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Review Paper

Detecting Those Who Can Detect Better: A Review Study on Individual Differences in Attending Disguised Objects

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ABSTRACT

Theoretical models and studies have well illustrated individual differences in their Cognitive Abilities. Attention and Visual Processing are among the cognitive abilities possessed by human. The processing involved here further guides their perception of their environment. Camouflage as a term refers to practice of deliberately disguising or hiding any object so as to escape it from attention of the viewer and thereby exclude that object specially from their visual processing. Keeping in light the fact of individual differences, it becomes a quest of interest if individual differences exist on their ability to detect camouflaged objects and if they do then further identify those who better possess this ability. The revelation and compilation of these parameters can in assessment and scrutiny in recruitment of applicants of a job profile where this ability is deserved, for example security personnels. The present study does a review of existing literature and studies the cognitive and behavioral aspects of human beings and finds that differences on this existed on physiological, psychological, gender, socio-economic and developmental basis. The characteristics of these bases are discussed in the paper.

Keywords: *Camouflage Detection, Cognitive Abilities, Attention, Individual Differences*

The book "Cognitive Psychology" by Neisser (1967), who is also referred to as father of this field, defined it as, "Cognitive Psychology refers to all processes by which the sensory input is transformed, reduced, elaborated, stored, recovered and used.". He listed various steps involved in cognitive processing of sensory input which are as:

i. *Transformation:* Information by our senses is brought from outside and transformed for further processing
ii. *Reduction:* The physical energy from environment is further converted to neural energy where the same is utilized for as basis for subsequent cognitive processing. Now, the use of term 'reduction' comes from a very unique function taking place in this step which is filtering of data for further processes, thus, justifying the term 'reduction'.
iii. *Elaboration:* It adds more data to the current info. For instance, the data from visual senses in the form of a rectangle with some height of a human and metal objects attached to it enters the body and is related to more general information.
iv. *Storage & Recovery:* The 'representations' are stored and recovered as per need.

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v. *Usage:* The process of Cognition has a function of efficient and productive value.

Approaches to Cognitive Psychology

The understanding of Cognitive Psychology goes by two approaches:

i. *Information Processing Approach:* Comparing Human Processing to a computer and information is processed one at a time.

ii. *Connectionist Approach:* Disbelieves one at a time information processing and talks views brain as a 'parallel-processing' machine and thus takes cognitive process as a cumulative function of many units.

Cognitive Abilities

Various cognitive abilities are found in human beings. These abilities listed below vary across human beings and play a key role in performance differences which individuals have, the abilities being Attention, Memory Knowledge Organisation, Language, Problem Solving, Reasoning and processing of information from senses such as that audio-visual information.

Spatial Cognition

Spatial Cognition is a branch of Cognitive Psychology which works to understand the relation between an individual environment and mental process related to it. It is that field of study which aspires to discover how humans and other animals attend, perceive, process, interpret and interact with their environment and its characters. Due to such a wide arena of cover involved in the study of Spatial Cognition with such a diversity of approaches and details involved from attention to perception, memory, categorization, problem solving, language, reasoning, Spatial Cognition becomes a multidimensional subject and has been traditionally organized in three basic fields of study:

i. The nature of the environment and the organism's fit to it.
ii. The mental structures and processes that sub serve spatial thought.
iii. The parameterization of spatial info itself.

Individual Differences in Spatial Ability

In order to study individual differences in spatial ability, researchers by the end of 20th century shifted their focus from psychometric method of evaluation to experimental and cognitive approach to examine the cognitive process leading to variation in spatial abilities among individuals. The bases of individual differences are discussed below:

i. *Role of Working Memory:* Baddeley (1986) in his research suggested that if an individual is subjected to repeated spatial tasks a then it will disrupt and negatively affect his ability to hold information in working memory more than if they are subjected to repeated verbal tasks.

ii. *Neural-Based individual differences in Spatial Skills*: Right hemisphere is responsible for more geometric, precise and mathematical processing of spatial information. On the other hand Kosslyn(1998) states that left hemisphere process visual spatial information in a categorical-language system in which images are perceived in relation to other spatial objects for example 'object A is situated beneath object B. Another research by Wendt and Risenberg(1994) found that its participants with poor mental rotation skill had no distinct hemispherical asymmetry in them.

iv) *Gender differences in Spatial Ability*: Researches by both Brown et al (1998) and Galea & Kimura(1993) found that in the process of navigating, males make more use of distance and cardinal information whereas females are more likely to use referential objects and landmark

to assist their navigation. In the performance of spatial visualization, Voyer et al. (1997) found no gender difference.

Study by Silverman & Eals (1992) found that Females performed better in spatial ability tasks which involved usage of location, landmarks and. Whereas, Linn & Petersen (1985) in their study stated that *Males* performed better on spatial perception and mental rotation skills and also males use of holistic method more – a method which involves whole object rotation, whereas, Pezarsis & Casey (1991) reported in their study that female adopt more to strategy which is less efficient and follow sequential approach to mental rotation- a method which involves part by part rotation of object. This was also supported by Jordan et al. (2002) in their study.

Individual Differences in Spatial Ability across the Physiological, Gender and Socio-Economic Bases

Physiological Bases

To study physiological basis of individual differences in spatial ability with a Kosslyn et al. (1998) designed a study which consisted of three sets of tasks and further blood flow correlation with each set was assessed using *Positron Emission Tomography (PET).* The findings of the above experiments were as, i) the left hemisphere was seen to be more activated for categorical judgment tasks than for coordinate judgment tasks, ii) the right hemisphere was seen to be more activated more for coordinate judgment tasks than for categorical judgment tasks, iii) three areas in the parietal lobe were activated more for the coordinate tasks than for the categorical tasks.

Another study over regional blood flow was done by Wendt and Risberg (1994) in which they took 19 normal right-handed volunteers as participants and blood flow was studied in two situations as i) rest and ii) three spatial tasks. The three spatial tasks were counting of rectangular shapes, metal rotation and cube analysis. The study found that there was high significant relation between performance on cube analysis task and left/right hemisphere flow symmetry. The study also demonstrated that participants who use right hemisphere strategy when solving certain spatial tasks perform better than participants with more bilateral involvement. The researchers also found that those participants who were poor at metal rotation skill had no distinct hemispherical asymmetry.

Gender Bases

Gender differences in strategy used for route information was studied by Brown et al. (1998) by including participants of age 20 to 78 years who were required to give directions to a hypothetical stranger while looking at map. The scoring of the participants was done on the basis of strategy used by them in giving directions. In order to influence the memory, participants were provided with the map all the time. The study demonstrated that middle age females used higher number of strategies as compared to young males, young females, middle age males, and older females. The accuracy of males was higher than females for relational strategy. The study also found that there was no effect on direction giving performance due to any age decline, when map was provided and memory demands were minimal. Similar research by Brandner (2007) over the sex differences in the strategy used during exploratory behavior employed a visuo spatial task and visual discrimination task to study exploration by participants. The research findings were, i) females preferred a local search strategy whereas males preferred a global search strategy, ii) female were more

conscious to safety and risk possibilities whereas males were comparatively less bothered about risk during exploration.

Galea and Kimura (1993) performed research in which they investigated the gender differences in strategy used for route learning whilst controlling the visual item memory. The participants (49 males and 48 females) were required to learn a route through a standard map. The research found that females were able to remember more landmarks than males, males were better than females in knowledge of the Euclidean properties of the map and males were more efficient and fast in learning the map as compared to females.

Proceeding further with studying gender differences in spatial abilities, Linn and Petersen8 tried to bring out the emergence and characteristics of such differences in their research. Their research tried to discover three topics as, i) the magnitude of gender differences in spatial ability, ii) the aspects of spatial ability which account to gender differences, iii) stage of life span when gender differences in spatial ability occur. The research which was based on meta-analysis gave out findings as, i) gender differences occur on some types of spatial abilities, and not all, ii) gender differences were high in the task of mental rotation, with males outperforming females ii) gender differences were low on measure of spatial perception, and iv) after detection of sex differences, they can be found across the life span.

Socio-Economic Bases

Lippa et al. (2009) in their research studied the sex differences in mental rotation and line judgment tasks across the various economic development status of 53 nations. The study assessed 1,11,000 male participants and 90,000 female participants from 53 nations of different economic status. Gender equality status obtained from data by UN and economic development of countries was assessed by their per-capita income and life expectancy. The study had findings as, i) participants belonging to more economic developed countries performed better in mental rotation skills, ii) effective gender equality and better economic development contributed to better performance in both visuo spatial tasks (mental rotation and line judgment), iii) the relation of gender equality and economic status to performance was stronger for males than females, iv) in terms of type task males were better in performance in mental rotation than line judgment.

Cross cultural approach to gender differences in spatial ability was studied by Geary & DeSoto (2001). In their research they tested spatial ability on two sample of adults from United States and China. The study found that there was a gender difference in mental rotation task of spatial ability and males outperformed females in mental rotation tasks (3D) across both the cultures. The research drew inference that the male advantage in mental rotation task independent of the cultural differences.

A meta-analysis by Voyer et al. (1995) focused on the consistency of the gender differences in spatial ability across various geographic locations the influence of globalization and economic development upon such differences in spatial ability. The researcher arrived on various findings as, i) Gender differences effect the performance in spatial ability tasks, but *interest* differences among participants also exists, ii) Gender differences in spatial ability is decreasing over time as a possible effect of globalization, economic development and gender equality measures being adopted by countries, and iii) the age of emergence of gender differences is dependent upon the test used for testing spatial ability.

Camouflage Detection

King et al (1981) stated in their research that the detection of camouflaged objects is dependent on two factors, the first being the object characteristics (how efficient is the hide) and second being the characteristics of the observer - how well they can detect hidden objects. Psychological processes involved during eye movements, when viewing a spatial region with multiple objects were studied by Monty & Senders (1976). This study suggested that some objects fixate attention upon them more easily than other objects. This fixation pattern was found to depend on the training received by the subjects before being engaged in search tasks.

Qualitative difference between the two modes of information processing, i) automatic detection and ii) controlled search was brought out by Shiffrin & Schneider (1984). in their study. They constructed a search, attention and detection based 'two focus theory'. Their study investigates the process followed in the learning of automatic detection and the automatic response following it, and also, dependence of automatic (autonomous) detection on the attending responses (objects which grab attention) and further studies how such responses interfere with the controlled processing and attention of cognitive processing system. Research findings indicated that in the absence of a search strategy, individuals automatically select successive.

The probability of detection of an object during search task was related experimentally to a 'conspicuity area' by Engel (1976). Conspicuity area was defined as a spatial area in which object detection was 'easy' i.e. a visual field in which the target can be identified in a single fixation of the eye. In the experiment, during the examination of the 'conspicuity area', small eye fluctuations took place in the direction of the target. The occurrence of fluctuations was found to depend on the target eccentricity (unique and separable) and upon the composition of the conspicuity area.

Research by Shah and Miyake (1996) focuses on the separability of spatial working memory and verbal working memory among college students. To study this, the research had two experiments; i) Experiment 1 had a spatial span task which counted on both 'processing' and 'storage' component of the spatial working memory. This experiment was correlated with just the spatial ability of spatial visualization and verbal ability measures were kept out. ii) Experiment 2 used the interference paradigm (between spatial and verbal ability) to study the processing and storage demands of spatial span tasks. The research found that processing and storage components are mutually important for spatial thinking and language processing tasks. It also deducted that these tasks require the ability to hold information in memory while other information is being processed and utilized.

Individual Differences in Camouflage Detection

Individual differences in the detection of camouflaged objects and the strategies used in the detection were part of a study by Troscianko et al. (2013). The study conducted four experiments, where the participants tasked with object searching in all the three camouflage types with different contrast levels. The results demonstrated that, i) disruptive coloration was the effective and efficient mode of camouflage, ii) high contrast made the detection tough than any other stimuli, iii) distractive pattern is an effective camouflage pattern than background matching.

Dazzle camouflage was studied by Von et al. (2013) by using objects which had different graphical patterns of stripes on them, which were as, i) longitudinal (parallel to movement

direction) and ii) vertical (perpendicular to movement direction). The study which hypothesized that pattern of stripes effected the probability of detection found that, i) longitudinal striped objects were detected more than the unicolored objects, ii) vertical striped objects were detected equally to the unicolored objects, and iii) the objects with longitudinal and vertical stripes were perceived faster than the unicolored objects and were detected more. Compiled results also demonstrated that, in dazzle camouflage, presence of stripes on objects effects the perception of their speed which thus effects their detection.

Neider and Zelinsky (2006) studied the effects of target-background similarity on visual search and object detection. The research was based on four experiments which involved search of toy targets among, i) distractors of various sizes and ii) target background similarity (TBS). The study gave findings as, i) manual errors and response time showed in increase due to target background similarity, ii) analyses of eye movements showed that major eye fixations were on distractors than on TBS area, even under situations when TBS was high than distractors in degree.

Individual differences in performance in embedded figures test were studied by Hock et al. (1976) using two experiments which were structured in the form of timed yes-no response task. The study found that, i) participants which focused on the analytic process were more effective in solving embedded figure test than the participants using structural process, ii) the strategy of focusing attention on parts of embedded figure is the best for solving this task, iii) familiarity with the objects makes detection of embedded figures easier for participants using analytic process, iv) for participants using structural process, familiarity makes detection of embedded figures easier only under the condition that 'template-matching' strategy was used by them (when target figure and embedded figure are physically identical).

CONCLUSION

The review aimed to extract those parameters on which individual differ on their spatial ability to detect camouflaged and disguised objects. The purpose of the study was also to suggesting ways of identifying outperformers. These suggestions may help in scrutiny of security personnels or those allied professions where this excellence in this ability is desired. A compilation of results of various researches on individual differences on their ability in detecting disguised objects is compiled below,

Individual Differences in Spatial Ability

- Individual differences exist in Spatial Ability and Camouflage Detection and these differences have a physiological, psychological, gender, socio-economic and developmental basis.

Physiological Basis of Individual Differences in Spatial Ability

- Adaption of the human eye to light plays a role in camouflage detection. An eye adapted to high luminance when suddenly exposed to a visual environment of low luminance then detection of object placed in darkness will be tough.
- During the examination of conspicuity area, swift eye-fluctuation takes place in the direction of target. These fluctuations depend on object eccentricity (unique and separable from the background).
- Left hemisphere and right hemisphere is activated more for categorical judgment tasks and coordinate judgment tasks respectively.

- High relation exists between performance in cube analysis task and left/right blood flow symmetry.
- Individuals who make use of right hemisphere during solving spatial tasks perform better than individuals who are involved in bilateral hemisphere use.

Developmental Basis of Individual Differences in Spatial Ability

- *Gender differences in spatial ability were present as early as four years.*
- *Gender difference among children is highest in mental rotation tasks.*
- *At the primary level of schooling females outperform males in language skills.*
- *The use of paper-pencil method to measure spatial ability in the age group 6 to 18 years is a feasible option.*

Gender Basis of Individual Differences in Spatial Ability

- Gender differences in spatial ability exist but they occur only on some types of spatial abilities and not all.
- Gender difference is high in mental rotation task.
- Gender difference is low in measure of spatial perception and object identification.
- During exploratory tasks, females preferred a local strategy whereas males preferred a global search strategy.
- Males outperform females in tasks as, i) accuracy of relational strategy use, and, ii) geometric analysis of map,
- Females outperform males in tasks as, i) recall of objects located in right visual hemifield, ii) storage and recovery of object location memory, and, iii) remembering landmarks.
- Middle age females used higher number of strategies in solving spatial ability task as compared to young males, middle age males, young females and older females.

Socio-Economic Basis of Individual Differences in Spatial Ability

- Individuals belonging to countries with better economic development status perform better in mental rotation skills.
- Effective gender equality and better socio-economic development result to an increase in performance in visuo-spatial tasks.
- Relation of gender equality and economic status to performance in spatial tasks was stronger for males.
- Gender difference in spatial ability is decreasing with time as a result of gender equal measures and globalization.
- Females outperform males even in cross cultural studies with participants taken from both eastern and western societies.

Stress and Camouflage Detection

- Stress negatively effects camouflage detection during search task and reduces detection ability.
- A study between stress and arousal found that, when a person is not stressed but in a state of arousal, then their performance increases in spatial tasks. The arousal is affected by heart rate and adrenaline secretion.
- Reduction in stress activation threshold gives incorrect and hasty responses in detection.

- Independence of individual in search task increases the stress activation threshold.

Attention and Object Fixation

- Individuals with good attentional capacity perform better on search task involving highly specified objectives and details.
- When viewing a spatial region with multiple objects, some of those objects fixate our attention upon them more easily than other objects.
- Fixation pattern on objects is majorly under the voluntary control of an individual engaged in the search task.
- In a spatial area where object detection is easier (conspicuity area), attention on non-targets is fixated quickly.
- Fixation on objects during search task depends on the training and instruction given before commencement.
- Sports person have a better performance in fixation on objects during search tasks as compared to others.

Spatial Working Memory and Change Detection

- Spatial working memory is separate from verbal working memory.
- For language processing tasks and spatial thinking, processing and storage components were found to be important.
- The effect of social influences on spatial memory demonstrates that social and spatial information influence memory, but not equally.
- Effect of spatial location of different types of faces in a visual field on their recognition and encoding demonstrates that recognition of cooperating/familiar faces is better than cheating/unfriendly faces. The recall of faces present in upper visual hemifield is better than faces in lower hemifield.
- Change detection ability of individual decreases when a break is introduced between the search processes.
- Individuals who are expert and familiar with the subject of change detection tasks perform better than novices.
- Conversation among individuals during change detection tasks hampers their performance.
- Large changes made in an image tend to escape detection.
- Video game players (VGP) outperform non video game players (NVGP) in change detection. Also, VGP employ different strategy for change detection as compared to NVGP and VGP comparatively have a broader search pattern (area wise).

Strategy Use in Spatial Tasks

- In embedded figure tasks, individuals who focused more on analytic method of solving the problem showed better performance.
- Individuals who were familiar with the object in the embedded figure tasks showed better performance
- The strategy on focusing attention on parts of the image of embedded figure test is found better than holistic analysis.

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Conflict of Interest

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