

**Foundations of Cognitive Robotics**  
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**Lecture - 11**

Good morning students, welcome to the course of Foundations of Cognitive Robotics. We have now reached the final week of the course. And in this week we are going to focus specially on intelligence. So, we will discuss about various theories of intelligence. And in the first lecture of this week, I would like to begin with the theories of intelligence from the psychologist's point of view.

I have chosen four psychologists - four very famous psychologist's point of view from this aspect. I will talk about Spearman; I will talk about Thurstone, Howard Gardner, and Robert Sternberg. So, let us look into that how they define intelligence.

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**Theories  
of  
Intelligence**



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## Content

- ❖ Concept and types of intelligence
- ❖ Charles Spearman—“g” factor
- ❖ Louis Thurstone — intelligence as a person’s “pattern” of mental abilities
- ❖ Howard Gardner — multiple intelligences
- ❖ Sternberg–Triarchic theory


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So, as we are discussing about the theories of intelligence, my outline of this talk will be that first I will talk about various concepts and types of intelligence. And then I will of course start with the Spearman and his g-factor. Then Thurstone’s view of this g-factor, and Gardner’s theory of multiple intelligences. And finally, I will talk about Sternberg’s Triarchic theory, so that is the way in which we discuss.

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## What is Intelligence? Psychologists POV

- **NO** standard definition of what exactly constitutes intelligence.
- Some researchers believe that it is single general ability, while others consider that intelligence encompasses a range of aptitudes, skills, and talents.
- It is a concept, not a thing.



How Psychologists Define Intelligence

The ability to learn

The ability to solve problems

The ability to recognize problems


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Now, our story of intelligence starts with first the Spearman’s point of view. And the reason why we are talking about the psychologist’s point of view intelligence is that so

far there is no standard definition in terms of that what exactly constitutes intelligence that is absent. Some researchers believe that it is a single general ability, while others as you will see that they would say that it contains of a range of aptitudes, skills, and talents. So, you know there is a difference in terms of this.

But in general this is agreed that intelligent (Refer Time: 02:47) is a concept; it is not a concrete thing. And what is this concept? These concepts will definitely have elements like the ability to learn, the ability to recognize that there is a problem there, and the ability to solve the problems. So, under these three corners, the fundamental tenets, the theories of intelligence will be actually defined by different psychologists in different way.

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Kinds of Intelligence	
 Crystallized Intelligence	 Fluid Intelligence
Accumulation of knowledge, facts, and skills that are acquired throughout life.	Ability to think and reason abstractly and solve problems.
Include reading comprehension and vocabulary exams.	Independent of learning, experience, and education.
Based upon facts and rooted in experiences.	Solving puzzles and coming up with problem solving strategies.
Becomes stronger with age as one accumulate new knowledge and understanding.	Peaks in adolescence and begins to decline progressively (after 35-40 age).
<i>Both types of intelligence increase throughout childhood and adolescence.</i>	



Now, let us first look into this Spearman's way of the theory of intelligence. Now, before we do that we have to keep in our mind that intelligence is generally described under two parts; one is called crystallized intelligence, and another is called fluid intelligence.

So, what is the crystallized form of intelligence? Well, crystallized intelligence consists of the accumulation of knowledge, facts and skills that are acquired throughout the life. And it includes reading, comprehension and vocabularies for example, based upon facts and rooted in experiences.

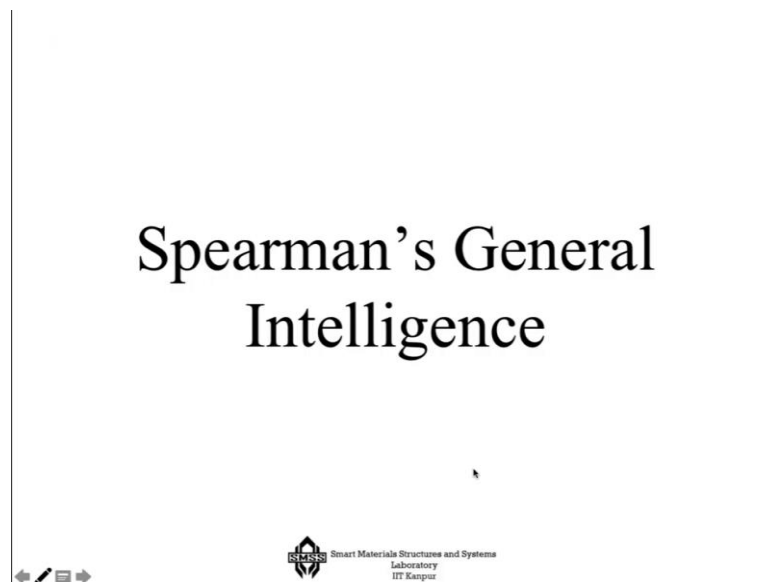
It becomes stronger with age as one accumulates new knowledge and new understand. But this is essentially the accumulation of knowledge.

Whereas, the fluid intelligence is something which refers to the ability to think and reason the ability to think and reason abstractly and solve the problems. And this is independent of that what knowledge you are having. You can have enormous knowledge, but you may not have that ability of the fluid intelligence to solve the problems.

This is generally independent of learning, experience, and education. And some parts which are important in it are like solving puzzles and coming up with problem solving strategies.

Generally, this speaks in adolescence, and begins to decline progressively beyond 35 to 40 years of age. However, both the types of intelligence increase throughout the childhood and adolescence, the crystallized intelligence and the fluid intelligence. So, these are two different aspects of the intelligence.

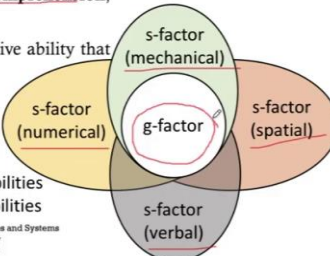

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## Two-factor theory of intelligence

- Proposed by **Charles Spearman**, British psychologist (1863-1945).
- Described a concept referred to as general intelligence or the **g factor**, which can lead to other specialized forms of intelligence, measured by specific or **s factor**.
- Noticed that people who did well on one test, tend to do similarly well on other tests of mental ability.
- g-factor** is a sum of **s-factor** scores that measure a person's abilities in one particular area. Generally expected **s-factors** of intelligence include **memory**, **attention**, **verbal comprehension**, **spatial skills**, and **abstract reasoning**.
- He concluded that intelligence is a general cognitive ability that can be measured and numerically expressed.



g - general abilities  
s - specific abilities

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Now, let us look into Spearman's general intelligence. Now, Spearman, between you know 1863 to 1945 is a famous British psychologist. He actually divided intelligence into two parts; one is the general intelligence or the g-factor, and another is the specific intelligence or the s-factor.

This is based on his observation that people who are generally well in one test tend to do similarly well on other tests of mental ability. So, which means there must be something general about the intelligence that is why this is possible that was the assumption based on this observation.


However, it is also found that people are not equally skilled on everything. So, there are some s-factors scores that measures a person's ability in one particular area like in terms of memory, in terms of attention, verbal comprehension, spatial skills and abstract reason.


So, we have all these s-factors like numerical, mechanical, spatial, verbal. And in short of overlap of them, but at the center lies something called a g-factor that is the general intelligence, so that is the two factor theory that was the first kind of you know way of defining what is called intelligence, the g-factor and the s-factor.

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g-factor	s-factor
Responsible for all mental activity.	Responsible for <u>doing specific work.</u>
<u>Acquired by genes.</u>	<u>Not by birth.</u>
<u>Present in all but varies.</u>	Specific intelligence present in all. Some people are good in scientific knowledge or singing, or sports, etc.
<u>Can't be changed by education, practice and experience.</u>	Can change or improve by education, practice and experience.

Not all psychologists agreed with Spearman and his general intelligence concept.



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Now, this g-factor is responsible for all mental activity. And this is generally acquired by the genes. It is present in all, but varies in terms of how much of g-factor one is having, and it is assumed that this cannot be changed by education, practice and experience. This is something which is kind of people are born with.

However, the s-factor is responsible for doing specific works, and this is not by birth, this is not by birth, this is something which is acquired. So, specific intelligence is related can be related to say scientific knowledge, singing, sports, these are all acquired. This can be changed or improved by education, practice, and experience. So, the s-factors according to Spearman's theories acquired, and g-factors that is something that comes as genetic; and the two together defines the intelligence.

However, not all psychologists have actually agreed with Spearman's you know general intelligence concept, this is something which is you know it is controversial, not all the psychologists are agreed with it. As there are different views of the psychologists particularly the view of that the g-factor is something which has been at a subsequent stage quite challenged by the other psychologists, and they try to redefine these factors in terms of more specific observable way of intelligence.

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## Thurstone's Modified g-factor Intelligence Theory



So, let us look into beyond these Spearman's definition we would go into Thurstone's theories of intelligence first. We will look into Thurstone's Modified g-factor Intelligence Theory.

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### Primary Mental Abilities

Instead of viewing intelligence as a single, general ability, **Louis Leon Thurstone's** (1887 - 1955) theory focused on seven different primary mental abilities.



- ✓ Associative memory: The ability to memorize and recall.
- ✓ Numerical ability: The ability to solve arithmetic problems.
- ✓ Perceptual speed: The ability to see differences and similarities among objects.
- ✓ Reasoning: The ability to find rules.
- ✓ Spatial visualization: The ability to visualize relationships.
- ✓ Verbal comprehension: The ability to define and understand words.
- ✓ Word fluency: The ability to produce words rapidly.

According to him: *Intelligence is a cluster of abilities. The g-factor is just an overall average score of these independent abilities.*



And in this case Thurstone, it is from 1887 to 1955 has actually developed this theory which is based on certain more you know distinct definitions of some of the aspects like associative memory, numerical ability, perceptual speed, reasoning, spatial visualization, verbal compensation, comprehension and word fluency.

So, Thurstone's focus are for example, associative memory which means how much you are able to actually memorize and you know this memory is not just from the hippocampus, but you know association of one memory aspect with other previously learned aspects of the memory. So, that is you know the ability the more you can do that association that it goes beyond the hippocampus area, so that is something that actually is defined in intelligence is kind of a telltale sign of this associative memory.

Then numerical abilities like the ability to solve arithmetic problems. Perceptual speed the ability to see the differences and similarities around objects. Reasoning, you know ability to find that there are some inherent rules in a system. Spatial visualization, the ability to visualize the relationships and between the things. And the verbal comprehension, the ability to define and understand the words, and the word fluency that is the ability to produce words rapidly in terms of explaining something.

So, according to him that the g-factor that Spearman has defined is something which needs to be more specific and he has defined these seven specific areas by which the g-factor can be actually defined. And this cluster of abilities is what he has focused on. So, even though he has not entirely challenged the Spearman's theory, but he had modified or sort of taken out the vagueness from the definition of Spearman.

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### Is intelligence one general trait or many specific abilities?

- Neither Spearman or Thurstone entirely denied the ideas of the other, but differed in what they thought mattered most.
- Most psychologists today agree there's a positive correlation between various tests of cognitive ability (g), but it is probably made up of multiple general ability factors.



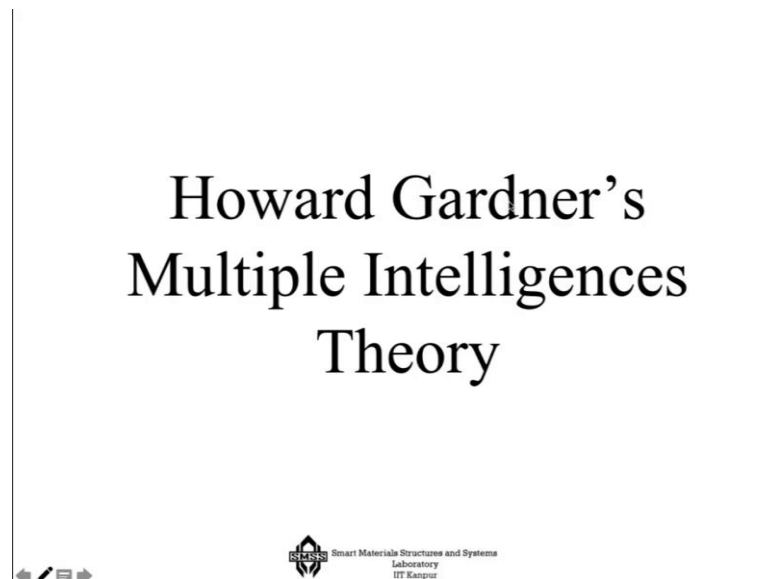
Now, the point here is that is intelligence, Is it really one general trait or many specific abilities because what Thurstone has said that the general intelligence itself has many specific abilities.

Now, in today's context neither Spearman nor Thurstone entirely denied the ideas of each other, but differed in what they thought which mattered most. But most psychologist today agrees that there is a positive correlation between various say you know aspects of the cognitive ability.

And those aspects that we had just discussed things like associative memory things like perception, things like you know numerical aptitudes all these have it has a positive relationship with the cognitive ability and that can be defined in terms of g-factor, but it is probably made up multiple general ability factors which Thurstones has said.

And it is the definition is still not very close there can be many other factors which can go inside. Now, let us look into some of the more advanced let us look into some of the more advanced theories of intelligence. So, beyond Thurstone as the focus is on multiple intelligence we look into Howard Gardener's point of view of intelligence now.

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We will now look into Howard Gardener's Multiple Intelligence Theory.


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## Theory of Multiple Intelligences

**Howard Gardner** (1943-present) at Harvard University proposed that the traditional idea of intelligence, based on IQ testing (that typically only account for linguistic, logical, and spatial abilities.), did not fully and accurately depict a person's abilities.



His theory proposed eight different intelligences based on skills and abilities that are valued in different cultures.


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Now, Howard Gardener is from 1943 to present, he is living psychologist one of the very famous and from Harvard University. He has proposed that the traditional idea of intelligence, based on so called IQ testing that typically only account for linguistic logical and spatial abilities, this did not fully and accurately depict a person's ability.

So, he proposed eight different intelligences based on skills and abilities that are valued in different cultures. Now, let us look into what are these eight different intelligences.

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Intelligence	Example
1 <u>Bodily-kinesthetic intelligence</u>	The ability to control <u>body movements</u> and to handle <u>objects skillfully</u> : <u>Athlete, dancer, craftsmen.</u>
2 <u>Interpersonal intelligence</u>	The capacity to detect and respond appropriately to the <u>moods, motivations, and desires of others</u> : <u>Politician, salesperson, clinical psychologist.</u>
3 <u>Intrapersonal intelligence</u>	Self-aware and in tune with inner feelings, values, beliefs, and thinking processes: <u>Philosopher, essayist.</u>
4 <u>Logical-mathematical intelligence</u>	The ability to think <u>conceptually and abstractly</u> , and the capacity to discern <u>logically or numerical patterns</u> : <u>Scientist, mathematician, navigator.</u>
5 <u>Musical intelligence</u>	The ability to produce and appreciate <u>rhythm, pitch, and timbre</u> : <u>Musician, composer, singer.</u>
6 <u>Naturalistic intelligence</u>	The ability to recognize and categorize <u>animals, plants, and other objects in nature</u> : <u>Zoologist, botanist, ecologist.</u>
7 <u>Verbal-linguistic intelligence</u>	Well-developed verbal skills and sensitivity to the <u>sounds, meanings, and rhythms of words</u> : <u>Poet, writer, public speaker.</u>
8 <u>Visual-spatial intelligence</u>	The capacity to think in <u>images and pictures</u> , to visualize accurately and abstractly: <u>Sculptor, painter, chess player, architect.</u>

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Well, the first one is what is called bodily kinesthetic intelligence. So, what it means is that the ability to control the body movements and to handle objects in a very skillful manner, is something like the athletes will be doing, something like the dancer will be doing or a craftsman will be doing, so that is called bodily kinesthetic intelligence.

Then there is something called interpersonal intelligence – the capacity to detect and respond appropriately to the moods, motivations, and desires of others; something which politicians do, a salesman or a clinical psychologist do, so that is what is called interpersonal intelligence.

Then there is something the third factor so bodily kinesthetic intelligence that is the first important factor, interpersonal intelligence the second important factor. And then there is a third important factor which is intrapersonal intelligence. So, this is something like the self awareness, and it is in tune with inner feelings, values, beliefs, and thinking process; and that is something which generally will observe in philosophers, essayist, etcetera. The intra personal intelligence something which is the inner feeling of a person.

And then he has talked about logical or mathematical intelligence. So, this is as the name itself suggests that the capacity to think conceptually and abstractly, capacity to discern logically or numerical patterns; something which a scientist would do, a mathematician or a navigator would do, so that is what is the fourth intelligence factor the logical mathematical intelligence.

Then there comes the musical intelligence, that means, the ability to produce and appreciate rhythm pitch and timbre which is as you know people like musicians, composers, or singers you will generally find it with them. The next type of intelligence he has noted is called naturalistic intelligence something which refers to the ability to recognize and categorize animals, plants, and other objects in nature like geologists, like botanists, like ecologists etcetera.

Then of course, there is the verbal linguistic intelligence like well-developed verbal skills and sensitivity to sound, meanings and rhythm of words something which you will find in poets, in writer, in public speakers, so that is what is the verbal linguistic intelligence.

And finally, the visual spatial intelligence, the visual spatial intelligence naturally talks about images and pictures, how to visualize accurately and abstractly like a sculptor does, a painter, chess player or architects. So, these are the eight categories.


The bodily kinesthetic intelligence, interpersonal intelligence, intrapersonal intelligence, logical mathematical intelligence, musical intelligence, naturalistic intelligence, verbal linguistic intelligence and visual spatial intelligence, these are the eight factors according to Howard Gardener which actually defines the core intelligence.

Now, this itself once again is not the final theorem. This itself is not the final theorem of intelligence. There is further you know we talk about Sternberg's the point of view of intelligence, and that is where we will try to complete the psychologists point of view. So, let us look into that what is Sternberg's point of view of intelligence.

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## Triarchic theory of intelligence

Psychologist **Robert Sternberg** (1949-present) at Cornell University defined intelligence as "mental activity directed toward purposive adaptation to, selection, and shaping of real-world environments relevant to one's life."



He agreed with *Howard Gardner* that intelligence is much broader than a single, general ability. But suggested that some of Gardner's types of intelligence should be better labeled as "skills" than "intelligences."

Sternberg stresses both the universal aspects of intelligent behavior and the importance of adapting to a certain social and cultural climate.

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We will now look into Robert Sternberg's Triarchic theory of intelligence. Now, this is from the psychologist Robert Sternberg at Cornell University who defines intelligence as mental activity directed towards purposive adaptation, selection and shaping of real-world environments relevant to one's life.

So, what Sternberg says is that whatever gardener is telling in terms of various types of intelligences, these are nothing but certain skills. And they all refer to in a sense all of them together refers to that what is the capacity of an individual towards purposive

adaptation towards selection or towards the shaping of the real world environment, you think of any of the capacities that we have discussed like say interpersonal abilities.

So, this talks about that how a person will be dealing with his environment in a way that actually improves the success of his or her ability to survive in the environment essentially acknowledging that the homo sapiens are in always in a socialistic animal. So, they are in a group. So, in a group survival depends on how you are actually convincing your group towards your points of view.

Like that if you look at other you know aspects of it, let us just took look at say something like intrapersonal the philosophical point of view. Again the person who is having an intrapersonal kind of skills will be able to abstract the various things that actually happen in life; and through that abstraction the person may actually gain you know significance in the society.

And that is the same way you look at all other abilities the ability of say for example the word, the vocal abilities or the other these are all some of them are related to entertainments. For example, the visual abilities or some of them are related to help homo sapiens to establish themselves in you know in the nature among the nature you know how to survive.

So, all of these are actually whatever you know has been defined by Gardener, this according to Sternberg are actually skills. And these skills are essentially certain aspects of mental activity which are directed towards the purposive adaptation, and shaping of the real-world environment, so that is what is his point of view.

He stress is that both the universal aspects of intelligent behavior and the importance of adapting to a certain social and cultural climate these are the important aspects of intelligence. So, that is what is the foundation of his Triarchic theory of intelligence.


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## Triarchic theory of intelligence

Sternberg proposed what he referred to as "successful intelligence," which involves three different factors:

- ✓ **Analytical intelligence:** Ability to evaluate information and solve problems.
- ✓ **Creative intelligence:** Ability to come up with novel ideas.
- ✓ **Practical intelligence:** Ability to adapt to a changing environment.

Sternberg believes that a **balanced** measure of all three forms of intelligence would result in the **greatest life success**.



Now, basically grouping you know regrouping all the things and abstracting it these are the three that he found to be important in terms of intelligence that is analytical intelligence that is the ability to evaluate information and solve problems; creative intelligence that means the ability to come up with novel ideas; and practical intelligence, ability to adapt to a changing environment.

So, these are the Triarchic these are the three you know things which are important in terms of successful intelligence parameters so that is what Sternberg believes that a balanced measure of all the three forms of intelligence would actually result in greatest life success, and that would actually ensure the continuation of the project, so that is what is Sternberg's point of view in terms of intelligence.

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## What is the best theory of intelligence?

- ❑ Spearman's theory of generalized intelligence remains one of the most recognized, but newer theories, like Gardner's and Sternberg's, offer new and promising insights.
- ❑ While IQ tests remain the standardized test of intelligence, this may not always be the case.
- ❑ As our world changes and new theories of intelligence continue to emerge, we may find that our assumptions about human intelligence aren't quite what we once thought.



So, if you ask me that what is the best theory in terms of intelligence, we would say that Spearman's theory is generally most recognized. However, there are Gardner's Theory or Sternberg's Theory which gives us more new and promising insights.

We can also say that while IQ tests remain the standardized test of intelligence, this may not always be the case. And as our world changes and new theories of intelligence will continue to emerge as we will be able to understand the world better. We may find that our assumptions about human intelligence itself is not quite what we once thought.

So, this is where we will put an end in today's talk on psychologist's point of view of intelligence. In the next talk, we will talk about the other points of view of intelligence particularly from the robotics or from the artificial intelligence point of view.

Thank you.