention To Detail

A form of Focused Attention or Vigilance. In performing these types of tasks, the objective is to attend to very small details and make some decision based on this information.

Examples:

Task Demands

Stimulus inputs suggest the need for attention to detail

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- ◆ Attention to detail represents a component of the attention process in which the observer must attend to the finer details of an object, as opposed to the gestalt or general form.
- ◆ Such tasks may be initiated by the task itself, such as reviewing materials forms.
- ◆ In other instances, the observer must recognize that the stimulus object cannot be clearly understood or identified unless one attends to specific details.

Attention To Detail – Exercise 1

Purpose: Provide stimulus inputs that simulate one possible attention to detail task performed during inspection

Task: Compare two pictures of the same object. Identify differences between the pairs of pictures

Work in small groups.

Study the pairs of pictures for three minutes to identify differences.

Four pairs of pictures.

Discuss findings in large group

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- ◆ This Attention to Detail task simulates one of the activities that an inspector may perform during an inspection. That is, determine whether information provided for a facility or a room in the facility differs from other information.
- ◆ Participants work in small groups to make these comparisons.
- ◆ These comparisons require great attention to detail, such that little difference will be identified.

Attention To Detail – Exercise 2

Purpose: Provide a more realistic comparison task requiring attention to detail.

Task: Study picture 1 for 30 seconds – then study picture 2 from the pair for 1 minute.

Work in small groups.

Generate a list of the differences.

Three pairs of pictures.

Discuss findings in the large group

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- ◆ This comparison exercise is more realistic than the earlier exercise in that there is a time delay between studying the first photograph and the second photograph.
- ◆ Participants work in small groups to perform these comparison tasks. Structure of the task can be determined by the group.

Example Sensory Inputs Warranting Attention

Visual:	Equipment, structure, process
Audio:	Alarms, lack of alarms, unusual sounds
Tactile:	Structural materials, equipment
Olfactory:	Unusual chemicals, lack of usual facility aromas, solvents, alcohol, cleaning materials
Gustatory:	Unknown – Suggestions?

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- ◆ During the first two sessions, much of the discussion has been focused on visual input or cues obtained from photographs.
- ◆ This represents an opportunity to identify other types of sensory cues that the observer may use to trigger attention.
- ◆ The list appearing above is not exhaustive. Thus, participants are encouraged to generate their own list of sensory cues based on prior inspection experiences.
- ◆ Examples of visual, audio, tactile, and olfactory cues have been identified. The potential for gustatory cues are unknown.

Sensory Inputs Warranting Attention

Human Behaviors and Organizational Practices

Generally not considered as sensory input

Can provide useful information concerning facility operations

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- ◆ In general, the examples and discussion have concentrated on examination of physical layouts, equipment, and audio inputs related alarms and enunciators.
- ◆ Another source of sensory input which often requires attention during an inspection relates to the human element.
- ◆ Some general guidelines concerning cues to consider are provided.

Examples Of Human Behaviors Warranting Attention

- ◆ Organization structure and policies
- ◆ Facility personnel as they perform on the job
- ◆ Interactions with facility personnel

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- ◆ Organization structure and policies: Within any facility, guidelines for operations are in place. An example of cues in this area are security and clearance requirements, with expected security systems not in place.
- ◆ Facility personnel perform on the job: Examples here may include observing who gives commands in the facility; is this in line with your knowledge of staff hierarchy?
- ◆ Interactions with facility personnel: Examples include casually chatting with staff during down time, or overhearing staff as they converse.
- ◆ It is important for observers to recognize that focusing on materials, equipment, and the site, in general, may be insufficient. Divided attention skills may be used to obtain input from these cues, as well as from facility staff.

Conclusions

- ◆ Facility environment provides numerous inputs that demand attention
- ◆ Inspection activities require using all forms of attention skills – focused, selective, divided, and attention to detail
- ◆ Factors can reduce your attention – individuals respond differently to different task demands
- ◆ Abstract features of the facility also provide cues – organizational structure, operations, and human behaviors

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- ◆ Inspection is a resource intensive activity that demands that the observer attend to many cues in the environment.
- ◆ The observer will be expected to use attention skills – focused, selective, divided, and attention to detail – throughout the inspection.
- ◆ Observers must recognize when to employ specific attention skills, to distinguish between stimuli that demand attention and stimuli that can safely be ignored.
- ◆ The observer must also be cautioned to avoid focusing on environmental cues and consider information available from facility personnel actions and interactions.

Techniques for Applying Attention Skills

- ◆ Identify your skill level for focused attention, selective attention, and divided attention
- ◆ Identify opportunities to practice these skills (e.g., practice attending to two conversations at one time)
- ◆ Identify facility features that you generally ignore – determine if these features are truly irrelevant or require your attention
- ◆ Practice “interpreting” human behaviors in situations that will allow feedback
- ◆ Practice attention to detail by focusing on very small details in the environment
- ◆ Schedule inspection activities to correspond to the presence of high and low level stressors (e.g., fatigue from jet lag).

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- ◆ Skill levels for the different attention skills have been assessed, in part, in the course exercises. Other methods include practice listening to two conversations at one time (divided attention – one modality). Practice checking numbers or reading while listening to a conversation (divided attention – dual modality).
- ◆ Before an inspection, make a point of planning to identify a critical feature of the facility that you might otherwise overlook (e.g., facility is known to have added new security systems – note their location).
- ◆ Observe colleagues from a distance. Determine the topic of conversation without being close enough to hear. Verify your conclusions by asking your colleagues about their conversation.
- ◆ Consider the stressors that influence your skill level, such as heat, cold, noise, fatigue. For those that have the greatest influence on your attention skills, determine when each might appear during the inspection and schedule your activities accordingly.

Session 3: Memory

Memory is the process by which you store observations for later use

Role of Memory in Safeguards Inspections

- ◆ Recalling knowledge about the facility
- ◆ Remembering to do specific things
- ◆ Recognizing facility features and conditions
- ◆ Accurately transcribing alphanumeric data
- ◆ Remembering to follow up
- ◆ Adding to your store of knowledge

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Memory has a number of important uses in safeguards inspections. These uses include

- ◆ Recalling relevant knowledge about the facility you are inspecting
- ◆ Remembering to do specific things during the course of an inspection
- ◆ Recognizing facility features and operating conditions that may have safeguards relevance, and encoding them for later recall
- ◆ Remembering what you read, see, or hear long enough to accurately write it down
- ◆ Remembering to follow up on potential discrepancies, anomalies, and other action items
- ◆ Adding to your store of knowledge about this facility or type of facility

Topics to be Addressed

- ◆ How memory works
- ◆ Improving your memory
- ◆ Application to safeguards inspections

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These materials address

- ◆ How memory works
- ◆ Memory improvement techniques
- ◆ Application of memory to safeguards inspections

Memory Questionnaire

Not rigorous, but will provide a sense of your memory compared to that of others

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- ◆ This questionnaire was developed by John Harris and Alan Sunderland to test everyday memory
- ◆ It is not a rigorous memory test, but will give you some sense of your memory compared to others

Memory Stages and Tasks

Memory Stages

- ◆ Sensory register
- ◆ Short-term memory
- ◆ Long-term memory

Memory Tasks

- ◆ Encoding
- ◆ Retrieval

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There are three stages of memory

- ◆ Sensory register
- ◆ Short-term memory
- ◆ Long-term memory

Linking these are two sets of key tasks

- ◆ Encoding information for storage in long-term memory
- ◆ Retrieval of information from long-term memory

Sensory Register

- ◆ Briefly holds incoming sensory image
- ◆ Decays in about a second unless transferred to short-term memory

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Sensory register

Briefly holds an incoming sensory image (visual, auditory, etc.)

- ◆ Portrays that image in rich, "photographic" detail
- ◆ The image decays very quickly (less than about a second); sight decays a little more quickly than sound
- ◆ In order for the information to last longer, it must be transferred to short-term memory

Short-Term Memory

- ◆ Holds contents of current attention
- ◆ Limited **capacity**: 6-7 items
- ◆ Limited **retention time**: 5-30 seconds without deliberate rehearsal

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Short-term (working) memory

An “active” memory that holds the contents of your current attention

- ◆ For the purpose of immediate manipulation (e.g., understanding or calculating) and subsequent retention (in long-term memory)
- ◆ Short-term memory has several important limits.
 - ◇ Limited access: your attention determines what gets into your short-term memory
 - ◇ Limited capacity: short-term memory can only store 6 or 7 items at one time
 - ◇ Limited retention time: you must consciously attend to information in short-term memory or it will decay within 5 to 30 seconds

Digit Span Exercise

- ◆ Indicates the number of digits you can accurately hold in short-term memory
- ◆ Typical digit span is 6 or 7
- ◆ Some people retain as few as 4-5
- ◆ Others reach 10 or more

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One means of measuring short-term memory is the digit span

Presents a sequence of digits

- ◆ Requires you to read them back in the same order
- ◆ Increases the length of the digit sequence until you always fail
- ◆ Digit span is the sequence length at which you are right half the time
- ◆ A typical digit span is 6 or 7, but some people get as few as 4 or 5 while others can remember 10 or more digits

Uses of Short-Term Memory

- ◆ Applies directly to transcribing telephone numbers, postal codes, and the like
- ◆ Or transcribing readout from a measurement instrument
- ◆ Short-term memory is the gateway to long-term memory

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Short-term memory has practical applications

- ◆ For example, in remembering telephone numbers and postal codes long enough to write them down – the error rate for such tasks is surprisingly high
- ◆ Or in a safeguards context, remembering the readout from an instrument long enough to accurately transcribe this information
- ◆ Perhaps more important, information must register in short-term memory in order to be stored in long-term memory

Example: The IAEA Directory

Ms TARE Nada	1582	2223	F0750	ADPR	MEDICAL SERVICE	
Mr TATSUTA Yoshinori	2777	2778	A2520	NENP	PLAN. + ECON.STUD	TATSUTA
Mr TATZBER Herbert	1761		GM162	RIAL	ISOTOPE HYDROLOGY	
Mr TAUCHID Mohamad	2754	2755	A2581	NENF	NUCLEAR MAT.+FUEL	TAUCHID
Ms TAYLOR Akossiwa	6008	6006	B1154	TC	PROGR. CO-ORD.	TAYLOR
Mr TCHEPKOSAV Anatoli	6182		B0548	NESI	SYSTEMS DEVELOP.	TCHEPKAS
Mr TEBB Graham	2826		A2436	NESI	INIS	TEBB
Ms TEMPLE Pauline	1516	1515	A1242			
Mr TER SCHIPHORST Gerrit	6147		B0504	NESI	COMP.USER LIAISON	TERSCHIP
Ms TESAR Elizabeth	6453	2276	A1918	SG	PROG.+RESOURCES	
Ms TEUFNER Audrey	6352	6362	A1380	SGDE	TRAINING	
Mr TEUSCHL Peter	2454		B0934	TC	INF.SYSTEMS	TEUSCHL
Mr THAILAYIL Jose	2661		A2649	NENF	WASTE MANAGEMENT	THAILAYI
Mr THANIKKAL Vincent de Paul	2568	2569	FM158	ADGS	COMMISSARY	
Mr THEIS Willi	2143	2144	A1707	SGOA	OPERATIONS A3	
Ms THIEBAUD Isabelle	2651	2650	A2653	NENF	DIRECTOR'S OFFICE	THIEBAUD
Mr THOEMING George	2871		A2420	NESI	INIS	THOEMING
Mr THOMAS Bernard	2685	6081	B0867	NENS	SAFETY ASSESSMENT	
Mr THORSTENSEN Svein E.	2069	2067	A1643	SGOC	DIRECTOR'S OFFICE	
Mr THOTTAKARA Chakkappan	1615		A2276	RIFA	PLANT BREEDING	THOTTAKA
Ms THOTTAKKARA Reena	2815	2817	A2567	NENP	NUCLP. TECH.DEV.	THATTAKK
Mr THURMAN Donald	1955	1957	A1826	SGOA	PROCEDURES AP	

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This excerpt from the IAEA Directory includes several examples of items you need to hold in short-term memory in order to use

- ◆ The staff member's telephone extension
- ◆ A second extension
- ◆ Their office address
- ◆ Their organizational affiliation

2407/100
2407
2407

22NA
1892-45-0
1892-45-10
1892-45-1
1892-45-1

26AL
1892-157-0

22P
54124-88-2
54124-88-1
54124-88-1

36C
54124-143-0

46 SC
51413-42-0
51413-42-100

54MN
3368-51-0
-1000

89
51413-53-0
51413-53-100

134 CS
2614-68-100
4491-2-500
4491-113-500

137 CS
4491-112-5000
4491-112-500
4491-112-500000

905 3-1-1000
338 3-1-1000
338 3-1-1000

22P
54124-88-2
54124-88-1
54124-88-1

46 SC
51413-42-0
51413-42-100

54MN
3368-51-0
-1000

226 Ra
37-117 0
-117-0
-117-25

226 Ra
50037-110-0
50037-130-0

226 Ra
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Country Code	Facility Code	MBA Code	Section Code	Item ID	Country Code	Facility Code	MBA Code	Section Code	Item ID
CN	CNR	CN-R	OB1	0968760	CN	CNT	CN-T	OB1	8077979
CN	CNZ	CN-Z	OB1	8675009	CN	CNP	CNP2	OB1	5570908
CN	CUA	CA-A	OB1	9896687	CN	CNV	CN-V	OB1	8675309
CN	CNT	CN-T	OB1	7798999	CN	CSF	CS-F	OC1	7833443
CN	CSI	CS-I	OC1	8896688	CN	CSH	CS-H	OC1	8899334
CN	CNN	CN-N	OB1	8809999	CN	CUC	CU-C	OB1	9873303
CN	CNV	CN-V	OB1	8675309	CN	CNS	CN-S	OB1	9899843
CN	CSD	CS-D	OC1	5708073	CN	CNH	CN-H	OB1	8866733
CN	CNV	CN-V	OB1	8675309	CN	CNT	CN-T	OB1	9899980
CN	CSB	CS-B	OC1	3535366	CN	CNV	CN-V	OB1	8675309
CN	CSI	CS-I	OC1	9877879	CN	CNI	CNI1	OB1	8987667
CN	CNV	CN-Z	OB1	8675309	CN	CND	CND1	OB1	9899765
CN	CNF	CNF1	OB1	6799848	CN	CSJ	CS-J	OB1	3488798
CN	COA	CO-A	OB3	1288303	CN	CSA	CS-A	OC1	6773339
CN	CNE	CNE1	OB1	8898844	CN	CZA	CZ-A	OC1	8898767
CN	CNV	CN-V	OB1	8675309	CN	CNV	CN-A	OB1	8675309
CN	CSB	CS-B	OB1	8867650	CN	CUC	CU-C	OB1	8765330
CN	CSZ	CS-Z	OC1	5388333	CN	CNS	CN-S	OB1	6676588
CN	CNV	CN-V	OB1	8675330	CN	COA	CO-A	OB3	9807788
CN	CSF	CS-F	OC1	8977989	CN	CSH	CS-H	OC1	8898770
CN	CZC	CZ-C	OC1	8896767	CN	CSM	CS-M	OC1	9876400
CN	CNV	CN-V	OB2	8675308	CN	CNV	CN-V	OB1	8675309
CN	CNZ	CN-Z	OB1	8879779	CN	CHZ	CH-Z	OB2	7896689
CN	CNP	CNP1	OB1	7855798	CN	CH-F	CNFE	OB1	7809998
CN	CNI	CNI2	OB1	8977989	CN	COA	CO-A	OB1	9877323
CN	CNV	CN-V	OB1	8675309	CN	CNU	CN-U	OB1	8879509
CN	CNI	CNI2	OB1	8799090	CN	CNV	CN-V	OC1	8675039
CN	CSE	CSE1	OB1	8769989	CN	CSI	CS-I	OC1	8098099
CN	CNO	CN-O	OB1	9796870	CN	CZC	CZ-C	OC1	9803880
CN	CNF	CN-F	OB1	4423090	CN	CSF	CS-F	OC1	8907099
CN	CNP	CNP1	OB1	3830080	CN	CNH	CN-H	OB1	9890380
CN	CNV	CS-V	OB1	8675809	CN	CNE	CNE1	OB1	9808989
CN	COA	CO-A	OB3	8980909	CN	CNV	CN-V	OB1	8673509
CN	CNF	CNFF	OB1	8789653	CN	CNU	CN-U	OB1	8675330
CN	CNO	CN-O	OB1	9476770	CN	CSB	CS-B	OC1	5693093
CN	CNI	CNI1	OB1	7456767	CN	CSF	CS-F	OC1	9087404
CN	CNI	CNI1	OB1	6739093	CN	CNB	CNB1	OB1	1302985
CN	CNZ	CN-Z	OB1	9874490	CN	CNU	CN-U	OB1	8976878
CN	CND	CN-D	OB1	8976954	CN	CNG	CNG1	OB1	3387329
CN	CNP	CNP1	OB1	8793309	CN	CNL	CN-L	OB1	4300221
CN	CSK	CS-K	OC1	6694090	CN	CNV	CN-V	OB1	8675319
CN	CSE	CSE1	OC1	2437869	CN	CNT	CN-T	OB1	9807608
CN	CNV	CS-V	OB1	8675809	CN	CUA	CU-A	OB1	7649989
CN	CUC	CU-C	OB1	8976540	CN	CZA	CZ-A	OC1	9869090
CN	CNP	CNP1	OB1	6685390	CN	CNI	CNI1	OB1	6098580
CN	CNU	CN-U	OA1	8909760	CN	CNZ	CN-Z	OB1	9870990

Country Code	Facility Code	MBA Code	Section Code	Item ID	Country Code	Facility Code	MBA Code	Section Code	Item ID
Q	Q002	Q002	OC2	7717710	Q	Q018	Q018	OC2	1175600
Q	QBRL	QBRL	OC2	1771177	Q	QBF1	QBF1	OC2	1711771
Q	QDRB	QDRB	OC2	9832117	Q	QDR7	QDR7	OC2	7711909
Q	QS16	QS16	OC2	7114234	Q	Q002	Q002	OC2	3373217
Q	QUK1	QUK1	OC2	4414884	Q	QBSZ	QBSZ	OC2	7314272
Q	QBQK	QBQK	OC1	9171173	Q	QBF7	QBF7	OC2	1711711
Q	QHLB	QHLB	OC2	7197119	Q	QBSZ	QBSZ	OC2	7124877
Q	QDR7	QDR7	OC21	9871171	Q	QBF1	QBF1	OC2	1711771
Q	QHNA	QHNA	OC2	7117711	Q	QDUA	QDUA	OC2	4432187
Q	QHPL	QHPL	OC2	5230033	Q	QS12	QS12	OC2	7681917
Q	QSLF	QSLF	OC2	7129071	Q	QDUA	QDUA	OC2	7190911
Q	QS33	QS33	OC1	1171090	Q	QSZ	QSZ	OC2	9117190
Q	QCAX	QCA4	OC2	7198171	Q	QBF1	QBF1	OC2	1717711
Q	QTWS	QTWS	OC1	1717878	Q	QDUB	QDUB	OC2	0917171
Q	QUK1	QUK1	OC1	6372123	Q	QHEY	QHEY	OC2	1906571
Q	QDR6	QDR6	OC2	1711090	Q	QBLR	QBLR	OC2	7117711
Q	QMCR	QMCR	OC2	1711901	Q	QHPL	QHPL	OC2	7917181
Q	QDRB	QBR9	OC2	7198077	Q	QBF1	QBF1	OC2	1711771
Q	QBSZ	QBS6	OC2	2217717	Q	QCA3	QCA3	OC2	7639383
Q	QHLA	QHLA	OC2	9087221	Q	QS07	QS07	OC2	1771271
Q	QBFL	QBFL	OC1	1711771	Q	QS33	QS33	OC2	7717171
Q	QCAX	QCAX	OC2	8817171	Q	QBKP	QBKP	OC2	8727722
Q	QBF7	QBF7	OC1	1771771	Q	QOLD	QOLD	OC2	4310090
Q	QSSR	QSSR	OC2	6277272	Q	QRFL	QRFL	OC2	7272727
Q	QBF1	QBF1	OC2	1711771	Q	QBSZ	QBS5	OC2	7200292
Q	QHPL	QHPL	OC2	4439071	Q	QBF1	QBF1	OC2	1711717
Q	QCAX	QCA3	OC2	7171711	Q	QPKF	QPKF	OC2	6363721
Q	QS32	QS32	OC2	6723212	Q	QDR1	QDR1	OC2	9831272
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Q	QMCR	QMCR	OC2	1817871	Q	QHR2	QHR2	OC2	2177811
Q	QOLD	QOLD	OC2	7172728	Q	QBF7	QBF7	OC2	7177787
Q	QSLF	QSLF	OC2	7171711	Q	QCPL	QCPL	OC2	7837383
Q	QHEY	QHEY	OC2	8739390	Q	QHR2	QHR2	OC2	7111090

Long-Term Memory

- ◆ Stores information from a few seconds to many decades
- ◆ Four key elements of remembering
 - ◇ Encoding
 - ◇ Retrieval from storage
 - ◇ Forgetting
 - ◇ Distortion

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Long-term memory

- ◆ Stores information durably enough to be accessible for more than a few seconds (i.e., anywhere from minutes to decades)
- ◆ Storage capacity is practically limitless

Remembering

- ◆ Remembering can be defined as storing information in long-term memory so that it can be accurately retrieved as the need arises
- ◆ There are four key aspects of remembering
 - ◇ Encoding: getting information into long-term memory
 - ◇ Retrieving information when needed
 - ◇ Not forgetting important information
 - ◇ Minimizing memory distortion

Encoding

- ◆ Putting information into long-term memory
- ◆ Three mental tasks
 - ◇ Attention
 - ◇ Association
 - ◇ Organization

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Encoding

- ◆ Putting information into long-term memory storage for later retrieval
- ◆ How we encode affects our subsequent memory; you are more likely to remember information later if you encode it in richness and detail
- ◆ Three mental tasks are particularly important to successful encoding:
 - ◇ **Attention** to what you want to remember
 - ◇ **Association** with related information you already know
 - ◇ **Organization** of complex information as part of a structured whole

Attention

- ◆ Short-term memory is the gateway to long-term memory
- ◆ Short-term memory capacity is limited
- ◆ Therefore you must **focus** your attention on the critical items you want to remember
- ◆ The key is **active observation**

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Attention

- ◆ Recall that what gets into long-term memory depends on short-term memory
- ◆ In turn, short-term memory capacity is limited and the environment can be rich, with many different items of available information competing for your notice
- ◆ Accordingly, it is critical to focus your attention on the critical items that you need to remember

Association

- ◆ We encode new information with reference to what we already know
- ◆ As a result, we tend to make associations automatically
- ◆ But you can improve the odds of remembering something by **conscious** association

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Association

- ◆ We typically encode new information with reference to related information that is already in long-term memory
 - ◇ For example, imagine meeting a facility operator for the first time
 - ◇ Your memory of him (or her) is likely to be encoded by making connections with various other items of information, such as his appearance, his background, the place where you met him, and who you were with
 - ◇ You may then associate him with bearded people, health physics experts, the office where you met him, and the other inspectors who were on your team for that inspection
- ◆ Association of this sort tends to happen automatically
- ◆ However, you can improve the odds of remembering an important item of information by consciously associating it with something you already know
- ◆ Indeed, association is the basis of many memory improvement techniques, as discussed below

Organization

- ◆ Encoding information as part of an overall structure helps you to remember it
- ◆ Especially **semantic memory**, your long-term memory for general knowledge
- ◆ Forms of memory organization include **associative models** and **schemata**

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Organization

- ◆ Information encoded as an organized whole is often much easier to remember than as a collection of individual items
- ◆ This is particularly true when the items themselves are interrelated or part of an overall structure
- ◆ For example, chess experts remember chess boards, bridge experts remember bridge hands, and electronics engineers remember circuits in this fashion
- ◆ Organized encoding is especially applicable to semantic memory, which is long-term memory for general knowledge
 - ◇ Under one leading theory, such knowledge is stored as a hierarchical network of interrelated concepts, often referred to as **associative models**
 - ◇ In addition, semantic memory appears to store knowledge about a particular topic as schemata or scripts
 - ◇ A script is an integrated package of information that provides context for the interpretation or understanding of an event
- ◆ As with attention and association, making a deliberate effort to encode information as an organized whole can facilitate long-term memory

In the absence of an organizational structure, this diagram appears hopelessly complex and is likely to be very difficult to encode

If you have an organizational structure, you will see and encode the diagram as an example of a familiar type.

Associative Model: One Example

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Source: Mary C. Potter, "Remembering" in D.N. Osherson and E.E. Smith eds., *Thinking: An Invitation to Cognitive Science, Volume 3* (Cambridge, MA: The MIT Press, 1990).

This is a typical example of an associative model

- ◆ Higher level categories include all the members of the categories below
- ◆ The characteristics of higher level categories are generally (but not always) shared by the members of the categories below

This associative model might represent knowledge of an IAEA safeguards inspector

Note that it has at least two uses

- ◆ Describes what the inspector knows
- ◆ Provides a framework for encoding new knowledge (such as Uranium Enrichment Plant, which is another Bulk Facility)

Retrieval

Process of accessing information from long-term memory

- ◆ Includes both **recall** and **recognition**
- ◆ Content addressing: analogous to finding a book in a library
- ◆ Retrieval cues: enable us to recall information stored at a nearby address
- ◆ Stress: beyond a certain point, hinders accurate memory

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Retrieval is the process of “calling up” information from long-term memory into short-term memory

- ◆ There are two basic ways in which we retrieve information from long-term memory: recall and recognition
 - ◇ Recall results from a self-initiated search for information in long-term memory
 - ◇ Recognition involves perceiving information presented to you as something that you already know
- ◆ Central to both forms of retrieval is the principle of content addressing
 - ◇ Retrieval starts with part of the content of the material to be recalled
 - ◇ Which in turn provides an “address” to the location in memory where related material is stored
 - ◇ Analogous to looking up a book in a library
- ◆ Retrieval cues are clues that enable one to recall other information that is stored at the same address as information that we do recall
 - ◇ Generally the feeling that something is on the tip of your tongue is probably correct – you can recall it, given the right cue, such as:
 - Broader categories of which the item is a member (especially if the item was encoded as a member of this category)
 - The first letter of a word
 - Closely associated words
 - Associated visual images
 - Associated smells
 - Aspects of the environment in which an event took place (often referred to as temporal contiguity)
 - ◇ One reason that recognition is generally easier than recall is that an item presented for recognition automatically includes a retrieval cue: the appearance of the item itself
 - ◇ You can often recall otherwise inaccessible information through an active process of introspection: taking the memory fragments that do suggest themselves and asking yourself for associations
- ◆ Stress can affect our ability to retrieve information from memory
 - ◇ A limited amount of stress can make us more alert and thus facilitate learning and memory
 - ◇ Beyond a certain point, though, stress starts to hinder accurate memory

Retrieval Cues Exercise

Example: name the capital of Canada

Hint: its first letter is "O"

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- ◆ This exercise illustrates how retrieval cues may help you to remember information on the "tip of the tongue".
- ◆ In this case, you may be able to recall a country's capital city if you are told its first letter

Forgetting

- ◆ Being unable to retrieve information from long-term memory
- ◆ Tends to follow a non-linear pattern

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Forgetting is being unable to retrieve information from long-term memory on demand

- ◆ Forgetting tends to follow a nonlinear pattern:
 - ◇ In many contexts, it is rapid at first and then slows down, in some instances becoming virtually frozen over long periods of time
 - ◇ The term permastore has been suggested for the stable level of retention
 - ◇ In some contexts, such as learning a foreign language, it is the initial level of learning (before the rapid initial drop-off) that determines the later level of permastore

Retention Over Time

Source: Elizabeth Loftus, *Memory* (New York: Ardsley House, 1988).

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Since the investigations of Hermann Ebbinghaus in 1885, numerous experiments have confirmed the "forgetting curve:" we forget much new information shortly after first learning it, but then forgetting becomes gradual.

Reasons for Forgetting

- ◆ The information was never stored
- ◆ Interference disrupts or obscures the memory
- ◆ There are few associations
- ◆ The information is not frequently asked
- ◆ The item has faded away
- ◆ “Motivated” forgetting: we “want” to forget the matter

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- ◆ There are several reasons you may forget a particular item of information
 - ✧ The item was never stored in long-term memory in the first place
 - E.g., you failed to notice it at all
 - Or you noticed it, but we did not pay enough attention to store it in long-term memory
 - ✧ Memory of the item has been disrupted or obscured through the process of interference
 - E.g., other intervening events prevent you from remembering the original event
 - For example, a classic experiment showed that subjects retain new information better when they go to sleep right away than when they go on with their daily routine
 - ✧ There are few associations or limited context for the information
 - For example, if you are not familiar with bulk-handling facilities, you may find it hard to remember details about operating conditions observed during an inspection
 - An inspector more experienced in this type of facility might readily recall quite subtle details
 - ✧ The information is used infrequently, unless there are no retrieval cues
 - For example, you may think you can recall little of a facility that you have not inspected for many years
 - Yet when you return to the facility itself, many details may come back to you
 - ✧ The memory trace has simply faded away with time and lack of use
 - ✧ You are motivated to forget
 - We “deliberately” forget because we “want” to forget
 - E.g., when the item is unpleasant, unflattering, or embarrassing

Distortion

- ◆ “Memory” of things we never perceived
 - ◇ Knew-it-all-along effect: we falsely “remember” having made a correct prediction
 - ◇ Constructive errors: we “fill in the blanks” with information that may not be accurate

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Distortion is a transformation of memory traces that cause us to recall things that never happened (or to recall things differently than as we originally perceived them)

- ◆ One example of distortion is the “knew-it-all-along” effect: we remember having anticipated how something would turn out, even when it was highly unlikely
- ◆ Distortion can also arise from constructive errors
 - ◇ The processes of encoding and retrieval does not work like a video recording and playback
 - We tend to encode and retrieve bits and pieces of information
 - For example, in recalling an event we remember a few facts, and then from these we make inferences to construct other “facts”
 - These constructed facts may or may not be true, but we remember them just as if we had observed them
 - ◇ As a result, our memory for details can be highly fallible
 - This is why “eye witness” testimony is so problematic
 - We may mis-remember details even though we are confident we have an accurate recollection
 - ◇ Indeed, as Elizabeth Loftus notes, every time we recall an event, we tend to re-color it in light of “succeeding events, increased understanding, a new context, suggestions by others, other people’s recollections”

Memory Improvement Techniques

- ◆ Starting point: determining what you need to do your job
- ◆ Useful distinction
 - ◇ Knowledge in the world
 - ◇ Knowledge in your head
- ◆ Plan to use both

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The starting point for memory improvement is to determine what information you need to remember in order to do your job

- ◆ As Donald Norman has observed, much of the information that we need in order to function is “knowledge in the world”
 - ◇ It is either preexisting – e.g.,
 - The signs and labels on instruments, equipment, and facilities
 - Pre-printed forms and checklists
 - ◇ Or you can create it – e.g.,
 - By making written notes
 - By placing items in specific locations so you won’t forget to use them
 - By using external aids, such as diaries, lists, calendars, timers, etc.
- ◆ Other information is “knowledge in the head” (in short-term or long-term memory)
- ◆ To develop a strategy, identify your memory needs, and then for each
 - ◇ Be aware of and plan to take advantage of knowledge already in the world
 - ◇ To the extent you can, supplement it through external aids that are comfortable for you
 - ◇ Plan to store the remaining information in your head and retrieve it through memory techniques that work for you

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INSPECTION PLAN (RS/1)

1. Name		2. Title		3. Organization	
4. Date		5. Time		6. Location	

7. Objectives	
8. Scope	
9. Methodology	
10. Resources	
11. Risks	
12. Deliverables	
13. Milestones	
14. Roles and Responsibilities	
15. Communication	
16. Reporting	
17. Review	
18. Approval	
19. Signatures	
20. Date	

This inspection plan form is an example of a pre-existing aid to help you remember the sequence of activities you will perform

Another example of a form that reduces what you need to remember unaided

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Memory Improvement Techniques – Short-Term

Chunking: segmenting characters into “chunks”

8763049 becomes 876 3049

A2653 becomes A26 53

Subvocalization: saying the words or
characters to yourself

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Techniques for improving short-term memory

- ◆ Chunking is parceling a sequence of digits or letters into groups (“chunks”)
 - ◇ The capacity of short-term memory is then determined by the number of chunks, rather than the number of digits
 - ◇ Chunks of 3 or 4 digits seem to work best
- ◆ Subvocalization is speaking the information aloud, or to yourself
 - ◇ Can be used to remember sequences of digits or letters
 - ◇ Or to remember complex sentences long enough to understand them (e.g., in a legal document)

Memory Improvement Techniques – Encoding for Retrieval

3-31

- ◆ Active observation: paying close attention
- ◆ Association: making connections
- ◆ Scrutiny to detect inconsistencies: avoiding the encoding of misimpressions

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Techniques for durably encoding items of information in long-term memory so they will be retrievable when needed, based on the principles of encoding discussed earlier in this session

- ◆ Active observation is the process of paying close attention to what you see, hear, or read
 - ◇ The techniques described in the session on Attention and Attention to Detail can thus help improve not only observation, but your memory of what you observe
 - ◇ The key ingredients are focus and interest: as William James said, attention “implies withdrawal from some things in order to deal effectively with others”
 - ◇ Think about the meaning of what you observe, how you might use it, what are its implications, how it confirm or contrasts with what you expected
 - ◇ One way of doing this is to engage in an imaginary dialogue in which you question what you observe and relate the material to what you already know or believe
 - ◇ Try to relate new information to yourself, your circumstances, and your interests as extensively as possible in the time available during encoding
 - ◇ Avoid passive observation (almost a contradiction in terms), in which you simply let information wash over you indiscriminately
- ◆ Association is the process of forming mental connections between what you want to remember and what you already know
 - ◇ Active observation will tend to trigger associations spontaneously
 - ◇ But you can help encode new information more durably by consciously making connections between it and other information
- ◆ Encoding to minimize later distortions can help improve the accuracy of memory
 - ◇ By carefully scrutinizing new information to detect inconsistencies as you observe, you avoid encoding misimpressions that you may later recall as what you actually observed
 - ◇ And if you rehearse an experience in your mind or out loud as you observe it or shortly thereafter, distortions are less likely to creep in later

Memory Improvement Techniques – Remembering Sequences

- ◆ Visual mnemonics: creating a sequence of mental images
- ◆ Verbal mnemonics: using words or phrases as retrieval cues

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Techniques for remembering sequences and lists, such as things to do

- ◆ Visual mnemonics have a rich historical tradition, dating to classical Greece (see The Art of Memory by Frances A. Yates)
 - ◇ One famous technique is the method of loci:
 - Say, for example, you are trying to remember a list of 10 items
 - Think of 10 locations in your home or office building or some other familiar place
 - Choose the locations so that the sequence from one location to the next is obvious and invariant
 - Now create a striking visual image which associates the first item with the first location, the second item with the second location, etc.
 - You should then be able to recall the list of items by mentally walking through the 10 locations and recalling the image of the item at each location
 - More broadly, simply visualizing something you want to remember to do, by creating a mental image of it, improves the odds that you will not forget
- ◆ Verbal mnemonics are of more recent, but still long-tradition
 - ◇ For example, you can group the first letters of a series of items in a list to form another word or a sentence whose words begin with the same first letters as the words on you list
 - ◇ May seem overly elaborate and inefficient in today's media-rich, high technology environment
 - ◇ But most of us still find verbal mnemonics useful on occasion ("Thirty days has September. ...")

Memory Improvement Techniques – Using Retrieval Cues

- ◆ Advance review: retrieving information before it is needed
- ◆ “Neighborhood search:” thinking of related information at a nearby address
- ◆ Alphabet search: looking for a letter that may be a retrieval cue

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Techniques for using retrieval cues to access information you know you have stored in long-term memory, but can't recall at the moment

- ◆ Advance review is really a way of avoiding or minimizing the problem by considering in advance and rehearsing information you believe you will need to access in the near future
- ◆ A “Neighborhood Search” exploits the principle of content addressing: you attempt to retrieve the item of temporarily forgotten information by thinking of related information likely to be stored at a nearby address
- ◆ An Alphabet Search simply involves going through the letters of the alphabet (paying attention to the sounds) to see if a letter jogs your memory

Application to Safeguards Inspections

- ◆ Assessing your memory needs
- ◆ Developing a memory strategy

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Applying memory skills to safeguards inspections involves a two-step process

- ◆ Assessing what you need to remember in order to do the job
- ◆ Developing a personal strategy for ensuring that those needs are met, using tools and techniques that work for you

Memory Needs

- ◆ Semantic knowledge of facilities
- ◆ Remembering to do specific things
- ◆ Recognizing features and conditions
- ◆ Remembering long enough to transcribe accurately
- ◆ Remembering to follow up
- ◆ Adding to your store of semantic knowledge

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The starting point is to assess your memory needs

- ◆ Remembering semantic knowledge of the facilities you are about to inspect – e.g.,
 - ◇ General knowledge about this type of facility
 - ◇ Design information for this particular facility
 - ◇ Past inspection results for this particular facility
- ◆ Remembering to do specific things during the course of an inspection – e.g.,
 - ◇ Reviewing records
 - ◇ Conducting independent measurements
 - ◇ Verifying equipment calibrations
 - ◇ Taking samples
 - ◇ Attaching, inspecting, and removing seals
 - ◇ Servicing surveillance equipment
- ◆ Recognizing and remembering facility features and operating conditions that may have safeguards relevance
- ◆ Remembering what you read, see, or hear long enough to accurately write it down – e.g.,
 - ◇ Measurement readings from an instrument
 - ◇ Items that you count
 - ◇ Numbers that you read in accounting records
- ◆ Remembering to follow up on potential discrepancies, anomalies, etc.
- ◆ Adding to your store of semantic knowledge about this type of facility or this specific facility – e.g.,
 - ◇ For use in debriefings
 - ◇ For use in subsequent inspections

Generic Strategy

- ◆ Identify memory needs
- ◆ Take advantage of knowledge in the world
- ◆ Supplement it through external aids
- ◆ Store remaining needed information through techniques that are comfortable to you

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After assessing your memory needs, you can then develop a strategy for making sure that you are addressing these memory needs, based on a combination of preexisting knowledge in the world, knowledge you place in the world (external memory aids), and knowledge in you head

Illustrative Strategy

Semantic facility knowledge

- ◆ Advance review of facility design information and inspection reports
- ◆ Personal notes, drawings
- ◆ Design documents
- ◆ Observed features, signage, etc.
- ◆ Your organized memory

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- ◆ For example, the general elements of such a strategy might be as follows
 - ◇ To recall semantic knowledge of the facilities you are inspecting, you might rely on
 - Advance review of facility design information and past inspection reports
 - Personal notes, drawings you bring to the facility to jog your memory regarding key or complex points
 - Facility design documents at the facility (if available)
 - Observed features and conditions, signage, etc.
 - Your organized memory for this type of facility and this particular facility based on facility training, design information documents, past inspection reports, and the pre-inspection briefing
 - If you are unable to recall information you believe you know, neighborhood or alphabet search

Illustrative Strategy (continued)

Remembering to do specific things

- ◆ Agency or personalized checklists
- ◆ Visual or verbal mnemonics – if they work for you

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To remember to do specific things during the course of an inspection, you could make use of

- ◆ Agency or personalized checklists – preprinted forms, diaries, notes, “to do” lists, etc.
- ◆ Visual or verbal mnemonics, such as the method of loci or an acronym that stands for a list of items – if they work for you

Illustrative Strategy (continued)

Remembering items you write down

- ◆ Chunking
- ◆ Saying aloud
- ◆ Recognizing features and conditions
 - ◇ Features and conditions themselves
 - ◇ Personal notes, drawings
 - ◇ Design documents
 - ◇ Action observation
 - ◇ Association

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To remember sequences of letters or digits long enough to accurately write them down, you can employ

- ◆ Chunking
- ◆ Subvocalization

To recognize facility features and conditions and encode them for later recall, you can plan to rely on

Advance review of facility design information and past inspection reports

- ◆ The features and conditions themselves
- ◆ Personal notes, drawings you bring to the facility to jog your memory regarding key or complex points
- ◆ Facility design documents at the facility (if available)
- ◆ Active observation
- ◆ Association – if it works for you
- ◆ Minimizing distortion – e.g., carefully scrutinizing new information to detect inconsistencies as you encode
- ◆ If you are unable to recognize details that you believe you know, neighborhood or alphabet search

Illustrative Strategy (continued)

Remembering to follow up

- ◆ Agency or personalized forms for taking notes
- ◆ CIR
- ◆ Personal “tickler file”
- ◆ Visual or verbal mnemonics – if they work for you

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To remember to follow up on potential discrepancies, anomalies, etc., you can make use of

- ◆ Agency or personalized forms for taking notes
- ◆ CIR
- ◆ Personal “tickler” file
- ◆ Visual or verbal mnemonics – if they work for you

Illustrative Strategy (continued)

Adding to your store of semantic knowledge

- ◆ Personal diary, lab notebook, etc.
- ◆ Active Observation
- ◆ Association
- ◆ Scrutiny to detect inconsistencies

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To expand your store of semantic knowledge about the type of facility you are inspecting (or this specific facility), you could use such tools and techniques as

- ◆ Personal diary, laboratory notebook, etc.
- ◆ Active observation: consciously attending to what you learned from this inspection – how it modified or expanded your knowledge
- ◆ Association – if it works for you
- ◆ Carefully scrutinizing new information to detect inconsistencies as you encode, and thus minimize distortion in later recall

Conclusions

- ◆ Memory skills are important
- ◆ Can be improved through technique
- ◆ Attention, association, and organization are key
- ◆ Assess your memory needs and develop a personal strategy

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Conclusions

- ◆ Memory skills are important to safeguards inspections
- ◆ Memory skills can to some degree be improved through technique
- ◆ The most critical technique is thinking and reflection – consciously weaving newly acquired information into your patterns of understanding
- ◆ It is important to assess your memory needs and develop a personal strategy for ensuring that these needs are met

Session 4: Mental Images, Maps, and Models

Mental images, maps, and models organize visual information in long-term memory.

Mental Images in Safeguards Inspections

- ◆ Recalling visual information
- ◆ Solving problems involving spatial relationships
- ◆ Navigating through sites, facilities, and buildings
- ◆ Interpreting what you observe: describing, explaining, predicting

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Introduction

- ◆ The creation and use of visual representations have a number of important uses in safeguards inspections, including
 - ◇ Recalling visual information
 - ◇ Solving problems involving spatial relationships
 - ◇ Navigating through sites, facilities, and buildings
 - ◇ Interpreting what you observe through description, explanation, and prediction

Topics to be Addressed

- ◆ Mental imaging
- ◆ Mental maps
- ◆ Mental models
- ◆ Applications to safeguards inspections

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- ◆ These materials provide an overview of these concepts, including
 - ◇ **Mental imaging:** seeing in your mind's eye
 - ◇ **Mental maps:** navigating 3-dimensional space
 - ◇ **Mental models:** representing systems
 - ◇ **Application** of related skills and techniques to safeguards inspections

Mental Imaging

- ◆ Seeing in your mind's eye
- ◆ Hearing in your mind's ear, etc.
- ◆ "Perception" of remembered information

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Mental Imaging

- ◆ Definition
 - ◇ Mental imaging is "seeing" in your mind's eye
 - ◇ It can also be hearing in your mind's ear, smelling in your mind's nose, etc. (although these materials will emphasize visual imaging)
 - ◇ In short, mental imaging is the "perception" of remembered information in the absence of immediate sensory input

Uses of Mental Imaging

- ◆ Retrieving information from memory about the properties of objects or scenes
- ◆ Solving problems involving spatial relationships

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- ◆ Uses of Mental Imaging
 - ◇ Imaging allows us to retrieve information from memory about the properties of imaged objects or scenes
 - Consider such questions as:
 - How many toes does a cat have?
 - Which is larger, a table tennis ball or a plum?
 - What is the shape of a fuel assembly in a boiling water reactor?
 - Most people seem to answer such questions by creating mental pictures of these objects and then examining them.

Example: A CANDU Fuel Bundle

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- Mental imaging is most often used when three conditions are met
 - The information to be retrieved is a subtle visual property
 - This visual property has not been previously considered and labeled
 - The property cannot be readily deduced from other stored information
- For many of us, these three conditions would apply to recalling the shape of a fuel bundle in a CANDU reactor

- Imaging also enables us to solve problems involving spatial relationships
 - For example, if you were asked how many items could fit in a dry storage unit, you would probably create an image of such a unit and mentally count the available spaces

Processes of Mental Imaging

- ◆ Generating the image
- ◆ Inspecting the image
- ◆ Retaining the image
- ◆ Transforming the image

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- ◆ Mental imaging involves four processes: generation, inspection, retention, and transformation

Generating Images from Parts

PATTERN

GOOD PART

BAD PART

- ✧ Generating the image
 - Mentally “picturing” something
 - Accessing and combining the information in long-term memory necessary to create the image
 - This process appears to involve at least two steps
 - The first builds up the image from individually activated parts
 - The second positions the parts spatially
 - Some parts (“good” parts) can be combined into images more easily than others (“bad” parts)

Inspecting an Image

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- Inspecting the image
 - Mentally “looking” at the picture
 - Similar in many respects to actual visual observation
 - E.g., create a small image of a honey bee
 - Try to determine the color of its head
 - You will probably have to “zoom in” to “see” the head – which probably would not have been necessary if you had initially created an image of a giant honey bee
 - More time is generally required to inspect parts of objects that you image at smaller sizes
- Retaining the image
 - “Holding on” to the picture once created
 - Retaining an image is generally difficult: after we form an image, like all information in short-term memory, it tends to fade rapidly unless we make a conscious effort
 - We have particular difficulty in retaining the image as a whole – individual parts quickly start to fade out
 - Our ability to retain a given image depends the number of perceptual units involved – an image of three lines is as hard to retain as an image of three squares

Mental Rotations Exercise

❖ Transforming the image

- For example, “rotating” or “expanding” the picture
- Much research has been done on our human ability to mentally transform images
- Shepard and Metzler have demonstrated that we can mentally “rotate” imaged objects by presenting pairs of figures and asking subjects whether the objects are identical if rotated to the same orientation
- In this exercise, you will
 - Represent the pair of images in short-term memory
 - Rotate one image until it is the same orientation as the other
 - Decide if they match
 - Respond

Individual Differences in Imaging Ability

- ◆ Tests on various aspects of imaging (generation, inspection, retention, transformation)
- ◆ Abilities vary widely
- ◆ Ability in one aspect does not necessarily correlate with abilities in others
- ◆ Imaging ability is thus not a single undifferentiated skill
- ◆ May improve with practice

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- ◆ Individual differences in imaging ability
 - ◇ Experimenters have also tested individual imaging abilities, both generally and for such specific skills as
 - Generation
 - Acuity
 - Speed
 - From verbal descriptions
 - Inspection
 - Speed in finding specific feature
 - Speed in making judgments
 - Retention
 - Quantity of material
 - Length of time
 - Transformation
 - Speed in reorganization
 - Speed in rotation
 - ◇ They have found a wide range of abilities
 - For a given individual, skill at one of these imaging tasks (such as ability to retain an image) did not necessarily correlate with skill in another (such as ability to rotate an image)
 - Indeed, there were some inverse correlations: doing well on some tasks seems to predict poorly on others
 - Thus imagery ability is not an undifferentiated skill
 - ◇ There is some evidence that imaging skills can improve with practice

Mental Imaging Techniques

- ◆ Exploit your “mental sketchpad” to solve spatial problems
- ◆ Consider converting non-visual problems to visual ones
- ◆ As necessary, supplement your mental sketchpad with an actual sketch

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- ◆ Techniques for using mental imaging as a memory and problem solving tool
 - ◇ Take advantage of your “mental sketchpad”
 - Just as with a real sketchpad, you can mentally create a screen for portraying images that help you recall visual information or solve spatial problems
 - If the question is “How many glove boxes are in Laboratory Room A-10?,” you could mentally sketch the room and count the glove box openings
 - If the question is “Could there be a hidden second floor above the first floor I just inspected?,” you could mentally sketch the exterior of the building, superimpose a cross-section of the first floor you visited, and estimate whether there is room above it for an additional story
 - ◇ Consider using your mental sketchpad to solve non-visual problems by converting them to visual problems
 - Try this problem:
 - Germany has no more reactors than Canada
 - Russia has more reactors than Canada
 - What can you conclude about Germany and Russia?
 - You could handle this by applying the rules of logic
 - But you might find it easier to make a mental sketch of three reactor programs and read off the relative sizes of the German and Russian from this mental picture
 - ◇ As necessary, supplement your mental sketch pad with an actual sketch
 - As both visual and non-visual problems get more complicated, so does generating, retaining, and manipulating the corresponding images
 - But often you can still capture the benefits of “thinking visually” by making a drawing with paper and pencil

Mental Mapping

- ◆ Short-hand for “spatial cognition”
- ◆ Acquisition and use of knowledge about large-scale space

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Mental Mapping

- ◆ Definition
 - ◇ Mental mapping is a short-hand term for “spatial cognition”
 - ◇ The acquisition and use of knowledge about large-scale space
 - Space that is large enough for a person to navigate
 - Space whose structure cannot be observed from a single viewpoint on the ground

Types of Spatial Knowledge

- ◆ Landmark knowledge
- ◆ Procedural knowledge
- ◆ Survey knowledge

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- ◆ There are three categories of spatial knowledge
 - ◇ Landmark knowledge
 - ◇ Procedural knowledge
 - ◇ Survey knowledge

4 Landmark knowledge

- Perceptual memories of prominent geographic features: also known as “perceptual icons”
- For example, buildings, signs, doorways
- Acquired through direct observation (or by viewing films, videos, photographs)
- Used to recognize locations
- This map cleverly includes landmarks as an aide to use

♦ Procedural knowledge

- An action sequences for following a particular route
- E.g., from Stephansplatz take the U1 toward Kagran and get off at Kaisermuhlen-VIC
- Generally acquired through the experience of navigating the route, but some maps, such as this one, are designed to convey procedural knowledge
- Can be used either to navigate or to mentally simulate navigation

❖ Survey knowledge

- A mental map of an area encoding features, relations, and distances
- E.g., of the VIC, of the Grabben, of Vienna, of Sellafield
- Most easily learned directly from studying an actual map or diagram, but can also be derived from repeated navigation experience
 - In uniform environments (for example, a city with rectangular street grids, or a building with a symmetrical layout, such as the towers of the VIC), navigation can rapidly lead to accurate survey knowledge
 - In irregular environments (many European cities), survey knowledge develops more slowly without a map
- Essentially visual
- Provides a 2-dimensional view
 - Can be either highly detailed (nearly “veridical”)
 - Or schematic (normalized or overly simplified)
- Most easily acquired by people with good visual memory and imaging abilities

Site diagram of a nuclear facility

You can acquire reasonably good survey knowledge by studying the diagram, but you will obtain richer and more complete knowledge by actually navigating the facility

- ◆ Good cognitive mappers appear to have a combination of skills
 - ✧ Acquiring survey knowledge from maps (including site and facility diagrams)
 - ✧ Acquiring procedural and survey knowledge from navigation
 - Learning from navigation results in a richer and more complete knowledge base than map study alone
 - Learning from navigation is highly desirable for situations requiring both procedural and survey knowledge
 - ✧ Making spatial judgments based on survey and procedural knowledge

Map Learning Exercise

Recreating a site diagram from memory

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- ◆ This exercise will give you a sense of how well you can build survey knowledge through map study
- ◆ There are specific techniques you can apply, which we will discuss next

Techniques for Effective Map Learning

- ◆ Partitioning
 - ◇ Spatial regions
 - ◇ Conceptual categories
- ◆ Memory-directed sampling

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- ◆ Techniques for learning from maps and diagrams
 - ◇ Partitioning
 - Divide the map or diagram into spatial regions (such as four quadrants) and learn one at a time, or
 - Divide the map or diagram into conceptual categories (such as boundaries, roads, and buildings) and learn each category in turn
 - ◇ Memory-directed sampling
 - Study the map or diagram for a given period of time, then test yourself by attempting to recall as much of the map or diagram as possible
 - After the recall attempt, make a mental list of the items that you did not remember
 - In subsequent study, focus on learning those items

Techniques for Effective Map Learning, continued

- ◆ Imaging
- ◆ Pattern encoding
- ◆ Relation encoding

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- ◇ Imaging
 - Generate a mental image of some portion of the map or diagram
 - While looking away close your eyes and attempt to recall the image
 - If unsuccessful, repeat with the same portion of the map or diagram; if successful, go on to another portion of the map or diagram
- ◇ Pattern encoding
 - Observe the shape of a particular map or diagram element
 - For example, notice that the river makes a U-like turn halfway across the map
 - Encode the element with reference to the pattern
- ◇ Relation encoding
 - Observe the spatial relationships among two or more map elements
 - For example, notice that two highways intersect just east of a particular city
 - Encode the elements with reference to their spatial relationships

Learning from Navigation

- ◆ Richer and more complete knowledge than map study alone
- ◆ Creates procedural knowledge
- ◆ Also leads to a special kind of survey knowledge in which the environment becomes “translucent”

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- ◆ Results in a richer and more complete knowledge of the environment than can be acquired from map study alone
- ◆ Creates procedural knowledge that enables you to navigate through a site, facility, building, or other location
- ◆ Also leads to a special kind of survey knowledge, providing a 3-dimensional “translucent” view of the environment
 - ◇ You can “look through” intervening obstacles to your destination
 - ◇ This view can be considered 4-dimensional if one includes the time dimension of moving through 3-dimensional space

Techniques for Learning from Navigation

- ◆ **Visual/perceptual strategy:** encoding based on attention and association
- ◆ **Verbal/analytic strategy:** encoding based on organization

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- ◆ Illustrative techniques for learning from navigation, based on encoding skills
 - ◇ Visual/perceptual – emphasizes attention and association
 - As you navigate, focus on landmarks and perceptual features of the environment, such as the appearance of buildings, the style of landscaping, and the overall topography of the environment and the route
 - Try to relate what you see to scenes that you have observed elsewhere
 - Note changes in the environment as you proceed along the route
 - Feel free to make personal, aesthetic judgments of what you see
 - Encode your observations as procedural knowledge (“turn left at the Baroque fountain”)
 - Then as you become more familiar with the route through repeated navigation, reorganize this information as survey knowledge
 - ◇ Verbal analytic – emphasizes organization
 - Create a grid-like mental image to organize your knowledge
 - As you navigate a route, pay particular attention to verbal information such as the names of streets and landmarks, and take care to observe the relationships among them
 - Encode route knowledge as verbal instructions (e.g., “turn right onto Herrengasse”)
 - Mentally map these instructions onto the grid to create a survey representation of the route

Mental Models

Internal representations of systems rely in part on mental images

- ◆ Represented as images
- ◆ Generated from perception or description

But more complex than mental images

- ◆ Multiple, interacting elements
- ◆ Cause and effect as well as spatial relationships

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Mental Models

- ◆ Definition
 - ◇ Mental representations of systems that may include ourselves, other people, technologies, or the environment
 - Mental models rely in part on mental images
 - They are ordinarily represented as mental images
 - They can be constructed from our own current or recalled perception of the system
 - Or they can be imagined from someone else's description of the system
 - But mental models are more complex than mental images, in that mental models portray systems and thus typically include
 - Multiple interacting elements
 - Not just objects and scenes, but people and technologies
 - Cause and effect as well as spatial relationships

Purposes of Mental Models

Source: William B. Rouse and Nancy M. Morris, "On Looking Into the Black Box: Prospects and Limits in the Search for Mental Models," *Psychological Bulletin* 100:3, 349-363.

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- ♦ Mental models have three broad purposes
 - To **describe** the purpose and form of a system
 - Why the system exists
 - What the system looks like
 - To **explain** the functions of a system and observed system states
 - How the system operates
 - What the system is doing
 - To **predict** future system states
 - What the system will be doing in the future
 - Prediction is particularly key to systems that we use, such as an automobile or an instrument

Elements of Mental Models

- ◆ Target system
- ◆ System image
- ◆ Mental model itself (user's model)
- ◆ True conceptual model
- ◆ Scientist's conceptualization

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- ◆ The elements of a mental model
 - ◇ The **target system**: what you are trying to describe, explain, predict, or use
 - ◇ The **system image**: the visible part of the system
 - ◇ Your **mental model** (sometimes called the user's model): how you think the system works, based on the system image and whatever other information you can glean
 - ◇ The **true conceptual model** (sometimes called the **design model**): a scientifically accurate, consistent, and complete representation of the target system
 - ◇ The **scientist's conceptualization**: a model of your mental model

Refrigerator Controls: Example of a System Image

Normal Settings	C	and	5	
Colder Fresh Food	C	and	6-7	1 set both controls
Coldest Fresh Food	B	and	8-9	2 allow 24 hours
Colder Freezer	D	and	7-8	to stabilize
Warmer Fresh Food	C	and	4-1	
Off (Fresh FD & FRZ)			0

Source: Donald A. Norman, *The Design of Everyday Things* (New York: Doubleday/Currency, 1989).

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Example of a system image

In *The Design of Everyday Things*, cognitive scientist Donald A. Norman offers this example of a system image: the control panel of his refrigerator

He also poses the question: Suppose the freezer is too cold, but the temperature of the fresh food section is just right – how would you adjust the controls to warm the freezer a bit, while keeping the temperature in the fresh food section the same?

Conceptual model suggested by the system image

After examining the control panel, most people would probably form a mental model in which the control marked Freezer adjusts the temperature of the freezer section and the control marked Fresh Food adjusts the temperature in the fresh food section.

True conceptual model

In fact, the system image is misleading.

One control adjusts a single cooling unit, while the other control allocates the relative proportion of cold air that goes to each of the two compartments.

Now how would you adjust the controls?

Steps to Creating a Mental Model

- ◆ Representing the **device topology**
- ◆ **Envisioning** how the system works
- ◆ Describing the **causal model**
- ◆ **Running** the causal model

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- ◆ The **device topology**: a mental representation of the physical structure of the system: its component parts and their interconnections
- ◆ **Envisioning**: the process of figuring out how the system works, given only its structure and a knowledge of basic physical principles
- ◆ The **causal model**: a description of how the system's components interact physically to produce results
- ◆ **Running** the causal model: a mental simulation of the system in operation

Mental model of sealed container

What does an intact seal tell you about the probable contents of the container?

What if the Operator had attached his own seal on the same seal wires?

Illustrative Mental Model: Nuclear Power Plant

Source: Anthony V. Nero, Jr., A Guidebook to Nuclear Reactors (Berkeley, California: University of California Press, 1979).

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Mental model of a nuclear power plant

A very simple model of a highly complex system

How might system image or observed conditions differ if the reactor was being used to produce weapons materials?

Mental model of a fuel cycle with fuel recycling

Another highly simplified model of a complex system

How would the model differ if reprocessed plutonium were being diverted?

Typical Limits of Mental Models

- ◆ Based on meager understanding
- ◆ Incomplete
- ◆ Limited ability to “run” them
- ◆ Unstable
- ◆ Lacking in firm boundaries
- ◆ Often “superstitious”
- ◆ Parsimonious

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- Limitations of mental models (Donald A. Norman)
 - ✧ Our understanding of the devices we interact with is “surprisingly meager, imprecisely specified, and full of inconsistencies, gaps, and idiosyncratic quirks”
 - ✧ Mental models are incomplete
 - ✧ Our ability to “run” our mental models is severely limited
 - ✧ Mental models are unstable: we forget details, especially if we have not recently encountered them
 - ✧ Mental models do not have firm boundaries: we tend to confuse the details of similar systems and operations
 - ✧ Mental models are unscientific: we maintain “superstitious” representations that we know are false because they happen to be convenient
 - ✧ Mental models are parsimonious: in modeling devices, we are willing to trade off extra physical work for reduced mental complexity

Strengths of Mental Models

- ◆ Help in addressing novel situations
- ◆ Play mental what-if games
- ◆ Draw inferences from observations

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- ◆ Strengths of mental models
 - ◇ You can better understand novel situations
 - Which of my repertoire of models does this situation fit most closely?
 - How would I need to modify an existing model to address this situation?
 - Or do I need a completely new model?
 - ◇ You can play mental “what if” games – e.g.,
 - If the system were doing this, what would be its observable behavior?
 - If the system were modified, how would its appearance or operating conditions change?
 - ◇ You can draw inferences about the system from observation of its appearance or operating conditions – e.g.,
 - Given observable physical modifications, how might the system’s purpose have changed?
 - Given observable operating conditions, how might the system’s purpose have changed?

Mental Modeling Techniques

- ◆ Consciously create a mental model as you learn about a system
 - ◇ Identify the target system
 - ◇ Describe its structure
 - ◇ Determine how it works
 - ◇ Mentally “run” your model

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- ◆ Mental modeling techniques
 - ◇ When you learn about a new system, consciously create a mental model of it
 - Identify the target system and its boundaries
 - Describe the system’s physical structure
 - Represent the system’s component parts and their interconnections by using your mental sketchpad or making an actual drawing
 - At first, include only as much detail as necessary to make the system comprehensible to you (you can always add more later)
 - Attempt to determine for yourself how the system works, given its structure, your knowledge of applicable physical principles, and any other pertinent information you can glean
 - Try to mentally “run” the system based on your model
 - If you cannot run the system because your model is incomplete, attempt to fill in the missing information
 - Ask “what if questions” – how would the system operate differently if various operating parameters were adjusted?

Mental Modeling Techniques, continued

- ◆ Relate observations of the actual system to your mental model
- ◆ Update and refine your model in light of new information
- ◆ Over time, create a “repertoire” of related models

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- ◆ As you observe the actual system in operation, attempt to relate observed structure, features, and operating conditions to your mental model
 - ◇ How well does the actual physical appearance and structure of the system correspond to your model?
 - Are observed differences cosmetic?
 - Or do they suggest your model may be inadequate to describe the system or this particular version of it?
 - ◇ How well do observed system operating conditions correspond to your model?
 - Are they consistent with your model and what you know or have been told about what is currently happening?
 - Or are your model inconsistent with what is happening or insufficient to explain it?
- ◆ Regularly update and refine your model in light of what you have observed or learned
 - ◇ Incorporate new information about system structure
 - ◇ Incorporate new information about system processes and causal relationships
- ◆ Over time, create a repertoire of models for the system
 - ◇ Recall the concept of associative models, or hierarchies of similarities and differences
 - ◇ Create a similar hierarchy of mental models that describe the system in its most general sense and then ever more specific variations in system design or situations

Applications to Safeguards Inspections – Recalling Visual Information

- ◆ Comparing present observation with recalled appearance
 - ◇ In prior inspection
 - ◇ In design information
 - ◇ At another facility
- ◆ Requires generation, retention, inspection of image
- ◆ May require transformation
- ◆ Facilitated by creative use of your mental sketchpad

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Applications of mental images, maps, and models to safeguards inspections

- ◆ Recalling visual information
 - ◇ You may observe a facility feature, item of equipment, or plant configuration and want to verify its appropriateness through comparison to something else, such as
 - How it appeared the previous time you saw it
 - How it appeared in facility design information that you reviewed prior to the inspection
 - The appearance of a similar item at another facility
 - ◇ This comparison will require the generation and inspection of mental images, as discussed in this session
 - ◇ Moreover, since what you observe may be of a different size or in a different orientation than the image of the item used for comparison, you may need to transform the image in order to use it
 - ◇ These tasks will be made easier by creative use of your mental sketchpad, possibly supplemented by an actual drawing

Applications to Safeguards Inspections – Solving Spatial Problems

- ◆ Addressing questions of spatial relationships – e.g.,
 - ✧ Matching observed building footprint to diagram
 - ✧ Considering the possibility of hidden rooms or spaces
 - ✧ Interpreting processes that are physically obscured by protective enclosures
- ◆ Also requires image generation, retention, inspection, and transformation
- ◆ Assisted by your mental sketchpad, supplemented by actual drawings and measurements

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- Solving problems involving spatial analysis
 - ✧ Certain inspection situations may raise questions of spatial relationships
 - For example, you might be concerned whether the building layout as observed during a walk-through matches the layout in the facility diagram
 - Or you might need to know whether there could be hidden rooms, compartments, or other spaces in the facility
 - Or you may need to be able to analyze whether the physical dimensions of a room and its entrances and exits would allow illicit items to be introduced (e.g., introduction of robotics into intermediate buffer material store)
 - ✧ Addressing such questions is also facilitated by the generation, inspection, and transformation of mental images by using your mental sketchpad and making actual drawings and measurements
 - ✧ And in certain facilities (such as new reprocessing and MOX fabrication plants), where much of the equipment and many of the process lines are enclosed in protective structures that do not permit direct observation, you must develop a mental image of the invisible process from schematic diagrams, models, and engineering drawings, as well as limited views into the process line, in order to interpret what you can see

Applications to Safeguards Inspections – Navigation

- ◆ Being able to independently navigate sites, facilities, buildings, and other spaces
- ◆ Dependence on escort is limiting
 - Even if escort never leaves your side, you need to be able to know where you are, where you are going, where you have not gone – otherwise, you could be literally led in circles
- ◆ Acquiring and using accurate survey and procedural knowledge is thus essential

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- ◆ Navigating through sites, facilities, and buildings
 - ◇ Inspections by definition require you to successfully make your way around and through sites, facilities, and buildings
 - ◇ If you are completely dependent on your escort, you will go only where your escort wants you to go and see only what your escort wants you to see
 - ◇ Therefore, you need to be able to acquire accurate survey knowledge from maps and diagrams, supplemented by procedural and survey knowledge acquired from actual navigation experience
 - ◇ The techniques discussed in this session will assist you in acquiring this knowledge

Applications to Safeguards Inspections – Interpreting What You Observe

- ◆ Interpreting the implications of observations
 - E.g., facility structures, features, operating conditions, observed or not observed
 - ◇ Presence consistent with the facility declaration?
 - ◇ Absence consistent with the facility declaration?
- ◆ Examining the “fit” between what you observe and alternative mental models would predict is the essence of enhanced observation

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- ◆ Interpreting what you observe
 - ◇ During inspections, you will observe structural features and facility operating conditions that may or may not have safeguards significance
 - ◇ Observations raise such questions as:
 - Are observed structural features and operating conditions anomalous?
 - Are they inconsistent with the declared purpose of the facility?
 - Are there are absent features or operating conditions that should have been observed given the facility’s declared purpose?
 - How could the presence or absence of such features be concealed or compensated for?
 - ◇ Such questions will be much easier to address if you create, use , and update your mental models of the systems you inspect

Session 5: Judgment and Decision Making

- ◆ Judgment and decision making occur as a result of the perception, recognition, encoding into short- and long-term memory, and comparison with mental models.
- ◆ The focus of this session is on the expectations that influence judgments and decisions, heuristics that can help or hinder judgments, and a description of the decision making process.
- ◆ Judgments and decisions result in some action or response.

Role of Judgment and Decision Making in Inspections

- ◆ Sample cues from the facility environment
- ◆ Evaluate specific cues concerning facility operations
- ◆ Integrate several cues to arrive at a decision
- ◆ Judgments and decisions are a function of expectations

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- ◆ Judgment and decision making occurs throughout the inspection process.
- ◆ Sensory input is perceived, identified, encoded, compared with similar inputs in long-term memory, and then a judgment is made concerning the meaning and value of the input.
- ◆ Both judgments and decision are influenced by the observer's expectations, knowledge, and motivations.

Expectations

- ◆ Perceived expectations influence judgments and decisions
- ◆ These expectations can be defined in terms of a costs and benefits for specific decisions
- ◆ Costs and benefits are defined by a Pay-off Matrix

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- ◆ Expectations influence what information is collected, and how the information is evaluated.
- ◆ These expectancies can include knowledge of a particular state, knowledge of a type of facility, and knowledge of a specific facility.
- ◆ Evaluation of the information is also influenced by knowledge of how the information is used or valued. This includes the costs and benefits associated with the decision (e.g., potential diversion is correctly identified).
- ◆ The process of evaluating the costs and benefits can be defined at the individual level in a pay-off matrix.

Pay-Off Matrix		
	Prediction	
	Diversion	Non-Diversion
	True Positive	False Negative
	Value _____	Value _____
True Outcome	False Negative	True Negative
	Value _____	Value _____
Diversion		
Non-Diversion		

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- ◆ The pay-off matrix is defined in terms of the value of different decision outcomes. These include correct decisions (e.g., identifying a “true” diversion) and incorrect decisions (e.g., identifying a “true” non-diversion as a diversion).
- ◆ Each observer identifies his/her own perceived matrix during the decision making process.
- ◆ For the later discussion on decision making, participants are asked to identify their perceived pay-off matrix.

Judgments

For purposes of this discussion, judgments are defined as:

- ◆ Evaluations of a single cue
- ◆ Judgments are made within a very short period of time (within seconds after the cue is presented)
- ◆ Resulting actions may be to collect more information, hold for later processing, or evaluate as non-meaningful

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- ◆ For purposes of this discussion, judgments are defined as evaluations the observer makes about a single sensory cue.
- ◆ Thus, in a normal inspection, the observer is likely to make hundreds or thousands of judgments.
- ◆ Judgments may result in any number of responses, such as not relevant, need to obtain more information, and make note of the information and save for debriefing or final report.

Judgment Exercise

Purpose: To evaluate information and provide a judgment about that information within a limited period of time. This exercise does not allow for further information gathering. Instead, it is designed to demonstrate several heuristics we commonly use in making judgments.

The exercise contains five judgment items.
Complete these in 10 minutes.

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- ◆ Much research has been conducted to assess the types of general heuristics that people use to evaluate information.
- ◆ This research has led to identification of the heuristics that people use when it is not possible to consult a resource.
- ◆ Observers should determine whether or not they rely on these heuristics. The judgment task is designed to demonstrate three commonly used heuristics.

Availability Heuristic

We assess the frequency or probability of an event based on the extent to which instances or occurrences are “available” to us in memory.

Vivid, easily imagined, and specific events are more readily recalled than dull, speculative, or vague events.

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- ◆ People often make judgments by thinking of examples. In thinking of examples, people will often refer to what has appeared recently in the newspaper or on television. Thus, recent, vivid information is more easily recalled than dull information.
- ◆ People also tend to rely on their own experiences to judge the probability of an event. So, if the event occurred in one's life, one is more likely to judge it as highly probable.
- ◆ In most instances, however, availability is as good a guide as one will have, if more systematic data are unavailable. One must take precautions to avoid errors.

Representativeness Heuristic

We assess the frequency or probability of an occurrence based on the similarity of that event to stereotypes of similar occurrences.

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- ◆ Based on this heuristic, people often fail to consider their knowledge of statistics when making judgments.
- This can involve failure to consider the base-rates (probability of occurrence) in a given population, sample size issues, and the impact of chance on probabilities or base-rates.
- ◆ Relying on one's knowledge of statistical reasoning can help to avoid these errors in judgment.

Anchoring and Adjustment Heuristic

We make assessments by starting from an initial value and adjusting it to reach a final value. This initial value can be highly arbitrary (suggested by the status quo, historical precedent, or random information).

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- ◆ This heuristic indicates that we are biased in favor of our present beliefs.
- ◆ Often people fail to consider the evidence that does not support a belief. Or, one fails to consider the validity of specific information used to make a judgment.

Decision Making

- ◆ More elaborate process than judgment
- ◆ Relies on multiple cues or inputs
- ◆ Used to make summary conclusions

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- ◆ For purposes of this discussion, decision making is defined as the process by which several pieces of information are combined to produce a response (e.g., go or no go).
- ◆ Thus, unlike in judgment tasks, the decision maker is using multiple inputs from many different sources to make a decision.
- ◆ For example, an inspector may use several pieces of information obtained from the inspection and combine this with technical knowledge, knowledge of the facility and state, and information from previous inspections to make a decision or draw a conclusion about a facility.
- ◆ Given the nature of this process, outcomes from the decision-making process are expected to have greater impact than those from the judgments.

Decision Making Process

- ◆ Sample inputs or cues from the environment
- ◆ Integrate cues
- ◆ Generate hypothesis or entertain alternative hypotheses
- ◆ Test hypotheses
- ◆ Evaluate decision or prediction

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- ◆ The optimal decision-making process contains five elements, sampling inputs, integrating cues, generating hypotheses, testing hypotheses, and evaluating the decision or prediction.
- ◆ At first glance, this process may appear time-consuming and difficult. It is, however, useful to frame decisions in this manner to ensure that you have considered all available inputs.
- ◆ This process also emphasizes incorporating statistical reasoning (knowledge of statistics) in the decision-making process.

Sample Cues or Inputs

- ◆ All observations or cues represent a sample from the total population of cues
- ◆ Inspection has some control over the cues sampled; focus on selecting cues associated with the target criterion
- ◆ Recognize the absence of cues as relevant

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- ◆ It is important to remember that all cues and sensory inputs collected during an inspection represent a sample of the population of cues. Thus, the observer must evaluate all cues in the context from which they were drawn.
- ◆ In evaluating the representativeness of the cues and input, it is also important to remember that the observer (inspector) has begun data collection with some theories or biases. Thus, data collection is often geared toward some form of criterion. This can both help and hinder data collection.
- ◆ One way to avoid bias in data collection is to focus on the absence of cues. Given a particular hypothesis or theory, there are cues that by virtue of their absence fail to support the theory.

Integrate Cues

- ◆ With many cues, this process is resource intensive
- ◆ Evaluate the reliability and value of each cue
- ◆ Cue salience
- ◆ Human versus machine in cue integration (clinical versus statistical)

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- ◆ Before making a decision, one must consider all cues and inputs. This process is resource intensive because one must consider several bits of information about each cue or input.
- ◆ Consider the merits of each cue – how reliable is it, is it valid, what is the source of the information? Cues and inputs may not be equally informative.
- ◆ Cue salience refers to the relative value of information. Are some cues more salient because they are associated with novel or unusual events?
- ◆ Because the integration process is resource intensive, there is much room for error. Past research has shown that, if possible, all cues and inputs should be collected by the human observer, but combined statistically by machine (computer).

Generate Hypothesis or Entertain Alternative Hypotheses

- ◆ Cognitive limitations in generating more than one hypothesis
- ◆ Simplifying hypothesis generation may eliminate useful cues and/or alternative hypotheses
- ◆ Judgment heuristics influence this process

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- ◆ Just as limitations of human memory and attention restrict the perceptual cues that are processed, the observer also experiences limitations in the process of entertaining multiple hypotheses (e.g., more than three or four).
- ◆ The observer generally reduces the number of hypothesis considered using the "elimination by aspects" heuristic. As a result, some cues or inputs may be eliminated.
- ◆ Several judgment heuristics can come into play in this process. These include representativeness and availability.

Test Hypothesis

- ◆ System complexity and memory limitations
- ◆ Confirmation bias
- ◆ Mental models and causal reasoning

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- ◆ Memory limitations can influence the number of hypotheses considered in the decision making process. Also, system complexity can have a similar influence.
- ◆ Confirmation bias is similar to the Anchoring heuristic and reflects the inertia that the observer experiences in favoring the hypothesis initially formulated.
- ◆ For any system, the observer has established a mental model of the system and the linkages between different components. Unless the system is very simple or the observer very well trained, the mental model may not be perfect and these imperfections can contribute to errors in decision making.

Evaluation of Decision or Prediction

- ◆ Reported confidence in accuracy of decision or prediction
- ◆ Limitations of feedback from the system
- ◆ Probability perception – risk seeking and risk aversion
- ◆ Effects of perceived payoffs: summary data from training group

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- ◆ After making a decision or prediction, one of the critical pieces of information is one's confidence in the accuracy of that decision.
- ◆ In most human response systems, it is important for the human observer to obtain feedback concerning a decision. If the feedback system is not in place, the observer cannot adjust the decision-making system to improve on later decisions.
- ◆ The decision-making process is influenced by the observer's perceived probability of risk. Research has shown that perceived risk is often a probability of an outcome is less than actual probability.
- ◆ Perceived pay-offs for specific decision outcomes influence the decision. Thus, we examine the average perceived pay-off matrix computed across all training participants.

Conclusions

- ◆ Judgment and decision making tasks are subject to bias and errors
- ◆ Review of knowledge of statistics can help to avoid some of these errors
- ◆ Decision making process is resource intensive; subject to errors and biases at each and every step
- ◆ Perceived pay-off for each type of decision outcome can influence the entire decision making process

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- ◆ This session covered some of the typical errors made during the judgment and decision making processes.
- ◆ In particular, it has been found that people often make mistakes in judgment due to the availability, representativeness, and adjustment or anchoring heuristics. Such errors can be avoided by using statistical reasoning,
- ◆ Decision making errors occur in sampling cues, integrating cues, generating hypotheses, and testing hypotheses. In some instances, the most efficient and accurate method is for the human to collect the data, and then use statistical methods to combine and interpret the data.
- ◆ We examined the perceived pay-off matrix computed across all participants. One's own perceived pay-off matrix plays a large role in the decision making process and should be examined.

Techniques for Improving Decision Making Skills

- ◆ Recognize potential for making snap judgments based on heuristics
- ◆ Consider statistical probabilities and use statistical reasoning in making judgments
- ◆ Assess ability to integrate multiple cues and generate competing hypotheses
- ◆ Recognize resource limitations may encourage you to reject cues and hypotheses

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- ◆ Judgment heuristics can prove useful in evaluating information; it is important for the observer to recognize when judgments are based on statistical reasoning or reflect a "best guess."
- ◆ Prior to an inspection, one can generate hypotheses concerning a particular facility. Further, if one generates competing hypotheses, one can also generate a list of cues that support one or the other. Such practice will help the inspector to generate multiple hypotheses during the inspection.
- ◆ Because of resource limitations in memory, it is not possible to consider all cues and hypotheses simultaneously. It is also likely that one will reject cues because they do not fit certain hypotheses. Therefore, the observer should retain some record of these cues (those that have been judged to meaningful, relevant, and reliable) for presentation in the inspection report or debriefing session.
- ◆ Continue to monitor your perceived pay-off matrix. This is necessary given perceived changes in the organizational system, and based on personal experiences in making and reporting inspection observations.

Techniques for Improving Decision Making Skills (continued)

- ◆ Track and report all cues collected throughout the entire inspection; evaluation and integration can be performed by others
- ◆ Assess your own perceived pay-off matrix before conducting an inspection. This knowledge may help to avoid biases

Session 6: Skill Integration

Integration Activity

- Perform hypothetical inspection
 - ✧ Briefing before the inspection.
 - ✧ Review video-taped facility walk-through.
 - ✧ Form into groups to summarize what you observed and your conclusions from this inspection.
 - ✧ Present group summaries and discuss conclusions.

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- ◆ Participants participate in a hypothetical inspection that requires them to practice using the skills covered in this training program.
- ◆ To prepare you for this activity, complete briefing is provided to describe the facility and its history.
- ◆ After this briefing, participants view a videotape walkthrough of the facility.
- ◆ Participants form two groups. Group members summarize what they observed during the walkthrough and their conclusions.

Summary and Conclusions

Summary and Conclusions

- ◆ “Strengthened safeguards” lead to broadened declarations and more open-ended inspections
- ◆ Inspection situations are becoming less tightly structured
- ◆ Inspectors are encouraged to “be more observant”

What Does This Mean?

- ◆ The objective for the VISUAL OBSERVATION SKILLS course has been to describe the cognitive (thinking) skills you use to make observations and the principles associated with these skills to increase the accuracy of your observations
- ◆ The course map defines the primary components of visual observation skills

Techniques for Applying These Skills

- ◆ For each cognitive skill, we have identified techniques for improving these skills, such as:
 - ✧ prepare for the inspection by “walking through it in your mind”
 - ✧ identify your expectations, biases, assumptions before the inspection
 - ✧ be prepared to explore the facility environment or ask questions

Summary of Techniques

- ✧ recognize when your attention is being diverted (appropriately or inappropriately)
- ✧ encode in ways that enhance memory
- ✧ use mental models to help evaluate information
- ✧ evaluate the process you used to reach a decision or make a judgment
- ◆ Focus on identifying your strengths and weaknesses in these cognitive skill areas
- ◆ Review your course exercises